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Minerals Yearbook

1985

Volume I

METALS AND MINERALS

Prepared by staff of the

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR • Donald Paul Hodel, Secretary

BUREAU OF MINES • Robert C. Horton, Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

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Foreword

This edition of the Minerals Yearbook discusses the performance of the worldwide minerals industry during 1985 and provides background information to assist in interpreting developments during the year being reviewed. Content of the individual volumes follows:

Volume I, Metals and Minerals, contains chapters on virtually all metallic and nonmetallic mineral commodities important to the U.S. economy. In addition, it includes a statistical summary chapter, a chapter on mining and quarrying trends, and a chapter discussing the statistical surveying methods used by the Bureau of Mines.

Volume II, Area Reports: Domestic, contains chapters on the mineral industry of each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, and the Commonwealth of Puerto Rico. This volume also has a statistical summary.

Volume III, Area Reports: International, contains the latest available mineral data on more than 150 foreign countries and discusses the importance of minerals to the economies of these nations. A separate chapter reviews the international minerals industry in general and its relationship to the world economy.

The Bureau of Mines continually strives to improve the value of its publications to users. Therefore, constructive comments and suggestions by readers of the Yearbook will be welcomed.

Robert C. Horton, *Director*

Acknowledgments

Volume I, Metals and Minerals, of the Minerals Yearbook, presents data on about 90 mineral commodities that were obtained as a result of the mineral information gathering activities of the Bureau of Mines.

The collection, compilation, and analysis of domestic minerals industries data were performed by the staffs of the Divisions of Ferrous Metals, Nonferrous Metals, and Industrial Minerals of the Assistant Directorate, Minerals Information. Statistical data were compiled from information supplied by mineral producers and consumers in response to canvasses, and their voluntary response is gratefully appreciated. Information obtained from individual firms by means of Bureau of Mines canvasses has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonproprietary sources or when permission of the respondent has been granted.

The chapter "Nonfuel Minerals Survey Methods" discusses in somewhat greater detail procedures for canvassing the minerals industry and the processing and evaluation of these data.

Other material appearing in this volume was obtained from the trade and technical press, industry contacts, and other sources, and this cooperation is gratefully acknowledged.

Statistics on world production were compiled in the Branch of Geographic Data, Division of International Minerals from numerous sources including reports from the U.S. Department of State. U.S. foreign trade data were obtained from reports of the Bureau of the Census, U.S. Department of Commerce.

The Branches of Publication Support Services and Editorial Services, Division of Publication, provided general guidance on the preparation and coordination of the chapters in this volume and reviewed the manuscripts to insure statistical consistency among the tables, text, and figures between this volume and other volumes, and between this edition and those of former years.

The Bureau of Mines has been assisted in collecting mine production data and other supporting information by numerous cooperating State agencies. These organizations are listed in the acknowledgments to Volume II.

Albert E. Schreck, *Chief, Division of Publication*

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Nonfuel Minerals Survey Methods

By Staff, Office of Statistical Standards

The Bureau of Mines Minerals Information organization collects worldwide data on virtually every commercially important nonfuel mineral commodity. These data form the base for tracking and assessing the health of the minerals sector of the U.S. economy.

This data collection activity was instituted by the 47th Congress in an appropriations act of August 7, 1882 (22 Stat. 329), to place the collection of mineral statistics on an annual basis. The most recent authority for the Bureau of Mines Minerals Information activity is the National Materials and Minerals Policy, Research and Development Act of 1980 (Public Law 96-479, 96th Congress), which strengthens protection for proprietary data provided to the U.S. Department of the Interior by persons or firms engaged in any phase of mineral or mineral-material production or consumption.

DATA COLLECTION SURVEYS

The Bureau of Mines initiates the collection of domestic nonfuel minerals statistics with an appraisal of the information requirements of Government and private organizations of the United States. Those information needs that can be satisfied by data from the minerals industries are formulated as questions on Bureau of Mines survey forms. Figure 1 shows a typical survey form, Alumina (6-1013-A). Specific questions pertaining to the production, consumption, shipments, etc., of mineral commodities by industrial establishments are structured to provide data that will be aggregated into meaningful totals. One hundred and sixty-six monthly, quarterly, semiannual, and annual surveys cover the entire mineral economic cycle from production to trade and consumption.

Once the survey form has been designed, a list of producers or consumers is developed. Many sources are utilized to determine the companies, mines, plants, and other operations that should be included in the survey to produce meaningful national and State totals. Bureau of Mines State Mineral Officers, State geologists, Federal organizations (e.g., Mine Safety and Health Administration), trade associations, and industry publications and directories are some of the sources that are explored to develop and update survey listings. With few exceptions, an attempt is made to canvass the entire population of appropriate establishments. The iron and steel scrap industry is an example of one of the exceptions where a sampling plan is employed rather than a complete canvass of the entire industry.

Prior to mailing, the survey form must be approved by the Office of Management and Budget (OMB). Under the Paperwork Reduction Act of 1980, OMB approves the need or requirement for collecting the data and protects industry from unwarranted Government paperwork.

The Bureau publishes a "Survey Forms Catalog," which describes the content of each survey. Copies of the catalog may be obtained by contacting the Office of Statistical Standards, U.S. Bureau of Mines, Washington, DC 20241.

Form 6-1013-A
Nonfer. (6-83)

C04

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D.C. 20241

ALUMINA

Form Approved
O.M.B. No. 1032-0004

INDIVIDUAL COMPANY DATA—PROPRIETARY

Unless authorization is granted in the section above the signature, the data furnished in this report will be treated in confidence by the Department of the Interior, except that they may be disclosed to Federal defense agencies, or to the Congress upon official request for appropriate purposes

Please separate forms at perforations

An extra copy is provided for your files

(Please correct if name or address has changed.)

Please reply to the following questions and return the form as promptly as possible in the enclosed envelope. An extra copy is provided for your files. If exact data are not available, enter your best estimates and mark "estimated." Submit a separate report for each plant.

Collection of non-fuel minerals information is authorized by Public Law 62-386 and the Defense Production Act. This information is used to support executive policy decisions pertaining to emergency preparedness and defense and analyses for minerals legislation and industrial trends. The Bureau relies on your voluntary and timely response to assure that its information is complete and accurate.

1. Location of plant: Nearest city or town ______ County ______ State ______

2. Production, Consumption, Shipments, and Stocks of Alumina and Primary Alumina Products During the Year. Report gross weights of each product in Columns 3–7.

Product (1)	Code	Average Al_2O_3 content (Percent) (2)	Stocks beginning of year (Metric tons) (3)	Production during year (Metric tons) (4)	Consumption during year (Metric tons) (5)	Shipments during year: Quantity (Metric tons) (6)	Shipments during year: Value ($000) (7)	Stocks end of year (Metric tons) (8)
Calcined alumina	201							
Commercial alumina trihydrate	202							
Litho or light hydrate	203							
Activated alumina	204							
Tabular alumina	205							
Other (specify)								

3. Shipments of Alumina During Year by Consuming Industries.
The total quantity of shipments reported should equal the total of the shipments reported in Section 2, Column (6).

Product (1)	Code	Quantity (Metric tons): Calcined (2)	Trihydrate (3)	Activated (4)	Tabular (5)	Other (6)
Abrasive	301					
Aluminum	302					
Chemical	303					
Refractory:						
Brick and shapes	305					
Monolithic	306					
Calcium aluminate cement	307					
Other (specify)						

(OVER)

4. Consumption of Aluminum-Bearing Materials in the Manufacture of Alumina.

Material (1)	Code	Quantity (Metric tons) (2)	Value at Plant (3)
Bauxite, Domestic	401		$
Bauxite, Foreign:			
Jamaica	402		
Guinea	403		
Surinam	404		
Brazil	405		
Guyana	406		
Dominican Republic	407		
Other Countries (specify)			
Total foreign	419		
Other materials specify)			

5. Consumption and Stocks of Bauxite.
The quantity in Section 5, Column 3, Line 505, should equal the quantity reported in Section 4, Column 2, Line 401. The quantity in Section 5, Column 3, Line 515, should equal the quantity reported in Section 4, Column 2, Line 419.

Kind of ore (1)	Code	Stocks beginning of year (Metric tons) (2)	Consumption during year (Metric tons) (3)	Stocks end of year (Metric tons) (4)
Domestic				
Undried	501			
Dried	502			
Activated	503			
Calcined or sintered	504			
Total domestic	505			
Foreign				
Undried or partially dried	506			
Dried	507			
Other (specify)				
Total foreign	515			

Remarks: ______

Publications: Annual statistical information is published for aluminum and bauxite. If you desire a copy of one or both these commodity reports, please check the appropriate box ☐ (1) Aluminum ☐ (2) Bauxite ☐ (3) Both

Name of person to be contacted regarding this report | Tel area code | No | Ext.

Address No Street | City | State | Zip

May tabulations be published which could indirectly reveal the data reported above?
Value data ☐ (1) Yes ☐ (2) No Other (including quantity) data ☐ (1) Yes ☐ (2) No

Signature | Title | Date

GPO 840-389

Figure 1.—A typical survey form.

SURVEY PROCESSING

The 166 surveys yield more than 60,000 responses from approximately 27,000 establishments annually. Each of the completed survey forms returned to the Bureau undergoes extensive scrutiny to ensure the highest level of accuracy possible in recording mineral data. Bureau specialists ensure that no error is introduced owing to reporting in units other than those specified on the survey form. Relationships between related measures such as crude ore produced and marketable product are analyzed for consistency. Internal numerical relationships such as column and row totals are checked. The data reported in the current reporting period are checked against prior reports to detect possible errors or omissions.

For automated surveys, the specialist reviews the form for correctness and completeness before the data are entered into the computer. The computer is programed to conduct a series of automated edit checks to ensure mathematical consistency and to identify any discrepancies between the data reported and logically acceptable responses.

The Bureau of Mines is modernizing and automating all of its survey processing methods. Automation of the commodity data subsystems supports the processing of individual surveys and the preparation of statistical tables for publication. A central data base includes the minerals data gathered through surveys as well as pertinent data from other sources. The data base enables Bureau specialists to retrieve the data required for analysis of minerals problems and for answering specific user questions.

Survey Responses.—To enable the reader to better understand the basis on which the statistics were calculated, each commodity chapter of the "Minerals Yearbook" includes a section entitled "Domestic Data Coverage." This section briefly describes the data sources, the number of establishments surveyed, the response percentage, and the method of estimating the production (or consumption) that is accounted for by nonrespondents.

Although the response to Bureau surveys is generally very good, the Bureau must employ an efficient procedure for handling instances of nonresponse in order to produce reliable aggregated data. Second mailings of the survey form may be made. Followup by telephone is employed extensively to provide complete data entries on the survey forms, to verify questionable entries, and also to encourage those not reporting to either complete and return survey forms or provide the information orally. Periodic visits to important minerals establishments are also made by Bureau commodity specialists or State Mineral Officers. These visits are made to gather missing data and also to point out the importance of the companies' reporting to the production of accurate national as well as State and county statistics. By showing the use of these statistics and the impact of nonresponse, the Bureau hopes to encourage as complete and accurate a canvass as possible.

The OMB "Guidelines for Reducing Reporting Burden" stipulates that the minimum acceptable response rate shall be 75% of the panel surveyed. In addition, the Bureau strives for a minimum reporting level of 75% of the quantity produced or consumed (depending on the survey) for certain key statistics. Response rates are periodically reviewed, and for those surveys not meeting the minimum reporting level, plans are developed and implemented to improve response rates.

Estimation for Nonresponse.—When efforts to obtain response to a Bureau survey fail, it is necessary to employ estimation or imputation techniques to account for the missing data. These techniques are most effective when the response rate is relatively high. The Bureau is continually striving to develop and make use of the most effective techniques. Some of the imputation methods depend only on knowledge of the prior reporting of the establishment, while others rely on external information to estimate the missing data. Survey forms received after publication cutoff dates are edited, and necessary imputations are made for missing data. The data base is updated, and these revisions will be reflected in subsequent publications.

Protection of Proprietary Data.—The Bureau of Mines relies on the cooperation of the U.S. minerals industry to provide the minerals data that are presented in this and other Bureau publications. Without substantial response to survey requests, the Bureau would not be able to present reliable statistics. The Bureau in turn respects the proprietary nature of the data received from the individual companies and establishments. To ensure that proprietary rights will not be violated, the Bureau analyzes each of the aggregated statistics to ascertain if the statistics of an individual company or establishment can be deduced from the aggregated statistics. For example, if there are only two significant producers of a commodity in a given State, the Bureau will not publish the total for the State since either large producer could readily estimate the production of the other. It is this obligation to protect proprietary information that results in the "Withheld" or "W" entries in "Minerals Yearbook" tables. When the company gives permission in writing, the Bureau may release data otherwise withheld because of proprietary considerations.

FOREIGN DATA

Volume I of the "Minerals Yearbook" contains a "World Review" section in each commodity chapter that usually includes a world production table. These tables are prepared in the Bureau's Division of International Minerals. These data are gathered from various sources including published reports of foreign government mineral and statistical agencies, the U.S. Department of State, or international organizations such as the United Nations and the Organization of Petroleum Exporting Countries. Missing data are estimated by the country specialist based upon information gathered from a variety of sources.

PUBLICATIONS AND DATA SERVICES

In addition to the three volumes of the "Minerals Yearbook," the statistical data collected are published in other reports, the principal series being the "Mineral Industry Surveys." Mineral Industry Surveys are concise monthly, quarterly, or annual reports that contain timely statistical and economic data on nonfuel mineral commodities. The surveys are designed to keep Government agencies, the minerals industries, and the business community regularly informed of trends in production, distribution, inventories, and consumption of nonfuel minerals.

One of the earliest publications containing information on mineral production, resources, reserves, imports, exports, uses, recycling, substitution, environmental considerations, and related subjects is "Mineral Commodity Summaries." Published in January, it covers approximately 90 mineral commodities for the previous calendar year.

"Mineral Facts and Problems" is a one-volume reference book containing worldwide production information and demand forecasts for all nonfuel minerals. It is published every 5 years. In the 1985 edition, each commodity chapter covers the structure of the industry, uses of the commodity, reserves and resources, technology, supply-demand relationships, byproducts and coproducts, strategic considerations, economic and operating factors, and forecasts to 1990 and 2000. Each chapter also compares U.S. and world reserves with cumulative demand to appraise the adequacy of world mineral supplies.

The "Mineral Perspectives" series reports on the mineral resources, industries, and related infrastructure of those foreign countries or regions of the world that assume major importance to our Nation's mineral needs.

"Minerals and Materials/A Bimonthly Survey" provides timely information on selected commodities. Data and analyses are presented that are germane to policy issues of current interest. Brief narratives are supplemented by statistical graphs and tables. Data are provided for the current month and the previous 22 months, and estimates are made for the upcoming month.

The "Minerals Yearbook" and "Mineral Facts and Problems" are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. For additional information on the other Bureau publications, contact the Division of Publication, U.S. Bureau of Mines, 4900 LaSalle Road, Avondale, MD 20782.

Two types of machine readable (computer compatible) data are provided. A 10-year time series of domestic supply-demand relationships data on each commodity is available on 5-1/4-inch floppy disks from the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161. These disks are compatible with many types of microcomputers and popular microcomputer application software packages. These data have been published every

5 years in "Mineral Facts and Problems" and are being updated annually in "Mineral Industry Surveys" and on the floppy disks. Copies of Bureau survey mailing lists are also available on magnetic tape or in printed form. These lists include the company and plant names, Standard Industrial Classification (SIC) codes, and the addresses to which the survey forms are mailed. Information on purchasing copies of mailing lists can be obtained from the Office of Statistical Standards, U.S. Bureau of Mines, 2401 E Street, NW., Washington, DC 20241.

Mining and Quarrying Trends in the Metals and Industrial Minerals Industries

By Thomas W. Martin, Daniel L. Edelstein, and Garrett H. Hyde

MINING AND QUARRYING TRENDS[1]

This chapter includes tables from 1984 that were not available in time for publication of the 1984 Minerals Yearbook, but does not include corresponding tables for 1985. The value of raw nonfuel minerals produced in the United States during 1985 was estimated at $23.2 billion, an increase of $0.07 billion over the value for 1984. This is the third consecutive year that the value has increased, and except for a decrease in 1982, the value for each year has increased since 1971, or 13 out of 14 years. However, while the value of industrial minerals production continued to grow, reflecting the growth of the domestic economy, the value of metal mine production decreased in 1985 by 6%. This drop was more than offset by a 3% increase in the value of industrial minerals production because the value of industrial minerals produced was more than three times larger than the value of metals. The decrease makes 1985 the third year in the past 5 years in which a drop in the value of metal mining production occurred in the United States where production continued to lag behind growing world production. Domestic production of such major commodities as aluminum, copper, iron ore, phosphate rock, and zinc continued to decline owing to a number of international and domestic factors. Gold continued to be the most active commodity in the domestic metal mining industry. Despite lower prices, gold output increased to 2.5 million troy ounces, a 19% increase over that of 1984. The estimated annual production capacity of new gold mines beginning production exceeded 1 million ounces.

Overproduction by nations that rely on export of mineral commodities to support their economies and service their international debt; the strong value of the dollar relative to that of other currencies, which favors imported products; relatively high domestic labor costs compared with those of developing nations; and the use of industrial minerals such as carbon fibers, glass fibers, and plastics in products historically constructed from metals have all contributed to create chronically depressed world metal prices and markets in which the U.S. producer finds it increasingly difficult to compete. As a result, the U.S. mining industry continues to operate in a transitional state with many companies forced to retrench by closing or selling properties and assets, reducing employment, and renegotiating labor contracts. The mines that continue to operate have developed improved mining methods and operating techniques, and many have embarked on modernization programs in order to survive. Virtually every mining operation in the United States today has undergone substantial change over the past 5 years, and the mining industry is working harder and more effectively as indicated by the continuing gain in productivity. This demand for cost and productivity improvement is, in turn, fueling the development of new technology. The result has been numerous small improvements as well as some potentially major new developments.

Legislation and Government Pro-

grams.—Two laws were passed in 1985 providing for the minting of gold or silver coins. In July, the Statue of Liberty-Ellis Island Commemorative Coin Act was signed by the President. This bill provides for the minting of silver and gold coins in commemoration of the centennial of the Statue of Liberty. The other law, the Gold Bullion Coin Act of 1985, provides for the minting of gold coins to compete with the South African krugerrand and specifies the use of newly mined gold from natural deposits in the United States.

Legislation was introduced in Congress designating lands in seven areas for inclusion in the National Wilderness Preservation System. Only one bill, covering 13,300 acres in Kentucky, was signed into law. The other bills, specifying a total of 2,873,724 acres throughout Colorado, Utah, Nebraska, Michigan, Nevada, and the Great Smokey Mountains in North Carolina and Tennessee, were in various stages of the legislative process.

A number of bills of concern to the mining and minerals industry were introduced, including several pertaining to the National Defense Stockpile activities. They include removing the President's authority to establish goals and place administration responsibility with the U.S. Department of Defense, adding coke to the stockpile, establishing an agriculture barter program to acquire materials, and disposing of 10 million troy ounces of silver from the stockpile. All of the bills have been referred to the appropriate committees. The only change in the law occurred when amendments to prohibit the President from reducing stockpile goals below the goals in effect on October 1, 1984, at any time prior to October 1, 1986, were approved as part of the Defense Authorization bill in the House and the Supplemental Appropriations bill in the Senate for fiscal year 1985.

Six major pieces of legislation concerned with problems of the U.S. steel industry were considered during 1985. They included a bill to form a Government corporation to revitalize the industry, a bill to ban the importation of consultation steel products from the European Economic Community until new arrangements are negotiated, a bill to amend the Steel Import Stabilization Act, a bill to remedy violations of bilateral steel products trade agreements with the European Communities, and companion bills in the House and Senate to establish a breakpoint tariff system on imports of certain ferroalloys. Under an amendment to the National Bureau of Standards Authorization Act, which was approved by the President, $2.5 million was set aside for a Government and/or industry research project to develop new steelmaking technologies.

A section entitled "Negotiations and Action Regarding Agreements to Restrain Copper Production Voluntarily" was attached to a spending bill, House joint resolution 465, signed by the President. This provision, although not binding by the law, is meant to express the intent of Congress and directs the President through the U.S. Trade Representative to negotiate production restraints with major copper exporting countries. The President earlier vetoed the same copper provision when it was attached to a textile import restraint bill.

A wide variety of trade bills was introduced. Toward the end of the session, a bipartisan group of 33 Senators introduced Senate bill 1860, the Trade Enhancement Act of 1985, to amend the Trade Act of 1974 to eliminate barriers and distortions to trade, to provide authority for a new round of trade negotiations, and to promote U.S. exports. This bipartisan, comprehensive measure indicates that Congress may be moving away from the protection of specific industries in favor of broader changes in U.S. trade policy.

Two bills, both entitled "Federal Technology Transfer Act of 1985," were introduced concurrently in the House and Senate. Both bills establish a Federal Laboratory Consortium (FLC) to assist in the transfer of technology from labs to private businesses. In the House version, the FLC would be established within the National Science Foundation, and in the Senate version, it would be established within the National Bureau of Standards. The House bill also contains provisions concerning Government sharing of patent-license royalties with the inventors and standards that would effectively guide Federal employees to avoid conflicts of interest.

In November, members of the National Critical Minerals Council were sworn in. Priorities of the group, as mandated by Congress, include the first long-range assessment of national material needs and establishment of an advanced research and development plan. The Council must also advise the President on trends in minerals and materials matters that affect national and economic security. The group can recommend methods to increase exploration and development methods for critical minerals within the United States and the boundaries of the Exclusive Economic Zone.

The first public hearing of the Council was held in January 1986.

The long dormant issue of regulation of mining and minerals processing waste under the Resources Conservation and Recovery Act (RCRA) of 1976 became active as a result of legal action by a group of citizens against the Environmental Protection Agency (EPA). In response, EPA proceeded with regulation of copper dump leach solutions and mining waste and tailings from gold, lead, silver, and zinc mining. The agency also initiated the first phase of rulemaking for other mining wastes and submitted its "Report to Congress. Wastes From Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden From Uranium Mining and Oil Shale."[2] Following review, this report is to be the basis upon which EPA plans to make decisions regarding the regulation of mining waste under RCRA.

A proposed transfer of responsibility from the Bureau of Land Management (BLM) to the U.S. Forest Service for the underground minerals in 205 million acres of national forests was agreed upon by the two agencies. The Forest Service currently makes recommendations on the mineral lands and the BLM issues the leases. The two agencies have shared in the supervision of operations. The transfer would result in consolidating responsibilities for minerals and effect an estimated annual savings of between $27 million and $32 million.

Before adjournment, the House of Representatives passed major tax reform legislation. The bill changes provisions in the current tax law dealing with corporate tax rates, investment tax credit, capital gains treatment of minerals and timber producers, percentage depletion allowances, and the existing 25% credit for increases in research and development.

Exploration.—Mineral exploration activity in the United States continued to decline in 1985. Starting in 1981, the BLM has collected data on claims and annual filings of assessment work on Federal lands. A summation of these filings provides an estimate of the prospects the industry is currently exploring or examining. The BLM data show that from 1983 to 1985 new claims in the Western States have declined by 38% and assessment filings have declined by 22%, resulting in a total decrease of 24%. These figures confirm the drop in exploration activities. Again, low metal prices created by worldwide excess production were the cause of reduced metal exploration expenditures. This led to the consolidation of exploration operations and to staff reductions by several major companies. Gold and precious metals continued to be the major commodities sought domestically, with up to 90% of the exploration and development activities estimated to be for these metals in 1985.

New exploration methods and techniques continue to be developed despite the reduced exploration activity, as companies increase their efforts to identify suitable targets and develop them at a lower cost. For many years, satellite data have identified potential mineralized areas, but the use of satellites will probably increase in the future. New satellites will give resolutions down to 10 meters and generate far more information than earlier systems. These satellite pictures, combined with computer analysis, can save exploration companies vast sums of money. If prospecting for a mineral in a remote area, the first step is to purchase Landsat satellite data tapes of the area. The data can be fed into a computer together with comparative data for a known area of the mineral deposits.[3] The computer builds up a spectral picture (pattern vector of different infrared and ultraviolet wavelengths) for the mineral. Then working with a deduction process like natural selection, the program locates areas where there is more than an 85% likelihood of success. The program can find logical rules and assumptions that might never occur to the human prospector. Recently, a major mining company completed a survey of the spine of the Andes, covering 5,000 kilometers from southern Chile to Peru. After Landsat images identified promising areas, then geologists went in by helicopter to collect samples. This technique proved highly effective and is reported to have identified promising precious metals deposits.

The use of computers is spreading to all phases of exploration as hardware becomes more powerful, more portable, and less costly. During analysis and interpretation, the computer does much of the time-consuming, costly work such as drawing maps, computing statistics, and searching for anomalies. As an example, a gyrosystem linked to a computer for the accurate surveying of boreholes has been successfully used at a number of minesites in the Republic of South Africa.[4] The new system, made by Boart Drilling, accurately measures borehole inclinations and determines the precise locations of intersection points in the boreholes. Based on eight boreholes surveyed for clients, the company has found the system to be a vast improvement over conventional borehole surveying techniques, which use magnetic compass-inclinometers and miniature photographic systems. The system is not affected by magnetic fields emanating from the surrounding rocks, drill rods, or the electrical components of the instrument. Two accelerometers measure the inclination of the probe in the borehole. The system is lowered down the hole on a seven-core electric cable. All data are relayed through this cable to a Hewlett-Packard minicomputer housed in a logging truck on the surface. The use of the computer has significantly improved sampling intervals and has resulted in virtually instantaneous data processing. The computer is capable of plotting the shape of the borehole viewed in any direction, such as a plan view from above or a horizontal view. Typically, the gyroscope data are logged every 10 meters, compared with every 54 meters with conventional surveying systems. Even with this increase in logging data, the new system can obtain a complete printout of all survey details in about 60% of the time required to log a borehole using magnetic photographic methods.

Development.—The strategy of curtailing development during periods of low prices and expanding development during profitable periods has historically been a standard mining practice to deal with fluctuating metal demand and prices. With the chronic weakness of the market over the last 5 years, rather than relying on this strategy, companies have been forced to develop innovative techniques to reduce mine development costs. An excellent example is the change from the use of conventional drill and blast methods to roadheaders at the San Manuel Mine, Arizona. Beginning in 1980, the mine started reducing its work force in response to falling copper prices, and early in 1983, all drift development was curtailed.[5] However, by mid-1983, San Manuel management was faced with the need for drift development to meet future production goals and decided to begin a program by the end of the year. At the peak of its effort, San Manuel had approximately 100 workers working 3 shifts per day driving between 500 and 700 feet of drift per month. With the poor economic climate, a method of development was needed that was less labor intensive but could still achieve the rapid advance rates required.

After extensive research into new methods, roadheaders were selected because they can achieve rapid advance rates, and an advantage was also foreseen in reducing the number of working areas and eliminating congestion and conflict with mine production. After driving more than 3,500 feet of preextraction development headings on haulage and grizzly levels for ongoing support of block caving at the mine, roadheaders have cut drifting costs by 30% and increased the rate of advance by 37% when compared to conventional drill and blast methods. Such results were achieved in formations ranging from 19,000 to 30,000 pounds per square inch compressive strength, rock that is more or less typical of a low-grade porphyry copper. By midyear 1985, the San Manuel Mine had four roadheaders in operation. One roadheader is equipped with high-pressure, water-assisted cutting heads, utilizing water pressures of 9,000 pounds per square inch to assist machine performance. Although still experimental, high-pressure, water-assisted cutting should allow the roadheaders to successfully cut the hardest rock, to reduce destructive vibration in the machine, and to dramatically reduce dust.

Hydraulics has permitted automation of the drilling process on a much greater scale than with pneumatic drills, but the operator still plays a crucial part in drilling productivity. Differences in the handling of booms and drills have been found to cause variations in productivity levels by up to 30%. The operator also controls the accuracy of the profile and pull of the round. The spacing between holes, their pattern, and alignment are critical as any underbreak or overbreak results in an increase in costs. Computer technology to fully automate the drilling jumbo is now available, and several companies have entered the market.

Tamrock of Finland produced a computer-controlled jumbo, Datamatic, on which booms move in accordance with a drilling pattern preprogrammed into its memory.[6] The location, length, and direction of each hole are predetermined, and the jumbo automatically executes each hole in succession. A constant laser beam provides the reference from which all coordinates are calculated. This reference beam enables the computer to work out the drill's position and calculate the required boom joint angles for each successive hole. Therefore, hole alignment is very fast, because it does not depend upon the position or direction of the rig itself. Besides drilling according to the preprogrammed pattern, the Datamatic can also be operated with coordinated or direct control. With coordinated control, the driller positions the booms in the desired direction while the computer calculates the boom joint positions. If, as occasionally will happen, it is impossible to collar the hole in the predetermined position because, for example, it coincides with a rough promontory on the face from which the bit slips, the driller can manually move the boom to a new position and press a button. The computer will then automatically compensate for drill direction so that the hole terminates at the same predetermined point. A visual display unit also aids the operator by continuously showing boom alignments, penetration rates, and drilling patterns, including the holes that have been and are to be drilled. The operator thus has a visual check on the proceedings, permitting him or her to alter pressures, rotation rates, and drifter positions to maximize productivity.

Montabert, a French manufacturer, developed a fully computerized jumbo, Robofore, that automatically controls the various drilling functions in a drilling cycle.[7] After a 2-year test program, an operational machine has been installed in the Arbed iron mines in France. In addition to providing fully automatic drilling capability, the jumbo offers accurate special feed positioning to about 20°; hole collaring positioning to about 2.5 inches; a traveling speed from hole to hole of about 10 seconds, compared with 24 seconds during manual operation; smoother boom movements because speed is progressive; and improved drilling efficiency. The basic boom movements are recorded by means of sensors. These sensors direct the gathered data to a computer that controls the boom cylinders. Using the same microprocessors, other functions are also computerized, such as boom auxiliary movements (extension and feed anchoring), automated control of the drilling phase (feed advance and retraction), drifter regulation, control of safety parameters (oil level and temperature, etc.), as well as other safety devices to avoid boom interference. After having positioned the rig and the booms, the operator selects the required drilling pattern, which is fed into the computer. There is no other human intervention during the drilling cycle. The operator, however, can manually take over the entire drilling cycle or continue to drill on a semiautomatic basis. In the latter case, the boom is maneuvered and positioned automatically, but hole collaring is controlled by the operator. When drilling conditions require a change, new programming must be introduced into the computer.

The Tround Blast Hole Drilling System, a new hard-rock drill that can perform at rates ranging from two to four times faster than a conventional drill, was tested with the cooperation of a major oil company at a gas well in Arkansas in formations consisting of hard sandstone and shale.[8] The test results were viewed as positive. Based on a technology known as the Open Chamber System, the drill involves multiple projectile cartridges fed into and ejected from a novel arrangement of firing chambers. This arrangement, along with the complete elimination of the reciprocating breech element of conventional guns, makes possible extremely high rates of fire, if required. The drill utilizes multiple projectiles, which when fired in salvo, do not impact simultaneously, but produce delays measured in millionths of a second owing to slight variations of projectile weight and gas dynamics. Against rock, this rapid secession of impact generates shattering shock waves ahead of conventional drill bits.

Underground Mining.—Faced with a chronically depressed domestic mining economy, surviving operations have been forced to curtail their work force and improve productivity. In nearly all operations, this has involved major changes and the development of new methods and techniques. Inco Ltd. of Canada, a company that operated at a loss for the 3 years prior to 1984, is a typical example of the changing mode of operations that characterize today's mine management.[9] In a priority program to reduce costs, the company established a formal mine research department with a broad mandate to develop easier, safer, and more productive mining systems. The initial focus of this program was directed toward ground control, stoping methods, and equipment development. Basic ground control research and the application of rock mechanics to bulk stoping systems were determined by Inco to be essential tools in the development of efficient mining methods at greater depths. As a result, numerical modeling techniques are being used to design the mining geometry, sequence, and destressing program required to produce optimum ground conditions. Microseismic source location systems are also being evaluated for their potential in forecasting impending problems. A spray-on, fiberglass-reinforced epoxy resin is being developed with the expectation that it will reduce or eliminate rockbolt support. The epoxy would provide support similar to shotcrete at 10% of the shotcrete volume and 25% of the time required for rockbolt installation. There would also be a reduction of the material handling problems associated with shotcrete.

A major problem faced by Inco was the high cost of underground stoping methods. Historically, near surface, larger ore bodies have been mined with bulk methods such as blasthole and caving, while smaller, irregular ore bodies and ores at depth or in pillars have been recovered by selective methods such as cut-and-fill or undercut-and-fill. However, as larger ore bodies have been depleted and as mining has progressed to deeper levels, reliance on the small blast, high-cost mining methods increased. By 1981, only one-third of Inco's production was recovered by bulk methods, and despite the use of mechanized equipment, the productivity of the mines was decreasing at that time.

To reverse this trend, the vertical crater retreat (VCR) method was instituted. This combines the productivity advantages of bulk mining with the ground control advantages of selective fill methods. At Inco, the ore zone is divided into a series of panels that are silled at the top for down drilling and developed at the bottom for ore removal. A panel is drilled from top to bottom, and explosive charges are placed near the bottom of the holes. Each charge is fired separately. A horizontal slice 10 to 12 feet thick is removed with each shot. Only the swell is removed after the blast. Final cleanup of the panel is done by remote (radio) controlled loaders. The panel is then filled with consolidated backfill, and the excavation of adjacent panels proceeds in a sequential manner. The company reports that VCR mining has increased bulk-mined ore from 32% to 70% of the total tonnage.

Another part of the Inco program is to build prototype equipment that can be applied to a particular mining concept or need rather than adapting the mining to suit available equipment. Under this program, Inco has built a prototype in-hole drill that features (1) low mast height to reduce the size of openings required for machine operation, (2) hydraulic control of the drill string for greater accuracy, (3) positive breakout of the rods to eliminate the use of wrenches, (4) power to drill 9-inch-diameter holes up to 400 feet long, (5) motorized wheels for maneuverability, and (6) breakdown features so that the rig can pass a 24- by 24-inch opening. The company is now incorporating mechanized rod handling and microprocessor monitoring and control to provide full automation of the drill. When completed, one employee will be able to monitor two or more drills. A prototype continuous loader capable of producing five times the output of conventional load-haul-dump units has also been constructed. The unit has an oscillating lip that changes the angle of repose of the muckpile, thus providing a continuous flow of muck to a short chain conveyor. The application of microprocessor monitoring, sensing, and control is now being developed for this loader.

Concurrently with its research program, the company reopened an idle mine at the start of 1983 and designated part of the mine as a working model for higher productivity development. Named the Research Mine, it has been used to test such ideas as concentration of production faces, a multidisciplined work force, and financial incentives to improve productivity. To concentrate production in as few workplaces, levels, and stoping methods as possible, and to maximize the output from each place, the model at the Research Mine has been designed so that all production comes from three active stopes on one level, using a VCR method that leaves no pillars. Inco plans to mine a typical block within 3 years, compared with the 15 years historically required. Using this method, productivity improved and only 33 operating employees were required per shift. This created another problem; under the existing job classification system, the 33 employees required the skills of 26 job classifications. To address the problem, 6 new job classifications were created that included the skills of the 26 former classifications. According to the company, the reclassification has increased flexibility in movement of people from one job to another, and it has provided job enrichment and higher pay for employees while simplifying administration. Underground computer terminals are used for transmission of timekeeping, personnel records, production data, and supply ordering. The normal time for paperwork has been reduced by 80%.

The concept of incentive earnings, which historically has been provided only for people in production or development where output can be measured (tons per worker shift or feet advance), was also examined. The present system leaves about 60% of the employees in a supporting role with little sense of motivation or participation. A unique incentive system was devised to pay support crews as a function of the output of production crews. The system has improved the level of service for production crews and encourages cooperation among all work groups. The system also provides a financial benefit to support crews when their working number is reduced. According to the company, the changes generated from these operations at the Research Mine has made a significant impact on the productivity of the company's other mines. Inco's innovative approach and research effort must be considered successful in that the company was operating at a profit by the end of 1984 and throughout 1985.

Another example of the innovative nature of mining today is a new mining method for use in highly stressed ground subject to rock bursting. Under a three-way memorandum of agreement between the Hecla Mining Co., the University of Idaho, and the Bureau of Mines, an extensive rock mechanics investigation is being conducted at an experimental stope in Hecla's Lucky Friday Mine at Mullan, ID. Termed the Lucky Friday Underhand Longwall (LFUL), this experimental stope is a radical departure from traditional overhand cut-and-fill mining. Development in the 500-foot-long, mechanized underhand cut-and-fill stope is through a modified spiral-ramp system, located in the footwall. The ramp is being supported with innovative ground-control systems such as cable bolts and steel-fiber-reinforced shotcrete. Ore from the stope is trammed in 2-yard, front-end loaders down the ramp system to a 5-foot-diameter ore pass. The reinforced shotcrete is also used in the ore pass for both primary support and as a liner system. A rock mechanics investigation includes the development of in situ stress data using overcoring and measurement of rock response during mining using multipoint extensometers in the foot and hanging wall, surface closure points in the access ramp, and load cells placed within the high-density sandfill. Geological site characterization studies include fracture mapping and coring for physical property testing. A two-dimensional, finite-element model of the test area has been constructed and is being calibrated with mine measurements for use as a predictive mine design tool. If the test stope proves successful, the mining method will be used throughout the mine.

A new mining prop has been developed to withstand high loads and to yield gently as closure occurs in the highly stressed openings of deep South African gold mines.[10] The Bestoprop, a patented design, uses a specially shaped timber inside a convoluted thin-wall steel casing. The timber has longitudinal radial grooves cut into the sides, deep at one end and tapering to a shallow point at a predetermined position along the length. The wood fiber fills the space as the prop compresses. Small convolutions at the ends of the steel casing allow it to concertina as closure takes place. By using different timbers and by varying the lengths and widths of the grooves, different load bearing and yield capacity props can be constructed. It is therefore possible to design props for the loading conditions of individual mines.

The Bureau of Mines, in cooperation with mines in the Coeur d'Alene Mining District, has investigated the use of lightweight concrete to form continuous tunnel liners in deep mines in which ground support is difficult owing to high rock pressures. The lightweight concrete is made by mixing a special prefoamed agent directly into the concrete mix, thereby reducing the density of the concrete. Typical densities for lightweight concrete range from 25 to 100 pounds per cubic foot. Depending on the design application, a lightweight concrete can be developed with adequate strength and with energy absorbing characteristics that are essential in soft, caving, squeezing, and bursting ground conditions. Several successful field trials of the lightweight concrete liner have been made at cooperator mines. The first test section has been in place for 3 years, and there has been no evidence of structural distress since placement.

One test placement used an innovative airbag formwork that can greatly reduce forming costs in underground mines. The formwork is shaped with dumbbell ends that function as self-sealing bulkheads. Also, a section of a spiral access ramp was lined with shotcrete containing steel fibers and silica fume. This became the primary ground support, replacing rock bolts and mesh. The test was a significant development because the rising cost of rock bolts has now made mine operators look for alternative, less costly ground control technologies. The same material was used to line an adjoining 200-foot-long raise-bored ore pass. Silica fume is a cement additive obtained from the manufacture of silicon metal. It appears to significantly increase the strength of shotcrete and allows the shotcrete to be built up several inches in thickness in a single application with reduced rebound.

The first practical electric truck system for underground mines has been developed in Sweden.[11] Powered through an overhead trolley line system, the truck has now completed more than 2,500 miles of underground operation in the Kiruna Mine. Each motor of the four-wheel-drive truck powers a pair of wheels. The motors have a continuous rating of 308 horsepower each, but for noncontinuous use, which is typical of mining operations, considerably higher levels can be generated, providing more power for high-speed haulage up steep ramps. The new truck has none of the ventilation problems, fumes, and heat associated with diesel trucks. It has a load capacity of 55 tons and easily achieves speeds of up to 16 miles per hour on 12% inclines. On level ground, it runs at up to 32 miles per hour and accelerates from zero to 25 miles per hour in 4 seconds unloaded or in 8 seconds loaded. Mechanical switches or turnouts are not used on the trolley line. At junctions or crossover points, the pickup arm is lowered and the truck proceeds under battery power for several feet until it is in the branch under the trolley line where the pickup arm is again raised. The truck also operates under battery power when it meets another truck on the line and at the ends of the line when the truck proceeds to the loading or dumping point. To engage the trolley line, the operator steers the truck under the approximate center of the line, presses a button, and the computer takes over. With the aid of sensors on the pickup arm, the contacts are precisely located and the system locked into position. More than 30,000 automatic connections and disconnections made during the mine trials have shown that truck speed during connection can be up to 9 miles per hour, and disconnection is possible at any speed. The trolley arm allows the truck to deviate more than 6 feet from the center line.

Operating costs of the electric truck are reported to be only 50% to 60% of similar size diesel trucks. In addition, maintenance costs are lower owing to the all-electric traction system and lower tire costs. Microprocessor-controlled speed regulation eliminates wheel spin and no tire wear has been noted on the prototype truck. The microprocessor also regulates and controls all vital electrical functions. The first series of electric trucks is expected to be on the market in 1986.

Four spray coolers were designed and built as part of a Bureau of Mines program to investigate direct-contact (warm air to cool water) spray cooling systems.[12] A single-stage cooling unit was tested in a New Mexico uranium mine, and a two-stage cooler and a three-stage cooler were tested in a South Dakota gold mine. During these in-mine tests, the two-stage cooler reduced 16,387 cubic feet per minute of 76.8° F wet bulb air to 69.3° F wet bulb using 55 gallons per minute of 50° F water. This represents a cooling power of 39 refrigeration tons. A three-stage unit cooled 26,200 cubic feet per minute of 80.1° F wet bulb air to 73.5° F wet bulb using 50 gallons per minute of 48.7° F water, demonstrating a cooling power of 59 refrigeration tons. The spray chamber cooling performance is considered excellent. In-service maintenance requirements have been minimal thus far. The units continue to undergo long-term evaluation.

Surface Mining.—Several surface mines were shut down in 1985 and others curtailed production. As in underground mining, the companies were forced to innovate and reduce costs to remain in operation. A good example is the $400 million, 3-year modernization plan announced for the Bingham Canyon copper mine, which suspended operations in March 1985.[13] The company plans to install a large portable, in-pit crusher that will feed a 5-mile belt conveyor system from the mine to a new grinding facility. The belt system will convey the ore from the lower levels of the pit through an existing railroad tunnel to the grinding plant. The new plant will house three grinding lines, each consisting of a grinding mill and two ball mills. Ore slurry will be transported from the flotation portions of the two existing concentrators through two 13-mile-long slurry pipelines. Existing facilities that will be eliminated by the project include the rail ore haulage system between the mine and concentrators, the Bonneville concentrator, and the crushing and grinding units at both the Magna and Arthur concentrators. The modernization is planned for completion in late 1988. Production capacity will be reduced 25% compared with production before closure, but the amount of refined copper produced will drop only 10%. This is due to improved processing efficiency. Optimally, the new installation could bring about a reduction in production costs of $0.20 per pound according to the company.

The use of computers in open pit mines continues to expand. More and better software is being developed to aid the miner in every aspect of operations. Optimum drilling locations and sophisticated borehole grade and tonnage programs are used for exploration and reserve analysis. Geomechanical data are input to design the mines and pit slopes and to determine ground pressure limits. Computers plan the production sequence designing optimal bench layout and haulage rock placement, often for years in advance. Blasthole designs are determined, and simulation programs are available to assess the effect of blasting and blasthole patterns. However, the use of microprocessor technology for onboard operation of equipment is the emerging new development, and the merging of electronic and mechanical technologies in heavy equipment continues to accelerate. Severe conditions, such as vibration, extreme temperature, dust, moisture, and physical shock, are rapidly being overcome, and mining equipment is becoming covered with sensors that feed information to microprocessors, which in turn make rapidly calculated decisions to optimize the operation of the equipment.

The Caterpillar Tractor Co. announced a new impact ripper that significantly advances ripping technology.[14] A hydraulic impactor transmits additional forces to the tip of a specially designed shank, adding force to the power normally delivered during conventional ripping by drawbar pull. The operation of the impact ripper is fully automatic and does not commence until the tip comes in contact with high-strength material. When the ripper tip passes back into low-strength material, the impactor automatically shuts down. The ripper can also be used for secondary breakage by positioning the ripper tip over a bolter and activating the impactor manually. Company tests compared a D9L tractor dozer equipped with an impact ripper with one fitted with a parallelogram ripper. The testing ground was cemented limestone with a seismic velocity of 11,000 feet per second. The results showed that the impact ripper produced 560 tons per hour, while the conventional parallelogram unit ripped 155 tons per hour. This represents a production increase of about 350%. The tests also demonstrated that there is a cost savings using the new impact ripper. The standard ripper costs were about $0.41 per ton, compared with $0.13 per ton with the impact ripper. Cost for blasting was $0.19 per ton.

Futher development of mobile crushers continued, and a trend is beginning toward the use of high angle conveying systems. These provide a lower cost alternative to transporting materials out of a pit with trucks. Continental Conveyor and Equipment Co. Inc., which installed the first commercial high angle conveyor at a western U.S. coal mine, is constructing a high angle conveyor for Majdanpek Copper in Yugoslavia. The conveyor will be 6.5 feet wide and have a lift of 304 feet and is designed to carry minus 10-inch copper ore with a density of 1.6 tons per cubic yard at a rate of 4,000 tons per hour up a 35.5° incline. The design uses a sandwich belt principle and will permit installation of a second conveyor to elevate ore from a deeper pit location and transfer it onto the tail of the first unit. Operation is scheduled to start in 1987. Goodyear Rubber Products Co. has developed a wraparound conveyor belt that can convey material up a 30° slope with potential speeds of 800 feet per minute. The folding conveyor belt, which encloses the material from loading to unloading, is made with specially constructed hinges fastened to the cover flaps at each edge. The flaps allow the sides of the conveyor to cover the material. A prototype belt has been installed in a fine coal processing unit in Ohio. The Australian Mineral Industries Research Association is investigating the potential to develop a high angle conveyor that does not rely on framework to support the conveyor. The proposed concept, which could be extended to open pit operations, is based on the recent successful installation of a Flexowall belt in Belgium. This conveyor raises 3,000 tons per hour of coal over a vertical lift of 40 feet as a freely hanging catenary without a supporting frame. Such a design would cost much less than present designs and would also be very mobile.

The world's two largest tractor dozers were both introduced in 1985.[15] Both incorporate new design features and claim superior performance with reduced fuel consumption. Komatsu Ltd.'s D475A is a 91-ton dozer capable of producing engine output of

740 horsepower. The combination of the new high-output engine and lockup torque converter is reported to increase workload by 40% and decrease operating costs by up to 30% compared with earlier models. The D475A has a capacity of 30 cubic yards with a straight blade, and 37 cubic yards with a universal blade. It can also be equipped with a single or multishank variable-type ripper. The physical ripping limit is rock with a seismic velocity of 9,800 feet per second and maximum ripping depth with a single shank of 5.5 feet.

Caterpillar Tractor's D11N is a 93-ton dozer capable of producing engine output of 770 horsepower. The D11N is 5% heavier than the D10, and a new engine provides 10% more power. The increased power and weight is reported to improve the new dozer's productivity by 10% to 15% over that of the D10. Blades have been redesigned with a more open profile and greater heel clearance. Capacity with the universal blade is 40 cubic yards. The standard shank ripper arrangement is 8 inches shorter than that of the D10. A shorter shank provides room for a deep arrangement with a longer shank offering the user more versatility. Maximum penetration with a deep ripping arrangement is 7 feet.

Remote Mining.—Low-grade ore combined with high processing costs prevent many deposits from being mined by conventional methods, but the development of solution mining continues to emerge as an alternative method for mining of such metals as copper, gold, silver, and uranium. The Bureau of Mines continued active research on in situ leaching and published several reports. One report describes the development and application of a computer program, PHASEQ/FLOW, for simulating the geochemistry of leaching.[16] The geomechanical flow simulator is capable of describing the dynamic changes in chemical composition of an aqueous solution during flow through a permeable medium. The report describes several applications: generic batch equilibria, flowing equilibria, uranium roll-front deposition, and roll-front leaching. Another report describes a mine test of the new potassium chloride-potassium carbonate two-stage in situ uranium leach process carried out at the Intercontinental Energy Corp. Zamzow project site in south Texas.[17] Substantial quantities of high concentration uranium were produced, indicating the feasibility of the leach solution. The test results yield information regarding the reservoir dispersivity, the average cation-exchange capacity of the formation, and the distribution coefficients describing cation-exchange reactions. The test results also demonstrate the existence of permeability anisotropy and of disturbed flow fields.

The Bureau of Mines has conducted research to improve technology for recovering precious metals from low-grade resources, and results were published.[18] Many of the reported findings are recent, and some of the work described is ongoing. Topics discussed include cyanidation of carbonaceous gold ores to enhance gold recovery, a new method for precipitating mercury during cyanide leaching of gold ores, a staged heap leaching process to generate suitable solutions for direct electrowinning of gold, use of anion-exchange resins to recover gold from cyanide solutions, and precious metals recovery from electronic scrap.

A midget submarine able to rest on the sea floor at a depth of 1,500 to 2,000 feet will shortly be available for seabed exploration and geological investigations.[19] It is 90 feet long and has two chambers. One chamber, where all machinery and navigational equipment are located, houses a crew of seven with six divers. The other is filled with helium-oxygen atmosphere compressed to the operating depth of the submarine. The vessel, where the divers can stay in saturation for a month or more, was built for either maintenance, repair, or installation of oil well heads or mineral exploration of the seabed. It can operate without repeated reference to a surface vessel in all weather and up to 150 miles from shore. The submarine will eventually be equipped with a nuclear reactor that will enhance the ship's range and enable it to operate under the Arctic ice. With the nuclear propulsion unit, the submarine's length will increase to 117 feet and its range to 300 miles.

The Bureau of Mines also evaluated the extent of recoverable phosphate resources in the Southeastern Coastal Plain of the United States by the experimental borehole mining method.[20] Phosphate resources at overburden depths greater than 100 feet are, as a rule, currently unsuitable for recovery through conventional mining methods because of economic, environmental, or technical considerations. In the identified deposit areas, borehole mining operations are projected to yield a more favorable rate of return and to be environmentally more desirable than conventional surface mining. The resources have been classified as hypothetical and speculative and are subject to updating as additional exploratory data become available. Hypothetical and speculative phosphate resources with a minimum in situ grade of 5% P_2O_5 amenable to borehole mining are estimated to total about 425 billion tons. With projected borehole mining capabilities and current conventional beneficiation procedures, this resource would make available approximately 70 billion tons of phosphate rock product at an estimated grade of 30% P_2O_5.

Beneficiation.—New technology and cost-reducing techniques were also the dominant factor in the processing of ores throughout the industry. Some notable advances were made in the crushing of materials. Rexnord announced a new cone crusher designed to fit an existing 7-foot crusher foundation with minimum modifications that provides twice the production capacity of the existing 7-foot cone.[21] A prototype, which features a head diameter of 90 inches and a scaled-up power rating of 1,000 horsepower, is being tested at Bougainville Copper Ltd.'s Panguna concentrator. According to the manufacturer, the following design features have increased the volumetric limit of the crusher compared with units of comparable size. The head diameter is approximately 10% larger, increasing volumetric capacity by the square of the diameter or 15% to 20%; head throw is 40% greater, increasing volumetric capacity by an equivalent amount; the larger diameter of the cavity feed zone also has increased volumetric capacity by 20% to 25%; and the elimination of the feed distributor has reduced the restriction of feed material flow and resulted in a 15% to 20% increase in capacity. In addition, the machine has a hydraulic tramp release system to provide a larger release stroke capability that remains the same throughout the liner wear life and a single head design that fits all crushing cavities.

The world's largest feeder breaker with a throughput capacity of 300 short tons per hour was constructed by W. R. Stamler Corp. for use in overburden and frozen tar sand at Syncrude operations in Canada.[22] The 250-short-ton feeder breaker is 27 feet long by 30 feet wide by 28 feet tall. The hopper capacity is approximately 110 tons, with an intake height of 15 feet. The unit can be fed by 12-cubic-yard front-end loaders or rear dump trucks. The feeder breaker also incorporates a special 40-foot-long by 7-foot-wide boom conveyor, constructed to Syncrude's specifications. The feeder-breaker channels broken material onto the boom conveyor, which can be raised or lowered to feed onto collecting conveyors, as well as directly into haulage equipment. Heater plates, built into the hopper walls, prevent frozen tar sand from sticking to the sides of the hopper.

Superconducting magnetic separators are becoming commercially available. Their use would be applicable to ores where magnetic fields of high intensity are required to separate the components of solid mixtures containing weakly magnetic particles. In a conventional electromagnet consisting of a copper coil and an iron yoke field, intensity is limited to about 2 tesla owing to the saturation magnetization of the iron. The technology of superconductive magnets helps overcome this limit. During operation, the magnetic system is kept at temperatures close to absolute zero by using liquefied helium. The coils of the electromagnet consist of superconducting wire made of special alloys, which, at a temperature of about -270° C, has no electrical resistance. Therefore, these alloys permit current densities 50 to 100 times higher than standard copper wire.

A superconducting magnetic separator was constructed for a kaolin clay processing plant in Georgia by Eriez Magnetics.[23] With a magnetic field strength of 2 tesla, the machine is expected to remove particles of ferritic impurities ranging down to micrometer size, thus producing a brighter, purer clay product. The new separator, measuring 13 feet by 13 feet by 7 feet and weighing 230 short tons, occupies 34% less space and weighs 47% less than conventional separators of the same strength, thus reducing plant floor space requirements as well as foundation and installation costs. Compared with similarly sized, conventional separators, electrical consumption by the new device will be 80% to 90% less, translating into annual savings of $150,000. The company is also operating a new 5-tesla laboratory model to test customer samples and obtain data for scaling up to commercial operations.

Another magnetic drum separator has been developed by KHD Humboldt Wedog AG.[24] The separator, named "Descos," is designed for both dry and wet high intensity magnetic separation, and the company has successfully tested a prototype of operational size. Bauxite and andalusite have been tested in continuous operation (dry process) with relatively high throughput capacity of up to 100 tons per hour. In processing bauxite from Brazil, the Fe_2O_3 content in a washed and in a calcined state can be sufficiently reduced so that the product meets specifications for the world refractory material industry market. In the prototype, the magnetic flux density outside the drum exceeds 3 tesla. Later models will have field intensities up to 5 tesla. The drum of the actual separator has a diameter of 4.8 feet and a length of 5 feet. The consumption of electric power and cooling water correspond to those of conventional, wet high intensity magnetic separators with considerably lower field intensity. The complete plant is skid mounted and may therefore also be used in existing preparation plants for pilot and field tests.

In general, gravity separation processes are inefficient when used on ores with five liberation sizes. A new type of mineral jig, which will gravitationally concentrate heavy minerals in particle sizes considerably finer than is currently possible, has been developed by Gev Logics Pty. Ltd.[25] The jig employs high centrifugal forces to concentrate the particles. Although still under development, the centrifugal jig is reported to have worked very well in a large number of tests with reported recovery of particles down to 20 micrometers and with a specific gravity differential of 1 to 1.5. Tests on tailings from a gold amalgamation and tabling operation recovered 60% of the gold rejected by the table, achieving a concentrate grade of 120 grams per ton of gold from a jig feed grade of 1.7 grams per ton. A new prototype is currently under construction that has been designed for higher centrifugal forces to allow effective concentration and recovery performance to be extended down to 10-micrometer particles.

Flash flotation cells developed by Outokumpu Oy and installed in Finnish concentrators have resulted in a dramatic increase in recovery.[26] They are used in classification circuits to process cyclone underflow and produce a final concentrate of coarse minerals that would otherwise be returned as circulating load to the grinding mill. Operating experience at the Hammaslahti concentrator has shown that the gold content of copper concentrate increased from 3.5 grams per ton to 4.4 grams per ton. In addition, copper recovery has increased about three percentage points when treating high-grade ores, with 30% to 50% of the copper recovery occurring during flash flotation. After vacuum filtration, the final moisture content of the concentrate was reduced by 1 to 2 percentage points, and the required cell volume for conventional flotation was reduced by 50%. The reduced cell volume cut energy requirements by 8,668 British thermal units per hour per ton of ore. Based on the results of the prototype cells at Hammaslahti, a commercial machine "Skim-air" is being marketed. Operations in Finland include the recovery of copper from magnetic iron ore tailings, use in a nickel-copper concentrator at Kotalahti, the Vuonos copper-cobalt concentrator, and flotation of copper from slag. Several other cells are being considered for use in the United States and Canada in gold and copper applications.

A flotation plant using a process developed by the Bureau of Mines was installed at a phosphate mine in Conda, ID.[27] The Bureau's process uses fluosilicic acid to depress the phosphate minerals while the carbonates are floated with a fatty acid emulsion. The carbonate float is followed immediately by a silica float with amine acetate. In 0.5-ton-per-hour pilot tests at the Conda mill, reconstituted feed material was deslimed before flotation. Reducing the desliming size made an additional 16% of phosphate available for recovery in the flotation circuit. Phosphate recoveries totaled 80% to 90%. A technique was also devised by the Bureau of Mines to recover coarse (plus 1,200-micrometer) North Carolina phosphate now discarded as waste.[28] Concentration utilizes the difference in particle sphericity between the relatively flat calcite and the rounded phosphate pebbles. Sizing, treatment in a continuous hydraulic classification system, and grinding upgraded a 17.0% P_2O_5 reject to 24.5% P_2O_5 with a phosphate recovery of 63%.

Instrumentation and control technology for mineral processing continues to produce substantial operating improvements. A report describing research on an advanced model-based control for semiautogenous grinding was released by the Bureau of Mines. This research was performed under Bureau of Mines contract by the University of Utah.[29] The report describes the derivation and verification of a simplified flotation model and discusses the implementation of a Kalman filter for estimating the values of unmeasured variables for input to controllers. It also describes several control strategies using the model-based approach. The strategies emphasize the nonlinear nature of the flotation plant. The report also discusses expected future trends in the implementation of such model-based flotation control strategies.

Another example of improving technology is a new mass flowmeter that combines a unique twin-loop sensor design with a smart digital transmitter to measure mass flow directly.[30] It is reported to have a high sensitivity to mass while remaining independent of other variables such as density, viscosity, temperature, and fluid inhomogeneity. The microprocessor-based transmitter preserves the high degree of accuracy available from the sensor and eliminates the instabilities characteristic of analog circuitry. During operation, the fluid enters the flowmeter and splits into two looped tubes that carry the fluid in a helical path. A driver causes the tubes to vibrate like a tuning fork. Sensors mounted on the flow-sensing tubes measure the deflections that occur owing to the Coriolis force. Because this effect is directly dependent upon mass flow rate, calculations, which are performed reliably and repeatedly by the microprocessor-based transmitter, yield accurate mass flow rate readings. These readings are presented in analog, frequency, and digital formats.

A northern Minnesota taconite company reports that the use of large complex polyurethane castings are reducing downtime and maintenance costs in iron ore processing.[31] Cast polyurethane discharge cones, pan liners, and trommel screens weighing up to 1,500 pounds each are said to last two to three times as long as rubber and metal components in handling hard, abrasive taconite ores. The largest, most complex of the parts developed by Irathane Systems Inc. are the discharge cones. In service for nearly 2 years in this taconite plant's 400-ton-per-hour, 36-foot-diameter autogenous mill, they are expected to last at least 6 years, twice as long as the cast iron cones previously used. Because the cast polyurethane parts can be patched with polyurethane-based trowelling compound, service life could exceed the 6 years anticipated. These wedge-shaped components measure about 6 feet high by 3 feet deep with a maximum width of 5 feet. At 1 taconite company, 9 such cones replaced 18 smaller cast iron cones and the installation took only one-half as long as for the metal units. Six years ago, a severe wear problem with trommel screens was also solved with the use of polyurethane. Steel-reinforced natural rubber screens were wearing out every 90 days; the current polyurethane screens are reported to last up to 300 days.

With the current interest in precious metals, a market for portable gold recovery equipment appears to have emerged. Vardax Consultants Inc. has reportedly sold six fine gold recovery plants.[32] The portable units are totally self-contained and engineered specifically to recover micrometer-sized precious metals. They are modular and can be built for production levels from 30 cubic yards per hour up to 500 cubic yards per hour. The raw material is completely scrubbed in a grizzly feeder and then put through a gravity concentrator. The 1/4-inch-size screened material goes through a series of accelerator concentrators to recover the fine and floating gold. A secondary system separates visual gold from black sands concentrate. Davage Technology Inc., the operator of a gold recovery system recently developed by the Battelle Memorial Institute, is making a mobile version of the system.[33] The 10-ton-per-hour unit, much smaller than the Vardax plant, is contained in a semitrailer with its own powerplant. It operates automatically on either dry material or slurry. It requires 50 gallons of water that can be recirculated. The five-step process uses no chemicals. The system has operated successfully during three 30-day runs on placers in Arizona and Nevada, recovering more than 95% of the gold present.

Another system that uses modular tanks to leach gold ores has been developed by Hitec Ore Processing Inc.[34] Any type of gold-bearing ore can be treated with tickle agitation or flood leaching, depending on the ore type. Leaching time is quite rapid compared with heap leaching. Tanks are charged, leached, flushed, and discharged in 9 hours. Gold recoveries are reported to be between 80% to 90% with low capital and operating costs. Typical operating costs for a 2,000-ton-per-day plant, using a 2.8-gram-per-ton ore, should be about $3.50 per gram. Capital costs for such an operation would be about $2 million. Savings come from the lower material handling costs, compared with heap leaching and conventional methods. Tundra gold mine near Talon, NV, will be the first site where tank leaching is used.

Health and Safety.—Preliminary injury statistics compiled by the Mine Safety and Health Administration show that fatalities in 1985 were the lowest in history with 56 miners killed in metal and industrial minerals mines. Although employment has dropped, the fatality rates are still very low, matching the previous low set in 1983. A new record low was also set for injury rates in 1985 at 4.26 per 200,000 employee-hours.

Two reports were released by the Bureau of Mines on ground-penetrating radar (GPR) systems to detect hazards. The first is on a system that is capable of penetrating 10 feet into the mine roof to identify anomalistic conditions.[35] It consists of a transmitter with carrier frequencies of 250, 500, and 1,000 megahertz, utilizing a dipole antenna and a receiver. A computer was used for data acquisition and data processing. Data analysis by computer enhancement revealed recognizable return radar signatures from the middle main roof of the test site. These stratigraphic anomalies can be cataloged for recognizable features, which from the past history of the mine, may have been shown to create strata control problems. The second Bureau of Mines report describes testing of a GPR system in the central Florida phosphate district to determine the feasibility of utilizing GPR technology for subsurface cavity detection.[36] The test area is situated in karst topography where sinkhole development is prevalent. State regulations require subsurface drilling of dam sites to identify underground anomalies; however, this method is not totally accurate in locating the subsurface cavities that could develop into sinkholes. The GPR system that was devised successfully penetrated over 50 feet of overburden and gave recognizable radar return signals characteristic of a rock-cavity interface.

Fires in underground metal and industrial mineral mines are one of the most life-threatening hazards faced by the workers. Contaminated air is the primary killer, and the most reliable defense against the spread of contaminated air throughout the mine is early fire detection and warning systems so that rapid evacuation of the workers can occur. Bureau of Mines research led to the design, prototype fabrication, and successful testing of an improved stench fire-warning system.[37] Stench systems are the most widely used means of warning miners in underground noncoal mines of fires or other emergencies. A stench system alerts miners that an emergency condition exists by injecting an odorant into the mine air. Although stench warning systems have been used successfully for over 60 years, present systems suffer several serious shortcomings, including odorant toxicity, unreliability of warnings, widely varying stench concentrations, and others. The new system overcomes the deficiencies of existing systems by substituting tetrahydrothiophene for the commonly used ethyl mercaptan stench odorant, and by using a specially designed stench injector. The improved injector reliably meters stench fluid into either ventilation-air or compressed-air streams at a precisely controlled rate. The Bureau has also designed and operated four other prototype warning systems for underground noncoal mines that are presently undergoing prolonged in-mine testing.[38]

Firefighting has made considerable progress in recent years owing primarily to the use of inert gases. In French underground mines, the use of nitrogen has changed the methods used to fight open fires.[39] With large quantities of nitrogen available onsite, it is possible to reduce the intensity of a fire and to extinguish it in a relatively short time. In a few hours or a few days after the use of the gas, it is possible for miners to come back to safe conditions in the workings. For this reason, all French coal mines are now equipped for the rapid use of nitrogen. Portable nitrogen generators are on-site, and contracts have been made with liquid nitrogen suppliers that guarantee delivery in short periods of time.

Table 1.—Material handled at surface and underground mines in the United States, by type

(Million short tons)

Type and year	Surface			Underground			All mines[1]		
	Crude ore	Waste	Total[1]	Crude ore	Waste	Total[1]	Crude ore	Waste	Total
Metals:									
1980	520	1,180	1,700	77	11	88	597	1,190	1,790
1981	592	1,050	1,650	82	15	97	674	1,070	1,740
1982	371	677	1,050	60	12	72	431	689	1,120
1983	380	557	938	47	6	53	427	564	991
1984	420	614	1,030	57	10	67	476	624	1,100
Industrial minerals:									
1980	2,060	620	2,680	78	(2)	78	2,140	620	2,760
1981[3]	1,150	584	1,740	68	6	74	1,220	590	1,820
1982[4]	837	366	1,200	61	2	63	899	368	1,270
1983[3]	1,070	155	1,230	62	1	62	1,130	155	1,290
1984[4]	1,060	286	1,340	40	1	41	1,100	287	1,390
Total metals and industrial minerals:[1]									
1980	2,580	1,800	4,380	155	11	167	2,730	1,810	4,540
1981	1,750	1,640	3,390	151	20	171	1,900	1,660	3,560
1982	1,210	1,040	2,250	121	14	135	1,330	1,060	2,390
1983	1,450	712	2,160	109	7	116	1,560	719	2,280
1984	1,480	901	2,380	97	11	108	1,570	912	2,490

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1981 and 1983 because of biennial canvassing.
[4]Crushed and broken and dimension stone data were not available for 1982 and 1984 because of biennial canvassing.

Table 2.—Material handled at surface and underground mines[1] in the United States in 1984, by commodity

(Thousand short tons)

Commodity	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
METALS									
Bauxite	1,130	W	1,130	--	--	--	1,130	W	1,130
Copper	171,000	312,000	483,000	22,200	W	22,200	193,000	312,000	505,000
Gold:									
Lode	37,600	114,000	152,000	2,950	502	3,450	40,500	115,000	155,000
Placer	8,520	288	8,810	23	188	211	8,540	476	9,020
Iron ore	176,000	84,300	260,000	W	W	W	176,000	84,300	260,000
Lead	W	W	W	5,550	1,140	6,690	5,550	1,140	6,690
Silver	3,070	15,900	19,000	4,800	526	5,320	7,870	16,500	24,300
Titanium (ilmenite)	W	W	W	--	--	--	W	W	W
Tungsten	2	W	2	273	W	273	275	W	275
Uranium	1,800	24,600	26,400	984	330	1,310	2,780	24,900	27,700
Zinc	--	--	--	5,790	970	6,760	5,790	970	6,760
Other[3]	20,500	63,000	83,400	14,100	6,440	20,600	34,600	69,400	104,000
Total metals[2]	420,000	614,000	1,030,000	56,700	10,100	66,800	476,000	624,000	1,100,000
INDUSTRIAL MINERALS									
Abrasives[4]	225	W	225	W	--	W	225	W	225
Asbestos	1,770	4,440	6,170	--	--	--	1,770	4,400	6,170
Barite	1,050	604	1,650	--	--	--	1,050	604	1,650
Clays	44,200	[e]38,400	82,600	331	[e]5	336	44,600	[e]38,400	83,000
Diatomite	1,450	5,340	6,790	--	--	--	1,450	5,340	6,790
Feldspar	2,600	1,270	3,870	--	--	--	2,600	1,270	3,870
Fluorspar	W	W	W	141	W	141	141	W	141
Gypsum	14,100	--	14,100	2,580	--	2,580	16,700	--	16,700
Mica (scrap)	1,040	685	1,720	--	--	--	1,040	685	1,720
Perlite	648	W	648	W	--	W	648	W	648

Phosphate rock	182,000	229,000	411,000	W	--	W	182,000	229,000	411,000
Potassium salts	--	--	--	15,600	W	15,600	15,600	W	15,600
Pumice[5]	560	28	589	--	--	--	560	28	589
Salt	967	W	967	14,100	W	14,100	15,100	W	15,100
Sand and gravel	804,000	--	804,000	--	--	--	804,000	--	804,000
Sodium carbonate (natural)	--	--	--	6,730	--	6,730	6,730	--	6,730
Talc, soapstone, pyrophyllite	1,010	5,430	6,450	113	W	113	1,130	5,430	6,560
Other[6]	2,760	787	3,550	563	861	1,420	3,320	1,650	4,970
Total industrial minerals[2]	1,060,000	286,000	1,340,000	40,100	866	41,000	1,100,000	287,000	1,390,000
Grand total[2]	1,480,000	901,000	2,380,000	96,800	11,000	108,000	1,570,000	912,000	2,490,000

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes antimony, beryllium, manganiferous ore, mercury, molybdenum, nickel, platinum, rare-earth metals, tin, and metal items indicated by symbol W.
[4]Includes abrasive stone, emery, garnet, millstones, and tripoli.
[5]Excludes volcanic cinder and scoria.
[6]Includes aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, magnesite, millstones, olivine, vermiculite, wollastonite, and industrial mineral items indicated by symbol W.

Table 3.—Material handled at surface and underground mines[1] (including sand and gravel and stone) in the United States in 1984, by State

(Thousand short tons)

State	Surface			Underground			All mines[2]		
	Crude ore	Waste	Total[2]	Crude ore	Waste	Total[2]	Crude ore	Waste	Total
Alabama	13,100	1,710	14,800	--	--	--	13,100	1,710	14,800
Alaska	34,200	417	34,600	--	W	W	34,200	417	34,600
Arizona	152,000	153,000	305,000	20,400	196	20,600	173,000	153,000	326,000
Arkansas	11,300	[illegible],000	20,300	--	--	--	11,300	9,000	20,300
California	120,000	22,400	142,000	592	210	802	120,000	22,600	143,000
Colorado	31,700	9,810	41,600	10,100	6,300	16,400	41,900	16,100	58,000
Connecticut	7,140	86	7,230	--	--	--	7,140	86	7,230
Delaware	1,000	--	1,000	--	--	--	1,000	--	1,000
Florida	189,000	224,000	414,000	--	--	--	189,000	224,000	414,000
Georgia	14,900	7,730	22,600	W	--	W	14,900	7,730	22,600
Hawaii	449	--	449	--	--	--	449	--	449
Idaho	16,900	44,000	60,900	974	178	1,150	17,800	44,200	62,100
Illinois	30,500	365	30,900	204	W	204	30,700	365	31,100
Indiana	16,900	568	17,500	W	--	W	16,900	568	17,500
Iowa	15,500	393	15,900	503	W	503	16,000	393	16,400
Kansas	13,300	798	14,100	1,170	--	1,170	14,500	798	15,300
Kentucky	8,660	699	9,360	1	5	6	8,660	703	9,360
Louisiana	17,900	475	18,400	5,180	W	5,180	23,100	475	23,600
Maine	7,930	W	7,930	--	--	--	7,930	W	7,930
Maryland	14,600	305	14,900	--	--	--	14,600	305	14,900
Massachusetts	14,500	208	14,700	--	--	--	14,500	208	14,700
Michigan	86,500	45,100	132,000	W	--	W	86,500	45,100	132,000
Minnesota	155,000	40,100	195,000	--	--	--	155,000	40,100	195,000
Mississippi	14,700	2,110	16,800	--	--	--	14,700	2,110	16,800
Missouri	10,800	1,600	12,400	7,520	1,110	8,630	18,300	2,710	21,000
Montana	16,400	13,300	29,700	3,580	28	3,600	20,000	13,300	33,300
Nebraska	12,000	156	12,200	--	--	--	12,000	156	12,200
Nevada	38,600	88,800	127,000	627	118	744	39,200	88,900	128,000
New Hampshire	5,650	W	5,650	--	--	--	5,650	W	5,650
New Jersey	12,300	W	12,300	W	W	W	12,300	W	12,300
New Mexico	39,500	132,000	171,000	19,200	581	19,800	58,700	132,000	191,000

New York	27,000	587	27,600	5,170	W	5,170	32,200	587	32,800
North Carolina	23,600	3,720	27,300	--	--	--	23,600	3,720	27,300
North Dakota	6,490	W	6,490	W	--	W	6,490	W	6,490
Ohio	35,400	1,660	37,000	3,970	W	3,970	39,300	1,660	41,000
Oklahoma	14,700	851	15,500	--	--	--	14,700	851	15,500
Oregon	17,400	4,810	22,200	(3)	3	3	17,400	4,810	22,200
Pennsylvania	16,200	852	17,000	W	W	W	16,200	852	17,000
Rhode Island	1,530	--	1,530	--	--	--	1,530	--	1,530
South Carolina	8,800	1,690	10,500	--	--	--	8,800	1,690	10,500
South Dakota	7,080	839	7,920	W	W	W	7,080	839	7,920
Tennessee	11,000	3,450	14,500	6,770	681	7,450	17,800	4,130	21,900
Texas	71,900	10,100	82,000	335	--	335	72,200	10,100	82,300
Utah	41,600	50,900	92,500	494	326	820	42,100	51,200	93,300
Vermont	4,750	W	4,750	--	--	--	4,750	W	4,750
Virginia	10,400	926	11,400	W	--	W	10,400	926	11,400
Washington	24,400	675	25,000	W	(3)	W	24,400	675	25,000
West Virginia	2,640	246	2,890	98	1	99	2,740	248	2,990
Wisconsin	18,800	--	18,800	--	--	--	18,800	--	18,800
Wyoming	10,900	19,600	30,500	6,730	W	6,730	17,600	19,600	37,200
Undistributed	31	924	955	3,240	1,220	4,460	3,270	2,150	5,410
Total[2 3]	1,480,000	901,000	2,380,000	96,800	11,000	108,000	1,570,000	912,000	2,490,000

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes estimated data in table 2.

Table 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1984

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total
METALS									
Bauxite	$13.90	W	$13.90	--	--	--	$13.90	W	$13.90
Copper	8.38	$1.11	9.49	$7.83	$3.22	$11.04	8.31	$1.36	9.67
Gold:									
Lode	12.70	1.36	14.06	44.46	9.69	54.15	15.00	1.96	16.96
Placer	1.62	--	1.62	--	--	--	1.62	--	1.62
Iron ore	12.56	W	12.56	W	W	W	12.56	W	12.56
Lead	W	W	W	28.73	17.38	46.12	28.73	17.38	46.11
Silver	10.06	1.40	11.46	45.26	11.41	56.67	30.59	7.24	37.83
Titanium (ilmenite)	3.27	3.94	7.21	--	--	--	3.27	3.94	7.21
Tungsten	1.07	--	1.07	40.49	W	40.49	40.26	W	40.26
Zinc	--	--	--	34.25	W	34.25	34.25	W	34.25
Average[1]	10.48	.68	11.16	18.34	4.40	22.74	11.43	1.13	12.56
INDUSTRIAL MINERALS									
Asbestos	19.01	--	19.01	--	--	--	19.01	--	19.01
Barite	29.70	W	29.70	--	--	--	29.70	W	29.70
Clays	22.97	.14	23.11	11.25	--	11.25	22.89	.14	23.03
Diatomite	67.57	--	67.57	--	--	--	67.57	--	67.57
Feldspar	8.84	29.51	38.35	--	--	--	8.84	29.51	38.35
Fluorspar	W	--	W	80.80	W	80.80	80.80	W	80.80
Gypsum	7.60	--	7.60	6.97	--	6.97	7.49	--	7.49
Mica (scrap)	7.01	W	7.01	--	--	--	7.01	W	7.01
Perlite	15.43	--	15.43	W	--	W	15.43	--	15.43
Phosphate rock	3.63	--	3.63	W	--	W	3.63	--	3.63
Potassium salts	--	--	--	13.30	--	13.30	13.30	--	13.30
Pumice	9.83	--	9.83	--	--	--	9.83	--	9.83
Salt	4.39	--	4.39	8.86	1.86	10.72	8.66	1.78	10.44

Sand and gravel	3.25	.02	3.27	--	--	--	3.25	.02	3.27
Sodium carbonate (natural)	--	--	--	65.75	--	65.75	65.75	--	65.75
Talc, soapstone, pyrophyllite	13.49	W	13.49	15.13	W	15.13	13.69	W	13.69
Average[1]	4.68	.08	4.76	19.24	.90	20.14	5.23	.11	5.34
Average, metals and industrial minerals[1]	6.17	.24	6.41	18.75	2.82	20.51	6.93	.39	7.33
Average, industrial minerals (excluding sand and gravel)[1]	7.59	.22	7.81	19.24	.90	20.14	8.83	.29	9.12
Average, metals and industrial minerals (excluding sand and gravel)[1]	9.07	.46	9.52	18.75	2.82	21.57	10.17	.73	10.90

W Withheld to avoid disclosing company proprietary data.
[1]Includes unpublished data.

Table 5.—Crude ore and total material handled at surface and underground mines in the United States in 1984, by commodity

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Antimony	--	100.0	--	100.0
Bauxite	100.0	--	100.0	--
Copper	88.5	11.5	95.6	4.4
Gold:				
Lode	92.7	7.3	97.8	2.2
Placer	99.7	.3	97.7	2.3
Iron ore	[1]100.0	W	[1]100.0	W
Lead	W	[2]100.0	W	[2]100.0
Manganiferous ore	100.0	--	100.0	--
Molybdenum	[1]100.0	W	[1]100.0	W
Nickel	100.0	--	100.0	--
Silver	39.0	61.0	78.1	21.9
Tungsten	.6	99.4	1.5	98.5
Uranium	64.6	35.4	95.3	4.7
Zinc	--	100.0	--	100.0
Average[3]	88.1	11.9	93.9	6.1
INDUSTRIAL MINERALS				
Abrasives[4]	[1]100.0	W	[1]100.0	W
Asbestos	100.0	--	100.0	--
Barite	100.0	--	100.0	--
Clays	99.3	.7	99.6	.4
Diatomite	100.0	--	100.0	--
Feldspar	100.0	--	100.0	--
Fluorspar	W	[2]100.0	W	[2]100.0
Gypsum	84.6	15.4	84.6	15.4
Mica (scrap)	100.0	--	100.0	--
Millstones	100.0	--	100.0	--
Olivine	100.0	--	100.0	--
Perlite	[1]100.0	W	[1]100.0	W
Phosphate rock	[1]100.0	W	[1]100.0	W
Potassium salts	--	100.0	--	100.0
Pumice	100.0	--	100.0	--
Salt	6.4	93.6	6.2	93.8
Sand and gravel	100.0	--	100.0	--
Sodium carbonate (natural)	--	100.0	--	100.0
Talc, soapstone, pyrophyllite	90.0	10.0	98.3	1.7
Vermiculite	100.0	--	100.0	--
Average[3]	96.3	3.7	97.0	3.0
Average, metals and industrial minerals[3]	93.9	6.1	95.7	4.3

W Withheld to avoid disclosing company proprietary data; included with "Surface" or "Underground."
[1]Includes underground; the Bureau of Mines is not at liberty to publish separately.
[2]Includes surface; the Bureau of Mines is not at liberty to publish separately.
[3]Includes unpublished data.
[4]Abrasive stone, emery, garnet, and tripoli.

Table 6.—Crude ore and total material handled at surface and underground mines in the United States in 1984, by State

(Percent)

State	Crude ore		Total material	
	Surface	Under-ground	Surface	Under-ground
Alabama	100.0	--	100.0	--
Alaska	100.0	--	100.0	--
Arizona	88.2	11.8	93.7	6.3
Arkansas	100.0	--	100.0	--
California	99.5	.5	99.4	.6
Colorado	75.8	24.2	71.7	28.3
Connecticut	100.0	--	100.0	--
Delaware	100.0	--	100.0	--
Florida	100.0	--	100.0	--
Georgia	[1]100.0	W	[1]100.0	W
Hawaii	100.0	--	100.0	--
Idaho	94.5	5.5	98.1	1.9
Illinois	99.3	.7	99.1	.9
Indiana	94.0	6.0	44.2	55.8
Iowa	96.9	3.1	96.9	3.1
Kansas	91.9	8.1	92.4	7.6
Kentucky	100.0	--	99.9	.1
Louisiana	77.6	22.4	77.9	22.1
Maine	100.0	--	100.0	--
Maryland	100.0	--	100.0	--
Massachusetts	100.0	--	100.0	--
Michigan	[1]100.0	W	[1]100.0	W
Minnesota	100.0	--	100.0	--
Mississippi	100.0	--	100.0	--
Missouri	58.9	41.1	58.9	41.1
Montana	82.1	17.9	89.2	10.8
Nebraska	100.0	--	100.0	--
Nevada	98.4	1.6	99.4	.6
New Hampshire	100.0	--	100.0	--
New Jersey	[1]100.0	W	[1]100.0	W
New Mexico	67.3	32.7	89.7	10.3
New York	84.0	16.0	83.3	16.7
North Carolina	100.0	--	100.0	--
North Dakota	[1]100.0	W	[1]100.0	W
Ohio	89.9	10.1	89.4	10.6
Oklahoma	100.0	--	100.0	--
Oregon	100.0	--	100.0	--
Pennsylvania	[1]100.0	W	[1]100.0	W
Rhode Island	100.0	--	100.0	--
South Carolina	100.0	--	100.0	--
South Dakota	80.7	19.3	79.9	20.1
Tennessee	62.0	38.0	66.0	34.0
Texas	99.5	.5	99.6	.4
Utah	98.8	1.2	99.1	.9
Vermont	100.0	--	100.0	--
Virginia	[1]100.0	W	[1]100.0	W
Washington	[1]100.0	W	[1]100.0	W
West Virginia	96.4	3.6	96.7	3.3
Wisconsin	100.0	--	100.0	--
Wyoming	61.7	38.3	81.9	18.1
Average[2]	93.9	6.1	95.7	4.3

W Withheld to avoid disclosing company proprietary data; included with "Surface."
[1]Includes underground; the Bureau of Mines is not at liberty to publish separately.
[2]Includes unpublished data.

Table 7.—Number of domestic metal and industrial mineral mines[1] in the United States in 1984, by commodity

Commodity	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
METALS							
Bauxite	6	--	--	4	2	--	--
Copper	25	2	3	3	--	9	8
Gold:							
Lode	82	35	8	8	20	10	1
Placer	31	5	8	11	5	2	--
Iron ore	21	--	1	3	4	5	8
Lead	13	3	1	1	6	2	--
Silver	33	9	7	7	8	2	--
Titanium (ilmenite)	3	--	--	--	2	1	--
Tungsten	9	5	2	--	2	--	--
Uranium	41	9	9	17	6	--	--
Zinc	11	--	1	1	7	2	--
Other[2]	21	2	5	5	4	5	--
Total	296	70	45	60	66	38	17
INDUSTRIAL MINERALS							
Abrasives[3]	12	2	4	5	1	--	--
Asbestos	3	--	--	--	3	--	--
Barite	15	--	4	7	4	--	--
Clays	944	56	226	531	131	--	--
Diatomite	10	--	2	4	4	--	--
Feldspar	15	--	3	5	6	1	--
Fluorspar	4	1	2	--	1	--	--
Gypsum	69	2	4	23	38	2	--
Mica (scrap)	12	1	2	5	4	--	--
Perlite	11	--	3	5	3	--	--
Phosphate rock	36	--	--	1	11	17	7
Potassium salts	5	--	--	--	1	4	--
Pumice	23	4	9	7	3	--	--
Salt	19	--	3	4	6	6	--
Sand and gravel	6,076	111	913	3,020	1,960	71	1
Sodium carbonate (natural)	5	--	--	--	2	3	--
Talc, soapstone, pyrophyllite	40	8	14	14	4	--	--
Other[4]	31	7	3	15	5	1	--
Total	7,330	192	1,192	3,646	2,187	105	8
Grand total	7,626	262	1,237	3,706	2,253	143	25

[1]Excludes wells, ponds, or pumping operations.
[2]Includes antimony, beryllium, manganiferous ore, mercury, molybdenum, rare-earth metals, and tin.
[3]Includes abrasive stone, emery, garnet, and tripoli.
[4]Includes aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, magnesite, millstones, olivine, vermiculite, and wollastonite.

Table 8.—Twenty-five leading metal and industrial mineral[1] mines in the United States in 1984, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
		METALS		
Morenci	Arizona	Phelps Dodge Corp	Copper	Open pit.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Sierrita	Arizona	Duval Sierrita Corp	Copper	Do.
Empire	Michigan	Empire Iron Mining	Iron ore	Do.
Utah Copper	Utah	Kennecott	Copper	Do.
Hibbing Taconite	Minnesota	Pickands Mather & Co	Iron ore	Do.
San Manuel	Arizona	Magma Copper Co	Copper	Caving and open pit.
Tilden	Michigan	Tilden Mining Co	Iron ore	Open pit.
Tyrone	New Mexico	Phelps Dodge Corp	Copper	Do.
Erie Commercial	Minnesota	Pickands Mather & Co	Iron ore	Do.
Chino	New Mexico	Chino Mines Co	Copper	Do.
Ray Pit	Arizona	Kennecott	do	Do.
Thunderbird	Minnesota	Oglebay Norton Co	Iron ore	Do.
Pinto Valley	Arizona	Pinto Valley Copper Corp	Copper	Do.
Round Mountains	Nevada	Copper Range Co	Lode gold	Do.
Peter Mitchell	Minnesota	Reserve Mining Co	Iron ore	Do.
National Pellet Project-Itasca.	do	The Hanna Mining Co	do	Do.
Green Cove	Florida	Associated Minerals Corp	Titanium	Dredging.
Eisenhower	Arizona	ASARCO Incorporated	Copper	Open pit.
Minorca	Minnesota	Inland Steel Mining Co	Iron ore	Do.
Inspiration	Arizona	Inspiration Consolidated Copper Co.	Copper	Do.
National Pellet Project-St.Louis.	Minnesota	The Hanna Mining Co	Iron ore	Do.
Butler Taconite	do	do	do	Do.
Henderson	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
New Cornelia	Arizona	Phelps Dodge Corp	Copper	Open pit.
		INDUSTRIAL MINERALS[2]		
Noralyn	Florida	International Minerals & Chemical Corp.	Phosphate rock.	Open pit.
Kingsford	do	do	do	Do.
Ft. Green	do	Williams Co	do	Do.
Hookers	do	W. R. Grace & Co	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Lee Creek	North Carolina	Texasgulf Inc	do	Do.
Haynsworth	Florida	American Cyanamid Co	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Lonesome	do	American Cyanamid Co	do	Do.
Suwanee	do	Occidental Petroleum Corp	do	Do.
Big Four	do	AMAX Phosphate Inc.,a division of AMAX Inc.	do	Do.
Wingate Creek	do	Beker Industries Corp	do	Do.
Swift Creek	do	Occidental Petroleum Corp	do	Do.
International	New Mexico	International Minerals & Chemical Corp.	Potassium salts.	Stopes.
Payne Creek	Florida	Agrico Chemical Co	Phosphate rock.	Open pit.
Hardee	do	C. F. Mining Corp	do	Do.
Irwindale	California	Koppers Co., Blue Diamond Materials.	Sand and gravel.	Dredging.
Radum	do	Koppers Co., Kaiser Sand and Gravel.	do	Do.
AMAX	New Mexico	AMAX Chemical Corp., a division of AMAX Inc.	Potassium salts.	Stopes.
St. Lucie	Florida	General Development Corp	Sand and gravel.	Dredging.
Saddle Creek	do	Agrico Chemical Co	Phosphate rock.	Open pit.
Hobbs	New Mexico	New Mexico Potash Corp	Potassium salts.	Do.
Retsof	New York	International Salt Co	Salt	Stopes.
Rockland	Florida	USS Agri-Chemicals	Phosphate rock.	Open pit.
Perkins	California	Teichert Aggregates	Sand and gravel.	Dredging.

[1]Excludes brines and materials from wells.
[2]Crushed and broken and dimension stone were not available in 1984 because of biennial canvassing.

Table 9.—Twenty-five leading metal and industrial mineral[1] mines in the United States in 1984, in order of output of total materials handled

Mine	State	Operator	Commodity	Mining method
METALS				
Tyrone	New Mexico	Phelps Dodge Corp	Copper	Open pit.
Morenci	Arizona	do	do	Do.
Utah Copper	Utah	Kennecott	do	Do.
Sierrita	Arizona	Duval Sierrita Corp	do	Do.
Empire	Michigan	Empire Iron Mining	Iron ore	Do.
Chino	New Mexico	Chino Mines Co	Copper	Do.
Inspiration	Arizona	Inspiration Consolidated Copper Co.	do	Do.
Ray Pit	do	Kennecott	do	Do.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Hibbing Taconite	do	Pickands Mather & Co	do	Do.
Tilden	Michigan	Tilden Mining Co	do	Do.
Thompson Creek	Idaho	Cyprus Mines Corp	Molybdenum	Do.
Battle Mountain	Nevada	Battle Mountain Gold Co	Lode gold	Do.
Thunderbird	Minnesota	Oglebay Norton Co	Iron ore	Do.
San Manuel	Arizona	Magma Copper Co	Copper	Caving and open pit.
Pinto Valley	do	Pinto Valley Copper Co	do	Open pit.
Erie Commercial	Minnesota	Pickands Mather & Co	Iron ore	Do.
Candelaria	Nevada	Nerco Minerals Co	Silver	Do.
Eisenhower	Arizona	ASARCO Incorporated	Copper	Do.
Mercur	Utah	Barrick Mercur Gold Mines Inc.	Lode gold	Do.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Do.
Henderson	do	do	do	Caving and open pit.
Maggie Creek	Nevada	Carlin Gold Mining Co	Lode gold	Open pit.
Round Mountains	do	Copper Range Co	do	Do.
Peter Mitchell	Minnesota	Reserve Mining Co	Iron ore	Do.
INDUSTRIAL MINERALS[2]				
Noralyn	Florida	International Minerals & Chemical Corp.	Phosphate rock.	Open pit.
Ft. Green	do	Williams Co	do	Do.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Suwannee	do	Occidental Petroleum Corp	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Lonesome	do	American Cyanamid Co	do	Do.
Hookers	do	W. R. Grace & Co	do	Do.
Wingate Creek	do	Beker Industries Corp	do	Do.
Swift Creek	do	Occidental Petroleum Corp	do	Do.
Big Four	do	AMAX Phosphate Inc., a division of AMAX Inc.	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Lee Creek	North Carolina	Texasgulf Inc	do	Do.
Ft. Meade	Florida	Gardinier Inc	do	Do.
Hardee	do	C. F. Mining Corp	do	Do.
Mabie Canyon	Idaho	Conda Partnership	do	Do.
Saddle Creek	Florida	Agrico Chemical Co	do	Do.
Vernal	Utah	Chevron Resources Co	do	Do.
International	New Mexico	International Minerals & Chemical Corp.	Potassium salts.	Stopes.
Payne Creek	Florida	Agrico Chemical Co	Phosphate rock.	Open pit.
Henry	Idaho	Monsanto Co	do	Do.
Copperopolis	California	Calaveras Asbestos Corp	Asbestos	Do.
Irwindale	do	Koppers Co., Blue Diamond Materials.	Sand and gravel.	Dredging.
Conda	Idaho	J. R. Simplot Co	Phosphate rock.	Open pit.
Radum	California	Koppers Co., Kaiser Sand and Gravel.	Sand and gravel.	Dredging.

[1]Excludes brines and materials from wells.
[2]Crushed and broken and dimension stone were not available in 1984 because of biennial canvassing.

Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines[1] in the United States in 1984, by commodity

Commodity	Surface			Underground			Total[2]		
	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product
METALS									
Bauxite ---- thousand long tons	1,130	843	1.3:1	--	--	--	1,130	843	1.3:1
Copper ---- thousand short tons	166,000	1,040	159.6:1	22,200	130	170.8:1	188,000	1,170	160.8:1
Gold:									
Lode ---- thousand troy ounces	37,900	1,330	28.3:1	2,950	364	8.1:1	40,900	1,700	24.0:1
Placer ---- do	8,480	38	223.2:1	--	--	--	8,480	38	223.2:1
Iron ore ---- thousand long tons	175,000	4,920	3.5:1	W	W	W	175,000	4,920	3.5:1
Lead ---- thousand pounds	W	W	W	5,460	307	17.7:1	5,460	307	17.7:1
Silver ---- thousand troy ounces	3,440	4,250	.8:1	4,820	26,800	.1:1	8,260	31,000	.2:1
Zinc ---- thousand short tons	--	--	--	5,810	205	28.3:1	5,810	205	28.3:1
INDUSTRIAL MINERALS									
Asbestos ---- do	1,270	63	20.1:1	--	--	--	1,270	63	20.1:1
Barite ---- do	849	771	1.1:1	--	--	--	849	771	1.1:1
Clays ---- do	44,200	43,000	1.0:1	331	331	1.0:1	44,600	43,300	1.0:1
Diatomite ---- do	1,790	628	2.8:1	--	--	--	1,790	628	2.8:1
Feldspar ---- do	2,610	695	3.7:1	--	--	--	2,610	695	3.7:1
Gypsum ---- do	12,600	11,700	1.1:1	2,580	2,580	1.0:1	15,200	14,300	1.1:1
Mica (scrap) ---- do	806	117	6.8:1	--	--	--	806	117	6.8:1
Perlite ---- do	1,070	494	2.1:1	W	W	W	1,070	494	2.1:1
Phosphate rock ---- do	324,000	54,000	5.9:1	W	W	W	324,000	54,000	5.9:1
Potassium salts ---- do	--	--	--	15,300	1,560	9.8:1	15,300	1,560	9.8:1
Pumice ---- do	501	501	1.0:1	--	--	--	501	501	1.0:1
Salt ---- do	967	620	1.5:1	21,000	13,100	1.6:1	22,000	13,700	1.6:1
Sand and gravel ---- do	804,000	799,000	1.0:1	--	--	--	804,000	799,000	1.0:1
Sodium carbonate (natural) ---- do	--	--	--	6,730	6,730	1.0:1	6,730	6,730	1.0:1
Talc, soapstone, pyrophyllite ---- do	1,420	994	1.4:1	207	205	1.9:1	1,630	1,100	1.4:1

W Withheld to avoid disclosing company proprietary data.
[1]Excludes wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.

Table 11.—Material handled per unit of marketable product at surface and underground mines[1] in the United States in 1984, by commodity

Commodity		Surface: Total material handled[3] (thousand short tons)	Surface: Marketable product (units)	Surface: Ratio of units of material handled to units of marketable product[4]	Underground: Total material handled[3] (thousand short tons)	Underground: Marketable product (units)	Underground: Ratio of units of material handled to units of marketable product[4]	Total[2]: Total material handled[3] (thousand short tons)	Total[2]: Marketable product (units)	Total[2]: Ratio of units of material handled to units of marketable product[4]
METALS										
Bauxite	thousand long tons	9,210	843	1.3:1	--	--	--	9,210	843	1.3:1
Copper	thousand short tons	483,000	1,040	408.1:1	22,400	130	170.5:1	505,000	1,170	381.6:1
Gold:										
Lode	thousand troy ounces	152,000	1,330	86.1:1	3,450	364	8.7:1	155,000	1,700	69.5:1
Placer	do	8,810	38	230.3:1	211	--	--	9,020	38	231.2:1
Iron ore	thousand long tons	260,000	49,200	5.3:1	W	W	W	260,000	49,200	5.3:1
Lead	thousand pounds	31	--	--	6,690	307	18.4:1	6,720	307	18.4:1
Silver	thousand troy ounces	19,000	4,250	2.7:1	5,320	26,800	.2:1	24,300	31,000	.5:1
Zinc	thousand short tons	--	--	--	6,760	205	31.3:1	6,760	205	31.3:1
INDUSTRIAL MINERALS										
Asbestos	do	6,170	63	75.9:1	--	--	--	6,170	63	75.9:1
Barite	do	1,650	771	2.1:1	--	--	--	1,650	771	2.1:1
Clays	do	e82,600	43,000	1.9:1	e336	331	1.0:1	e83,000	43,300	1.9:1
Diatomite	do	6,790	628	10.7:1	--	--	--	6,790	628	10.7:1
Feldspar	do	3,870	695	5.6:1	--	--	--	3,870	695	5.6:1
Gypsum	do	14,100	11,700	1.2:1	2,580	2,580	1.0:1	16,700	14,300	1.2:1
Mica (scrap)	do	1,720	117	13.9:1	--	--	--	1,720	117	13.9:1
Perlite	do	989	494	1.9:1	W	W	W	989	494	1.9:1
Phosphate rock	do	411,000	54,000	7.6:1	W	W	W	411,000	54,000	7.6:1
Potassium salts	do	--	--	--	15,800	1,560	10.1:1	15,800	1,560	10.1:1
Pumice	do	589	501	1.2:1	--	--	--	589	501	1.2:1
Salt	do	970	620	1.6:1	14,700	13,100	1.1:1	15,700	13,700	1.1:1
Sand and gravel	do	804,000	799,000	1.0:1	--	--	--	804,000	799,000	1.0:1
Sodium carbonate (natural)	do	--	--	--	6,730	6,730	1.0:1	6,730	6,730	1.0:1
Talc, soapstone, pyrophyllite	do	6,450	994	5.4:1	113	105	1.1:1	6,560	1,100	5.0:1

eEstimated. W Withheld to avoid disclosing company proprietary data.
[1]Excludes material from wells, ponds, or pumping operations.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes material from development and exploration activities.
[4]Material from development and exploration activities is excluded from the ratio calculation.

Table 12.—Mining methods used in open pit mining in the United States in 1984, by commodity

(Percent)

Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting[1]
METALS		
Bauxite	92	8
Copper	95	5
Gold:		
Lode	97	3
Placer	1	99
Iron ore	95	5
Manganiferous ore	--	100
Mercury	15	85
Molybdenum	100	--
Rare-earth metals	100	--
Silver	85	15
Titanium (ilmenite)	--	100
Tungsten	5	95
Uranium	34	66
INDUSTRIAL MINERALS		
Aplite	15	85
Asbestos	62	38
Barite	74	26
Clays	--	100
Diatomite	--	100
Feldspar	66	34
Fluorspar	100	--
Gypsum	98	2
Iron oxide pigments (crude)	--	100
Kyanite	100	--
Magnesite	100	--
Mica (scrap)	16	84
Millstones	100	--
Olivine	100	--
Perlite	72	28
Phosphate rock	12	88
Pumice	48	52
Salt	8	92
Sand and gravel	--	100
Talc, soapstone, pyrophyllite	96	4
Vermiculite	55	45
Average	40	60

[1]Includes drilling or cutting without blasting, dredging, mechanical excavation and nonfloat washing, and other surface mining methods.

Table 13.—Development and exploration activity in the United States in 1984, by method

Method	Metals: Feet	Metals: Percent of total[2]	Industrial minerals: Feet	Industrial minerals: Percent of total[2]	Total[1]: Feet	Total[1]: Percent of total[2]
DEVELOPMENT						
Drifting, crosscutting, or tunneling	373,000	67.9	11,300	100.0	384,000	68.5
Raising	63,400	11.6	W	W	63,400	11.3
Shaft and winze sinking	1,530	.3	W	W	1,530	.3
Solution mining	111,000	20.3	W	W	111,000	19.9
Total[1]	549,000	100.0	11,300	100.0	561,000	100.0
EXPLORATION						
Churn drilling	27,000	.6	W	W	27,100	.6
Diamond drilling	836,000	17.9	112,000	61.5	949,000	19.5
Percussion drilling	982,000	21.0	31,000	17.0	1,010,000	20.9
Rotary drilling	2,540,000	54.4	39,400	21.6	2,580,000	53.2
Trenching	29,200	.6	W	W	29,200	.6
Other drilling	258,000	5.5	--	--	258,000	5.3
Total[1]	4,680,000	100.0	183,000	100.0	4,860,000	100.0
Grand total[1]	5,230,000	XX	194,000	XX	5,420,000	XX

W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.
[2]Based on unrounded footage.

Table 14.—Development and exploration in the United States in 1984, by commodity

(Feet)

Commodity	Development					Exploration						
	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Solution mining	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
METALS												
Copper	--	31,700	28,000	--	59,700	6,640	--	4,000	--	100	160	10,900
Gold:												
Lode	332	10,100	59,600	--	70,000	218,000	--	298,000	271,000	20,000	17,400	825,000
Placer	25	20	1,200	--	1,250	--	W	--	--	300	W	300
Iron ore	--	--	W	--	W	15,700	--	--	--	--	--	15,700
Lead	--	W	24,700	--	24,700	134,000	W	--	W	W	--	134,000
Silver	779	2,440	112,000	--	116,000	102,000	--	83,600	21,300	30,400	W	237,000
Tungsten	W	--	W	--	W	650	--	--	W	--	--	650
Uranium	--	3,760	52,300	111,000	168,000	108,000	--	1,560,000	281,000	167,000	1,650	2,110,000
Zinc	W	5,180	71,700	--	76,800	83,400	--	9,000	273,000	2,000	1,000	368,000
Other[2]	397	10,300	23,100	--	33,800	169,000	27,000	594,000	136,000	38,000	8,160	972,000
Total[1]	1,530	63,400	373,000	111,000	549,000	836,000	27,100	2,540,000	982,000	258,000	29,200	4,680,000
INDUSTRIAL MINERALS												
All industrial minerals[3]	W	W	11,300	W	11,300	112,000	W	39,400	31,000	--	W	183,000
Grand total[1]	1,530	63,400	384,000	111,000	561,000	949,000	27,100	2,580,000	1,010,000	258,000	29,200	4,860,000

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes bauxite, beryllium, mercury, molybdenum, platinum-group metals, and items indicated by symbol W.
[3]Includes barite; boron minerals; diatomite; fluorspar; lime; potassium salts; salt; and talc, soapstone, and pyrophyllite.

Table 15.—Development and exploration in the United States in 1984, by State

(Feet)

State	Development					Exploration						
	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Solution mining	Total[1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total[1]
Alaska	--	W	W	--	W	44,300	W	W	--	W	1,170	45,500
Arizona	W	W	29,000	--	29,000	16,000	--	39,200	4,850	W	100	60,200
California	80	585	2,500	--	3,160	16,800	W	368,000	66,100	1,440	9,400	462,000
Colorado	--	5,690	29,400	--	35,100	118,000	--	68,900	115,000	18,200	250	321,000
Idaho	729	W	14,800	--	15,500	13,400	--	W	--	--	--	13,400
Missouri	--	--	25,100	--	25,100	W	W	--	--	W	--	W
Montana	30	W	487	--	517	125,000	--	W	10	365	2,540	128,000
Nevada	--	2,490	7,870	--	10,400	12,300	--	318,000	263,000	33,300	13,800	640,000
New Mexico	--	9,770	58,600	--	68,300	14,600	--	190,000	W	W	--	205,000
Oregon	--	--	509	--	509	W	--	W	--	100	50	150
South Dakota	--	W	W	--	W	W	--	W	1,500	--	--	1,500
Tennessee	--	W	41,000	--	41,000	W	--	--	273,000	--	--	273,000
Texas	--	--	--	108,000	108,000	W	--	955,000	--	--	--	995,000
Utah	W	W	90,600	--	90,600	48,900	--	70,100	9,860	15,800	1,400	146,000
Washington	--	--	50	--	50	--	--	--	W	--	--	W
Wyoming	--	--	W	3,040	3,040	2,000	--	211,000	--	--	--	213,000
Undistributed[2]	694	44,900	84,500	--	130,000	537,000	27,100	323,000	280,000	188,000	500	1,360,000
Total[1]	1,530	63,400	384,000	111,000	561,000	949,000	27,100	2,580,000	1,010,000	258,000	29,200	4,860,000

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes Alabama, Georgia, Illinois, Kentucky, Louisiana, Michigan, Minnesota, New Hampshire, New Jersey, New York, South Carolina, Virginia, and items indicated by symbol W.

Table 16.—Total material (ore and waste) produced by mine development in the United States in 1984, by commodity and State

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Stripping	Total[1]
COMMODITY					
METALS					
Copper	--	58	122	59,400	59,600
Gold:					
Lode	W	W	252	36,700	37,000
Placer	(2)	(2)	166	64	230
Lead	--	W	1,040	W	1,040
Silver	W	W	259	7,360	7,620
Uranium	--	W	234	5,170	5,400
Zinc	W	W	335	--	335
Other[3]	17	1,650	4,700	10,620	17,000
Total[1]	17	1,710	7,110	119,000	128,000
INDUSTRIAL MINERALS					
Talc, soapstone, pyrophyllite	--	W	W	1,060	1,060
Other[4]	2	4	102	1,740	1,850
Total[1]	2	4	102	2,800	2,910
Grand total[1]	19	1,720	7,210	122,000	131,000
STATE					
Alaska	--	W	W	64	64
Arkansas	--	--	--	8,080	8,080
California	W	2	180	10,900	11,100
Colorado	--	1,540	4,700	W	6,240
Idaho	W	W	94	1,200	1,300
Kentucky	1	(2)	3	--	5
Missouri	--	--	1,020	31	1,050
Montana	(2)	W	3	7,590	7,590
Nevada	--	W	81	26,400	26,400
New Mexico	--	35	276	W	311
Oregon	--	--	3	W	3
Utah	W	W	168	W	168
Washington	--	--	(2)	W	(2)
Wyoming	--	--	W	5,160	5,160
Undistributed[5]	18	140	685	62,800	63,600
Total[1]	19	1,720	7,210	122,000	131,000

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Undistributed."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes bauxite, beryllium, iron ore, molybdenum, nickel, tungsten, and items indicated by symbol W.
[4]Includes asbestos, barite, diatomite, fluorspar, mica (scrap), millstones, perlite, pumice, salt, wollastonite, and items indicated by symbol W.
[5]Includes Alabama, Arizona, Illinois, Louisiana, New Jersey, New York, North Carolina, South Dakota, Tennessee, Texas, Vermont, and items indicated by symbol W.

Table 17.—U.S. industrial consumption of explosives

(Thousand pounds)

Year	Coal mining[1]	Metal mining[1]	Quarrying and industrial mineral mining[1]	Total mineral industry	Construction work and other uses[2]	Total industrial
1980	2,503,359	559,229	624,184	3,686,772	587,690	4,274,462
1981	2,249,262	695,449	493,771	3,438,482	902,567	4,341,049
1982	2,269,565	530,384	423,353	3,223,302	687,189	3,910,491
1983	2,126,263	481,129	467,710	3,075,102	655,150	3,730,252
1984	2,758,659	437,217	479,873	3,675,749	681,109	4,356,858

[1]Some quantities of this use are included with "Construction work and other uses" to avoid disclosing company proprietary data.
[2]Includes some quantities from "Coal mining," "Metal mining," and "Quarrying and industrial mineral mining."

Note.—Data for 1980 are not comparable to data for prior years owing to change in reporting by the Institute of Makers of Explosives.

Table 18.—U.S. consumption of explosives in the minerals industry

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and industrial mineral mining	Total
PERMISSIBLE EXPLOSIVES				
1980	52,476	81	716	53,273
1981	49,814	166	1,638	51,618
1982	43,401	287	1,317	45,005
1983	35,181	311	657	36,149
1984	37,721	195	345	38,261
OTHER HIGH EXPLOSIVES				
1980	24,912	25,085	50,138	100,135
1981	22,314	23,384	43,223	88,921
1982	19,360	13,108	29,322	61,790
1983	17,964	8,861	31,833	58,658
1984	20,357	7,771	29,658	57,786
WATER GELS AND SLURRIES				
1980	93,916	171,213	99,947	365,076
1981	99,796	174,528	86,671	360,995
1982	104,364	90,738	80,503	275,605
1983	94,578	49,699	94,261	238,538
1984	99,340	78,959	102,849	281,148
AMMONIUM NITRATE: FUEL—MIXED AND UNPROCESSED				
1980	2,332,055	362,850	473,383	3,168,288
1981	2,077,338	497,371	362,239	2,936,948
1982	2,102,440	426,251	312,211	2,840,902
1983	1,978,540	422,258	340,959	2,741,757
1984	2,601,241	350,292	347,021	3,298,554
TOTAL				
1980	2,503,359	559,229	624,184	3,686,772
1981	2,249,262	695,449	493,771	3,438,482
1982	2,269,565	530,384	423,353	3,223,302
1983	2,126,263	481,129	467,710	3,075,102
1984	2,758,659	437,217	479,873	3,675,749

FROTH FLOTATION[40]

Froth flotation is a process for separating and selectively concentrating finely divided minerals. The process involves the crushing and grinding of ore to a fine enough size to liberate or free the mineral species from each other, followed by the selective recovery of the desired minerals by the injection of air into a mineral-water slurry. Chemicals added to the slurry as collectors are selectively adsorbed on the surfaces of particles of the desired minerals making them hydrophobic (water repellent) and allowing air bubbles to attach to the particles' surfaces. The hydrophobic particles are borne to the surface by air bubbles rising through the slurry and become concentrated in a surface froth, which is skimmed off to form a mineral concentrate. Conversely, other reagents called depressants may be added to the slurry to selectively render surfaces of the specific mineral particles hydrophilic (wettable) to suppress the attachment of bubbles on their surface to further enhance mineral separation. Flotation is generally a multistage process, particularly in complex ores containing several recoverable minerals. Some of the minerals floated in the first stage, or rougher (bulk) float, may subsequently be depressed in later flotation stages. Surface-active reagents called modifiers may be added to the slurry to affect the flotation response of the minerals. The development of flotation as an economic minerals beneficiation process has allowed the mining of previously uneconomic complex and low-grade ores. Flotation is used to obtain more than one-third of U.S. mineral concentrates, and its importance to minerals processing has been ranked with that of the development of smelting.

Every 5 years the Bureau of Mines conducts a survey of domestic mineral processing plants that employ froth flotation. The survey requests operational data on capacity, recovery rates, ore and concentrate grades, and consumption of utilities as well as consumption of reagents. Data received from the plants surveyed indicated that in 1985 more than 422 million short tons of ore and raw coal was processed by froth flotation to produce over 80 million tons of mineral concentrates. This required almost 8 billion kilowatt-hours of electricity, 947 billion gallons of water, and 1.4 billion pounds of chemical reagents. Of particular significance is the overall decline, since 1980, in the number, capacity, throughput, and reagent consumption of domestic flotation plants, particularly those processing copper, lead, and zinc sulfide ores.

The 1985 flotation survey has been modified from previous surveys to ensure greater accuracy in reporting and to obtain a more detailed breakdown of reagent consumption. Therefore, some of the data may not directly correlate with that of the previous data shown in tables 23-27. The following list describes some of the assumptions made in the 1985 survey and some of the factors that distinguished it from previous surveys.

1. In previous surveys, estimates were made to account for nearly all nonreporting companies, with the exception of coal processing plants and small precious metal producers. Estimates were not made for all of the nonrespondents to the 1985 survey owing to insufficient information, particularly for plants that processed only part of their production by flotation, most notably, those processing industrial mineral (nonmetallic) ores.

2. The 1985 survey differed from previous surveys in that reagents were listed and grouped by their chemical identity, rather than by the previous mixture of generic and trade names. In the 1985 survey, modifiers have been differentiated between pH regulators and dispersants. Other reagents have been classified according to the following definitions:[41]

Collectors.—Reagents used to render the surface of the mineral to be floated hydrophobic to improve the adherence of air bubbles to the mineral surface.

Activators.—Reagents that enhance collector adsorption, thereby promoting mineral flotation.

Depressants.—Reagents that reduce or inhibit the flotability of a mineral.

Flocculants.—Reagents that cause aggregation of small mineral particles into larger clusters.

Frothers.—Reagents used to promote a froth of sufficient stability or permanence, principally by reducing surface tension, that is adequate to permit removal of mineral-carrying bubbles.

3. Reported data on consumption of water, energy, and grinding media pertained to all operations inherent in the minerals processing plant; they were not limited to the flotation section of the plant and may include data on other separation or classification processes, such as gravity or magnetic separations. Energy consumption data were not reported for some ore types processed by flotation.

4. In past surveys, reagents used in effluent treatment were excluded from the tabulations of flotation reagents if reported separately. The 1985 survey specifically included effluent treatment chemicals; these have been tabulated separately.

5. Operating data have been presented on an annualized basis. Where plant capacity was reported on an hourly or daily basis, annual capacity was estimated using general plant practice for the type of ore being treated. For example, sulfide flotation plants were assumed to operate 350 days per year, 3 shifts per day, while coal preparation plants were assumed to operate 2 shifts per day, 250 days per year.

6. In previous surveys, reagent consumption was reported per ton of material processed by flotation, and total consumption was calculated from plant throughput. The 1985 survey canvassed the total consumption of reagent plus the quantity of reagent per ton of ore passing through that part of the circuit, as shown in tables 27-38.

Data for the 1985 flotation survey were received from 171 flotation plants. Data for eight more plants were estimated from past flotation surveys and from production data reported on other Bureau of Mines surveys. An additional 55 flotation plants surveyed were determined to be inactive, and 161 other plants failed to respond to the survey. Owing to insufficient data on their operating status or production of concentrates from froth flotation, no estimates were made for these nonreporting plants. However, it was estimated that 140 of the nonreporting plants were coal preparation plants, 8 were small gold or silver producers, 4 were metallic carbonate plants, and

9 were industrial mineral plants.

DATA COVERAGE

Sulfide Plants.—Consumption data for the five base metal sulfide ore nonrespondents, comprising 14% of the ore treated in 1985 shown in table 23, were estimated from past flotation survey reports and 1985 mine production data reported to the Bureau of Mines. Data for the gold and silver properties that did not report were not estimated owing to their relatively small size and uncertain operational status.

Metallic Carbonate Plants.—Owing to insufficient data, no estimates were made for the metallic carbonate plants that did not respond to the survey. Reporting companies accounted for 100% of the data shown in table 24.

Industrial Mineral Plants.—Of the 12 industrial mineral plants that did not respond to the survey, estimates for consumption data were made for the 2 feldspar-quartz-mica plants and 1 potash plant, representing less than 1% of the ore treated shown in table 25. Owing to insufficient data, estimates were not made for two nonreporting kyanite plants nor for nonreporting glass sand plants. The data shown in table 35 for glass sand may account for as little as 55% of glass sand processed by flotation.

Coal Preparation Plants.—No attempt was made to estimate data for nonreporting coal preparation plants, many of which were probably not operating, operating intermittently, or no longer using froth flotation.

RESEARCH AND TECHNOLOGY

The economic pressures of the international marketplace have forced innovative improvements in existing froth flotation and other minerals beneficiation technology and have prompted the development of revolutionary new methods. Two new concepts currently being transferred to industrial-scale operations are (1) control of the electrochemical environment of the slurry, and (2) control of bubble size in column flotation.

Froth flotation makes use of differences in the chemical properties of the surface of finely ground minerals to obtain separation. Bureau of Mines research has shown that changing the electrochemical potential of many sulfide minerals can be used to control their surface properties and, thus, their flotation response.[42] The principal reason for this is that the surface chemical reactions between collectors (such as xanthate) and most sulfide minerals are electrochemical processes. Furthermore, the electrochemical potential regions where the individual minerals float are sufficiently distinct to suggest that precise control of the electrochemical potential could be used to selectively separate the valuable minerals. This would substantially reduce the need for chemical modifiers such as cyanide and the need for pH control reagents, such as lime. Consequently, the chemical accumulation that complicates downstream stages of a multistage flowsheet would be reduced, and significant savings in flotation reagent costs would be realized.

The projected savings in reagent costs are the primary incentive for industry interest in electrochemical flotation technology. A typical copper flotation mill could anticipate savings on the order of $1 million annually by eliminating pH control reagents in pyrite-copper mineral separations, for example. Other benefits include increased revenues from higher recoveries that result from improved selectivity, and lower operating costs that result from simpler flowsheets and fewer chemicals.

In principle, electrochemical control is already being utilized in mill practice for the separation of copper from molybdenum by using the reducing agent sodium hydrosulfide to adjust the electrochemical potential of the copper minerals to below the flotation threshold. However, hydrosulfide losses due to oxidation have led to excessive hydrosulfide consumption. Consequently, some mills have gone to the expense of using nitrogen-purged flotation cells to reduce oxidative losses.

Column flotation cells are becoming more widely used in flotation mills.[43] Column cells do not use mechanical agitation to suspend particles and disperse air. They are tall columns that can be considered as having two distinct regions separated by the ore feed port situated about two-thirds of the way up the column. The interaction of downflowing ore particles and the rising air bubbles below the feed port in the lower collection zone determine mineral recovery. In the upper cleaning zone, product grade is determined (almost independently) by the rising mineral-laden froth and the downflowing washwater. Thus, a single column cell can substitute for several flotation stages, as is the case in some copper-molybdenum separations where single column flotation is achieving upgrading that previously required as many as seven stages of mechanical cells. Also, because air bubbles can be generated external to the column cell, column cells have the advantage of allowing for more efficient control of the bubble size. Bubble size is known to have an impact on metallurgical performance, especially on recovery of fine particles. Bubble generators and delivery tubes developed by the Bureau of Mines permit adjustment and control of bubble size from less than 0.1 millimeter up to 3 millimeters in diameter using a minimum quantity of frother. In addition, delivery tubes can be operated indefinitely without plugging and changed without interrupting operation when worn out. Increased utilization of column flotation cells should result in significant reductions in both capital and operating costs as well as in improved metallurgy.

For a number of years, improvements in beneficiation technology have been the result of evolutionary extensions of present practice. Where mill throughput was sufficiently large, the trend has continued toward larger grinding mills and flotation machines. Several years ago, the largest flotation machines were 1,350 cubic feet. Today, cells are available with a capacity of 2,500 cubic feet. Flotation circuits continue to be remodeled with fewer, but larger machines. Larger equipment reduces the number of units required, which helps lower maintenance costs, reduces floor space requirements, reduces energy costs, and simplifies computerized process control systems.

Introduction of angular spiral liners[44] for grate discharge ball mills is the most significant recent improvement in commercial grinding circuits. When placed in service at the San Manuel, AZ, concentrator of Magma Copper Co., grinding media consumption decreased by 19% and grinding energy consumption decreased by 16%. Similar savings were obtained after installation in Corporación Nacional de Cobre de Chile mills in Chile. These are substantial savings in the two highest cost areas of mineral beneficiation—energy and grinding media consumption. Further savings are resulting from a better understanding of the mechanisms of grinding media loss. Grinding media (balls, rods, and mill liners) are consumed through abrasion, corrosion, and fracture. Research[45] has shown that the relative contribution of each of these factors depends on the metallurgical properties of the media (usually steel), the type of ore being ground, and the grinding conditions (wet or dry). Abrasive wear is influenced by the rheological properties of the ore slurry and is the dominant wear mechanism for nonsulfide ores. For sulfide ores, electrochemical reactions between the sulfide mineral and the grinding steel increases the corrosive wear. The electrochemical reactions also dissolve metal ions into solutions, reducing the efficiency of subsequent flotation steps,[46] creating an environmental problem in effluent disposal, and affecting water recyclability. As a result, research into grinding media wear and the development of methods to reduce it are helping to reduce other production and environmental costs.

With respect to flotation mill size classification problems, screen classifiers are receiving attention as potential substitutes for cyclones in closed circuit grinding down to the 270-mesh level. Screen characteristics such as capacity, blinding avoidance, and screen cloth life have been improved, making them more cost effective. Vibrating screens up to 12 by 28 feet have been employed. Classification of grinding mill output with respect to mineral as well as particle size would help reduce overgrinding and energy consumption. Mineral-specific classification would enable the removal of a mineral as soon as it is liberated, whether or not it has been reduced to a particular size. Incorporation of a flotation cell into the grinder output just ahead of the hydrocyclone size classifier (flash flotation) is one method of mineral classification that is currently being evaluated on a commercial scale.

Automatic control is being applied to an increasing number of flotation concentrators.[47] However, fully automatic control using advanced computer technology has yet to be realized. Problems include lack of appropriate sensors and lack of a sufficiently detailed model of the processes being controlled. The most important sensor in a flotation control system at present is the on-stream X-ray analyzer, which provides chemical analysis of the metal content of process streams. Mineral content, the parameter needed for control, can only be inferred from these chemical data. The problem is particularly acute if the pulp consists of a complex mixture of sulfides. Based on elemental analysis alone, it is difficult to distinguish, for example, between chalcocite (CuS_2), cubanite ($CuFe_2S_3$), chalcopyrite ($CuFeS_2$), and pyrite (FeS_2). These minerals have very different flotation properties and require very different conditions for optimum flotation. Research continues to develop more comprehensive models of flotation systems and to identify new control parameters to more fully utilize the advanced process control technology available today. For example, the Comminution Generic Center at the University of Utah, sponsored by the Bureau of Mines, for example, is conducting research in particulate characterization by automated image analysis for the measurement and prediction of mineral liberation. If this technology can be adopted to on-line measurements, mineral content would be available as a control parameter.

The search for more selective reagents dominates industrial flotation research efforts.[48] The first comprehensive conference devoted exclusively to mineral processing reagents, "Reagents in the Minerals Industry," was held in Rome, Italy, in September 1984. The domestic minerals industry uses flotation reagents worth more than $180 million annually. However, custom designed reagents are generally made by chemical companies only for the larger deposits because of the costs of the research in comparison to the size of the market. Several new thio reagents have been claimed in the patent literature to be effective collectors for sulfide minerals. Furthermore, the reagent picture for sulfide minerals is likely to change substantially as electrochemical control becomes commercial practice. The need for oxidizing and reducing chemicals should increase, with a corresponding decrease in the need for custom designed collectors, modifiers, and pH controllers.

New developments in magnetic separation technology include higher fields, resulting from industrial utilization of superconducting magnets, and selective magnetic coatings. Present applications of magnetic separation include removal of contaminants in silica, quartz, feldspar and other oxide or industrial minerals, and improving the "whiteness" of particular clay minerals. Magnetic separation offers several potential advantages that include separation based on a bulk materials property instead of a highly variable surface property; better fine particle handling; no requirements for chemicals such as cyanide, avoiding contamination of products or effluents (a dispersant may be required for some applications); dry processing capability eliminating the need for water; and more facility for automation. Mineral processing flowsheets need to be reexamined for the potential use of this new magnetic separation technology.

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[1]By Thomas W. Martin, supervisory mining engineer, Spokane Research Center. Statistical data compiled by Stephen D. Smith, supervisory mineral data assistant, Division of Ferrous Metals.

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Table 19.—Froth flotation plants operating in 1985, by type of ore and State[1]

Type of ore and State	Number
Anthracite coal: Pennsylvania	2
Barite:	
Georgia	1
Nevada	1
Total	2
Bastnaesite: California	1
Bituminous coal:	
Alabama	2
Colorado	1
Illinois	7
Kentucky	8
Maryland	1
Missouri	1
Ohio	3
Pennsylvania	11
Utah	1
Virginia	12
West Virginia	28
Total	75
Borate: Nevada	1
Copper:	
Arizona	3
Idaho	2
Montana	1
New Mexico	2
Total	8
Copper-lead-zinc: Missouri	3
Copper-molybdenum:	
Arizona	6
Utah	1
Total	7

See footnote at end of table.

Table 19.—Froth flotation plants operating in 1985, by type of ore and State[1] —Continued

Type of ore and State	Number
Copper-zinc-iron: Tennessee	1
Feldspar-mica-quartz:	
Connecticut	1
Georgia	1
New Mexico	1
North Carolina	7
Total	10
Glass sand:	
California	2
Georgia	1
Louisiana	1
Michigan	2
Pennsylvania	1
Tennessee	1
Total	8
Gold: Nevada	1
Gold-silver:	
Idaho	1
Montana	1
Washington	1
Total	3
Iron:	
Michigan	2
Minnesota	1
Missouri	1
Total	4
Lead-zinc:	
Colorado	2
Idaho	3
Missouri	2
New York	1
Oregon	1
Total	9
Limestone-magnesite:	
Maryland	1
Nevada	1
Texas	1
Vermont	1
Total	4
Mercury: Nevada	1
Molybdenum:	
Colorado	2
Idaho	1
New Mexico	1
Total	4
Phosphate:	
Florida	20
North Carolina	1
Utah	1
Total	22
Potash:	
New Mexico	4
Utah	1
Total	5
Silver: Idaho	1
Talc: Alabama	1
Tungsten: California	1
Vermiculite: South Carolina	1
Zinc: Tennessee	4
Grand total	179

[1]Includes only those plants responding to, or estimated for, by the Bureau of Mines.

Table 20.—Flotation mill production and consumption in 1985

Plants			Ore treated (thousand short tons)	Energy used (kilowatt-hours)		Water used[1] (gallons)		Rod consumption (pounds)		Ball consumption (pounds)		Steel liner consumption[2] (pounds per ton)	Flotation concentrates produced[3] (thousand short tons)
Type	Number	Capacity (thousand short tons)		Total (millions)	Per ton	Total (millions)	Per ton	Total (thousands)	Per ton[2]	Total (thousands)	Per ton[2]		
Anthracite coal	2	W	W	W	W	W	W	--	--	--	--	--	W
Barite	2	W	W	W	W	W	W	--	--	W	W	--	W
Bastnaesite	1	W	W	W	W	W	W	--	--	W	W	--	W
Bituminous coal	75	36,114	27,666	399	6.5	38,886	326	--	--	--	--	--	19,505
Borate	1	W	W	W	W	W	W	--	--	--	--	--	W
Copper	8	56,135	68,815	1,051	15.3	47,687	693	7,402	0.385	90,015	1.308	0.092	2,771
Copper-lead-zinc	3	W	W	W	W	W	W	W	W	W	W	W	W
Copper-molybdenum	7	165,966	125,766	1,664	13.2	49,465	393	11,206	.556	133,713	1.063	.161	3,070
Copper-zinc-iron	1	W	W	W	W	W	W	W	W	W	W	--	W
Feldspar-mica-quartz	10	2,920	2,084	83	44.5	10,356	4,429	2,709	1.159	160	.257	.200	1,399
Glass sand	8	4,467	2,774	NA	NA	5,593	1,464	341	.324	265	1.104	--	2,379
Gold	1	W	W	W	W	W	W	--	--	W	W	--	W
Gold-silver	3	180	130	1	66	38	560	--	--	152	2.202	.063	5
Iron	4	39,989	24,205	2,045	40.1	210,370	3,965	7,179	.669	9,853	.918	.129	19,428
Lead-zinc	9	4,824	3,580	63	17.7	1,860	520	258	.090	1,792	.511	.054	740
Limestone-magnesite	4	370	194	NA	NA	224	555	66	.331	91	.923	--	238
Mercury	1	W	W	W	W	W	W	--	--	W	W	W	W
Molybdenum	4	36,923	24,054	255	16.0	7,066	294	--	--	27,701	1.736	.221	67
Phosphate	22	160,087	120,687	1,849	11.3	565,852	3,164	304	.008	540	.491	--	27,081
Potash	5	15,850	11,100	121	10.9	793	71	4	.001	4	.010	--	1,668
Silver	1	W	W	--	--	W	W	--	--	W	W	W	W
Talc	1	W	W	W	W	W	W	--	--	W	W	W	W
Tungsten	1	W	W	W	W	W	W	W	W	W	W	--	W
Vermiculite	1	W	W	W	W	W	W	W	W	--	--	--	W
Zinc	4	5,655	3,310	34	13.4	1,233	581	212	.214	545	.132	.010	186
Total	179	540,363	422,662	7,758	XX	947,356	XX	31,167	XX	269,154	XX	XX	80,100

NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.

[1]Includes new or makeup and reclaimed water.

[2]Weighted average only for company reporting this data.

[3]Excludes concentrates produced by other physical separation methods.

Table 21.—Consumption of reagents at flotation plants in 1985, by ore type

(Thousand pounds)

Type of ore	Flotation reagents							Effluent treatment		
	Collectors	De-pressants	Activators	pH regula-tors	Frothers	Flocculants	Dispersants	pH regula-tors	Flocculants	Filtering aids
Sulfides:										
Copper	2,231	5	--	224,268	2,901	453	--	--	1,432	74
Copper-lead-zinc	W	W	W	W	W	W	--	--	--	W
Copper-molybdenum	5,347	25,329	14,613	359,395	4,747	648	325	352	262	716
Copper-zinc-iron	W	W	W	W	W	W	--	W	W	--
Gold	W	--	--	--	W	--	--	--	--	W
Gold-silver	4	--	--	94	1	--	--	--	--	--
Lead-zinc	441	694	684	982	217	2	--	2,875	102	246
Mercury	28	--	--	--	18	--	--	--	--	--
Molybdenum	12,861	1,046	--	9,500	1,341	--	32	--	--	--
Silver	W	W	--	--	W	W	--	--	--	W
Zinc	167	--	1,371	--	118	49	--	--	--	--
Total[1]	22,283	29,426	17,836	621,457	9,611	1,190	356	5,295	1,804	1,176
Metallic carbonates and oxides:										
Iron	5,695	33,638	76	61,295	408	1,271	2,439	20,330	18,312	5,231
Limestone-magnesite	648	159	--	6	25	76	--	--	5	--
Tungsten	173	--	--	177	--	--	841	569	142	--
Total[1]	6,515	33,798	76	61,477	433	1,347	3,280	20,898	18,460	5,231
Industrial minerals:										
Barite	W	W	--	W	--	--	--	--	--	--
Bastnaesite	W	W	--	W	--	--	--	--	--	W
Borate	W	--	--	--	--	W	W	--	--	--
Feldspar-mica-quartz	2,758	560	599	2,540	169	384	--	2,017	99	--
Glass sand	3,469	20	36	3,807	22	--	344	210	20	--
Phosphate	327,065	2,114	--	168,876	145	19	126	8,440	1,655	--
Potash	3,874	1,732	--	156	772	487	--	--	--	--
Talc	--	--	--	--	W	W	--	W	W	--
Vermiculite	W	--	--	--	W	W	--	--	--	--
Total[1]	339,601	4,695	635	177,267	1,150	1,137	491	10,684	1,777	--
Anthracite and bituminous coal	5,913	--	--	779	3,748	2,811	--	1,023	1,823	1,647
Grand total	374,312	67,919	18,547	860,982	14,941	6,485	4,128	37,900	23,863	8,054

W Withheld to avoid disclosing respondent proprietary data; included in "Total" and "Grand total."
[1]Data may not add to totals shown because of independent rounding.

Table 22.—Consumption, value, and function at flotation plants in 1985

Function and name	Consumption: Total (thousand pounds)	Consumption: Pounds per ton
FLOTATION REAGENTS		
Collectors:		
Ethylxanthate	1,833	0.041
Amylxanthate	741	.014
Isopropylxanthate	702	.013
Isobutylxanthate	123	.006
Unspecified xanthates	224	.006
Alkyl dithiophosphate	1,232	.018
Aryl dithiophosphate	49	.065
Unspecified dithiophosphate	64	.024
Xanthogen formate	48	.006
Thionocarbamate	952	.017
Mercaptobenzothiazole	38	.070
Mixtures of thio reagents	338	.025
Unspecified thio reagents	26	.003
Primary amine	885	.177
Secondary amine	4,847	.223
Diamine	241	.027
Unspecified amine	5,418	.718
Amine derivative	6,891	.221
Amine salt	11,306	.305
Quarternary ammonium salt	1,874	.221
Fatty and rosin acids and soaps	156,373	1.385
Fatty acid ester	186	.150
Fatty acid derivative	11,221	.790
Petroleum sulfonates	500	.309
Petroleum derivative	11,001	.470
Unspecified sulfide collector	795	.028
Unspecified nonsulfide collectors	90	.057
Phosphorus derivatives	18	.060
Sulfates	564	3.360
Fuel oil	145,783	.544
Kerosene	9,341	.131
Other	610	.140
Total pounds [1]	374,312	
Value	$75,361,184	
Depressants:		
Caustic soda	24	2.000
Hydrofluoric acid	525	1.144
Phosphorus pentasulfide	2,816	.190
Cyanide salt	3,890	.318
Sodium dichromate	311	.210
Sulfide salt	19,745	1.762
Sodium silicate	1,905	.202
Sodium silicofluoride	239	.940
Zinc sulfate	2,141	.299
Lignin derivative	35	.300
Starches, celluloses, derivatives	34,277	1.669
Gums and dextrans	1,732	.208
Synthetic polymer	55	.030
Unspecified depressant	101	.023
Other	124	9.000
Total pounds [1]	67,919	
Value	$14,725,536	
pH regulators:		
Hydrochloric acid	156	.059
Sulfuric acid	157,959	1.486
Sulfur dioxide	1,624	.787
Carbon dioxide	14,846	.830
Caustic soda (NaOH)	57,191	1.327
Lime	598,726	2,768
Soda ash	2,088	5.210
Ammonia or ammonium hydroxide	28,392	.294
Total pounds	860,982	
Value	$36,960,194	
Frothers:		
Aliphatic alcohol	6,594	.049
Pine oil	1,090	.025
Phenol	777	.036
Polyglycol	31	.093

See footnote at end of table.

Table 22.—Consumption, value, and function at flotation plants in 1985 —Continued

Function and name	Consumption: Total (thousand pounds)	Consumption: Pounds per ton
FLOTATION REAGENTS —Continued		
Frothers —Continued		
Polyglycol ether	1,679	.029
Unspecified polyol	2,444	.032
Petroleum-based blends	2,326	1.516
Total pounds	14,941	
Value	$8,817,894	
Flocculants:		
Aluminum salts	819	.144
Anionic polyacrylamide	1,754	.007
Cationic polyacrylamide	166	.026
Nonionic polyacrylamide	224	.006
Unspecified polyacrylamide	197	.027
Polyacrylate	439	.012
Polyacrylonitrile	486	2.499
Polyethylene oxides	21	.001
Unspecified polymer	2,379	.214
Total pounds	6,485	
Value	$5,166,789	
Activators:		
Copper salt	3,163	.283
Sodium sulfide or hydrosulfide	14,673	.662
Hydrofluoric acid	599	.813
Sodium hydroxide	36	.730
Other	76	.023
Total pounds	18,547	
Value	$8,171,890	
Dispersants:		
Sodium silicate	3,204	.099
Polyphosphate	924	.028
Total pounds	4,128	
Value	$1,059,555	
Total reagents:		
Pounds	1,347,314	
Value	$150,263,042	
EFFLUENT TREATMENT REAGENTS		
pH regulators:		
Sulfuric acid	9,879	4.181
Caustic soda (NaOH)	1,738	2,578
Lime	26,284	1.317
Total pounds[1]	37,900	
Value	$2,244,760	
Flocculants:		
Aluminum salts	7,436	.416
Starch-cellulose	1	.004
Anionic polyacrylamide	2,753	.081
Cationic polyacrylamide	853	.275
Nonionic polyacrylamide	9	.195
Unspecified polyacrylamide	974	.015
Polyacrylate	62	.200
Polyamide	26	.320
Polyethyleneimines	11	.800
Unspecified polymer	11,739	.161
Total pounds[1]	23,863	
Value	$14,185,648	
Dispersants:		
Lignin sulfonate	2,682	10.600
Total pounds	2,682	
Value	$174,330	
Total reagent:		
Pounds	64,445	
Value	$16,604,738	

See footnote at end of table.

Table 22.—Consumption, value, and function at flotation plants in 1985 —Continued

Function and name	Consumption: Total (thousand pounds)	Consumption: Pounds per ton
OTHER REAGENTS		
Filtering aids:		
Nonionic surfactants	6,391	.199
Polyacrylamides	36	.028
Polyamines	844	.216
Unspecified polymer	782	.270
Total pounds [1]	8,054	
Value	$5,670,295	
Grinding aids:		
Sodium hexametaphosphate	7	.500
Total pounds	7	
Value	$4,080	

[1]Data may not add to totals shown because of independent rounding.

Table 23.—Froth flotation of sulfide ores

	1960	1965	1970	1975	1980	1985
Operational data:						
Number of plants	95	108	105	86	71	42
Capacity of plants[1] thousand short tons	191,100	217,700	301,700	346,500	354,400	278,713
Ore treated do	155,100	200,800	281,700	278,400	279,900	233,100
Concentrates produced do	5,855	7,213	8,863	7,395	7,356	8,178
Concentration factor	26.5	27.8	31.8	37.6	38.1	28.5
Reagent consumption:						
Collectors thousand pounds	25,346	23,983	32,133	27,972	38,704	22,283
Depressants do	6,338	10,863	17,061	33,313	51,433	29,426
Activators do	7,859	8,983	8,488	11,333	7,530	17,836
Modifier:[2]						
pH regulators in flotation do	NA	NA	NA	NA	NA	621,457
pH regulators in effluent treatment do	NA	NA	NA	NA	NA	5,295
Dispersants in flotation do	NA	NA	NA	NA	NA	356
Dispersants in effluent treatment do	NA	NA	NA	NA	NA	--
Total do	489,707	765,677	1,198,743	1,107,425	864,791	627,108
Frothers do	12,411	15,502	20,612	18,814	17,717	9,611
Flocculants:[2]						
In flotation do	1,129	551	2,624	4,708	1,984	1,190
In effluent treatment do	NA	NA	NA	NA	NA	1,804
Total do	1,129	551	2,624	4,708	1,984	2,994
Other reagent: Filtering aid do	NA	NA	NA	NA	NA	1,176

NA Not available.
[1]Annual capacity for 1960-80 calculated from daily capacity assuming 350 operating days per year.
[2]Only the totals are available for historical data, which excludes effluent treatment.

Table 24.—Froth flotation of metallic carbonate and oxide ores

	1960	1965	1970	1975	1980	1985
Operational data:						
Number of plants	13	14	13	13	13	9
Capacity of plants[1] thousand short tons	4,900	6,800	22,750	31,500	52,850	41,059
Ore treated do.	2,854	16,079	22,213	30,149	42,903	24,490
Concentrates produced do.	941	7,086	13,040	15,582	24,049	19,670
Concentration factor	3.0	2.3	1.7	1.9	1.8	1.7
Reagent consumption:						
Collectors thousand pounds	22,573	23,695	31,819	22,931	18,487	6,515
Depressants do.	610	1,588	2,627	18,226	30,393	33,798
Activators do.	1,280	--	--	--	--	76
Modifier:[2]						
pH regulators in flotation do.	NA	NA	NA	NA	NA	61,477
pH regulators in effluent treatment do.	NA	NA	NA	NA	NA	20,898
Dispersants in flotation do.	NA	NA	NA	NA	NA	3,280
Dispersants in effluent treatment do.	NA	NA	NA	NA	NA	--
Total do.	6,639	15,280	31,635	39,457	[r]93,053	85,655
Frothers do.	1,345	865	164	397	808	433
Flocculants:[2]						
In flotation do.	1,306	458	220	1,985	[r]9,135	1,347
In effluent treatment do.	NA	NA	NA	NA	NA	18,460
Total do.	1,306	458	220	1,985	[r]9,135	19,807
Other reagents:[2]						
Filtering aid do.	NA	NA	NA	NA	NA	5,231
Grinding aid do.	NA	NA	NA	NA	NA	7

[r]Revised. NA Not available.
[1]Annual capacity for 1960-80 calculated from daily capacity assuming 350 operating days per year.
[2]Only the totals are available for historical data, which excludes effluent treatment.

Table 25.—Froth flotation of industrial mineral ores

	1960	1965	1970	1975	1980	1985
Operational data:						
Number of plants	55	64	56	75	75	51
Capacity of plants[1] thousand short tons	50,400	66,850	132,300	163,650	196,400	184,313
Ore treated do.	36,191	52,653	80,963	100,939	149,850	137,351
Concentrates produced do.	11,888	17,376	23,823	29,111	42,812	32,711
Concentration factor	3.0	3.0	3.4	3.5	3.5	4.2
Reagent consumption:						
Collectors[2] thousand pounds	163,967	188,119	528,669	345,208	431,942	339,602
Depressants do.	9,231	4,346	11,023	7,314	11,719	4,695
Activators do.	2,988	511	484	393	1,122	635
Modifier:[3]						
pH regulators in flotation do.	NA	NA	NA	NA	NA	177,267
pH regulators in effluent treatment do.	NA	NA	NA	NA	NA	10,684
Dispersants in flotation do.	NA	NA	NA	NA	NA	491
Dispersants in effluent treatment do.	NA	NA	NA	NA	NA	2,682
Total do.	82,456	54,889	161,470	112,639	116,819	191,124
Frothers do.	2,475	4,870	2,863	4,740	6,508	1,150
Flocculants:[3]						
In flotation do.	875	3,207	751	2,477	2,614	1,137
In effluent treatment do.	NA	NA	NA	NA	NA	1,777
Total do.	875	3,207	751	2,477	2,614	2,914

NA Not available.
[1]Annual capacity for 1960-80 calculated from daily capacity assuming 350 operating days per year.
[2]Includes fuel oil used as an extender or activator.
[3]Only the totals are available for historical data, which excludes effluent treatment.

Table 26.—Froth flotation of anthracite and bituminous coal

	1960	1965	1970	1975	1980	1985
Operational data:						
Number of plants	31	69	66	78	80	77
Capacity of plants[1] thousand short tons	6,750	11,750	15,600	16,075	19,575	36,278
Raw coal treated do	4,112	9,500	13,006	13,079	12,901	27,720
Clean coal produced do	2,795	7,033	8,418	8,179	7,557	19,540
Reagent consumption:						
Collectors thousand pounds	8,142	4,055	7,772	4,615	4,917	5,913
Modifier:[2]						
pH regulators in flotation do	1,609	298	2,716	298	26	779
pH regulators in effluent treatment do	NA	NA	NA	NA	NA	1,023
Total do	1,609	298	2,716	298	26	1,802
Frothers do	585	1,555	2,564	2,668	3,044	3,748
Flocculants:[2]						
In flotation do	394	2,301	2,204	1,303	3,521	2,811
In effluent treatment do	NA	NA	NA	NA	NA	1,823
Total do	394	2,301	2,204	1,303	3,521	4,634
Other reagent: Filtering aid do	NA	NA	NA	NA	NA	1,647

NA Not available.
[1]Annual capacity for 1960-80 calculated from daily capacity assuming 250 operating days per year.
[2]Effluent treatment not available for historical data.

Table 27.—Froth flotation of copper in 1985

OPERATING DATA

Plants:		Energy used, kilowatt-hours:	
Number	8	Total millions	1,051
Design capacity[1] thousand short tons	56,135	Per ton	15.3
Ore treated:[1]		Rod consumption, pounds:	
Quantity do	68,815	Total thousands	7,402
Grade:		Per ton[2]	0.385
Copper percent	0.85	Ball consumption, pounds:	
Gold troy ounce per ton	0.001	Total thousands	90,015
Silver do	0.326	Per ton[2]	1.308
Water used, gallons:		Liner consumption, pounds:	
Total millions	47,687	Steel total thousands	3,706
New or makeup do	12,627	Per ton[2]	0.092
Reclaimed do	35,059	Rubber total thousands	48
Per ton	693	Per ton[2]	0.004

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)	Grade (percent)	Recovery (percent)	Byproducts: Type	Byproducts: Grade (troy ounce per ton)	Byproducts: Recovery (percent)
Copper	1,853	25.02	79	Silver	11.277	88
				Gold	.013	49

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Ethylxanthate	632	$354	0.028	$0.015
Amylxanthate	307	194	.025	.016
Isopropylxanthate	154	104	.005	.003
Alkyl dithiophosphate	629	546	.015	.013
Thionocarbamate	146	202	.011	.015
Mixtures of thio reagents	338	473	.025	.035
Unspecified thio reagents	26	18	.003	.002
Total	2,232	1,891	XX	XX
Depressants: Cyanide salt	5	4	.014	.012
pH regulators: Lime	224,268	10,667	3.397	.162

See footnotes at end of table.

Table 27.—Froth flotation of copper in 1985 —Continued

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents —Continued				
Frothers:				
Aliphatic alcohol	1,044	$650	.037	$0.023
Pine oil	271	116	.021	.009
Polyglycol ether	20	20	.006	.006
Unspecified polyol	1,566	834	.041	.022
Total	2,901	1,620	XX	XX
Flocculants:				
Aluminum salts	155	22	.055	.008
Anionic polyacrylamide	74	46	.026	.016
Nonionic polyacrylamide	111	200	.006	.011
Unspecified polymer	113	65	.036	.021
Total	453	333	XX	XX
Effluent treatment:				
Flocculants:				
Anionic polyacrylamide	136	109	.009	.007
Unspecified polyacrylamide	694	386	.024	.013
Unspecified polymer	602	452	.034	.026
Total	1,432	947	XX	XX
Filtering aids: Nonionic surfactants	74	49	.008	.005

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.

Table 28.—Froth flotation of copper-molybdenum in 1985

OPERATING DATA

Plants:		Energy used, kilowatt-hours:	
Number	7	Total — millions	1,664
Design capacity[1] — thousand short tons	165,966	Per ton	13.2
Ore treated:[1]		Rod consumption, pounds:	
Quantity — do.	125,766	Total — thousands	11,206
Grade:		Per ton[2]	0.556
Copper — percent	0.54	Ball consumption, pounds:	
Molybdenum — do.	0.05	Total — thousands	133,713
Gold — troy ounce per ton	0.002	Per ton[2]	1.063
Silver — do.	0.030	Liner consumption, pounds:	
Water used, gallons:		Steel total — thousands	16,388
Total — millions	49,465	Per ton[2]	0.161
New or makeup — do.	20,728	Rubber total — thousands	15
Reclaimed — do.	28,736	Per ton[2]	0.002
Per ton	393		

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)	Grade (percent)	Recovery (percent)	Byproducts: Type	Byproducts: Grade (troy ounce per ton)	Byproducts: Recovery (percent)
Copper	2,052	27.46	83	Gold	0.054	62
Molybdenum	32	48.64	25	Silver	1.467	81

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Ethylxanthate	417	$250	0.022	$0.013
Amylxanthate	261	167	.007	.004
Isopropylxanthate	70	50	.004	.003
Isobutylxanthate	123	84	.006	.004
Unspecified xanthates	224	388	.006	.010

See footnotes at end of table.

Table 28.—Froth flotation of copper-molybdenum in 1985 —Continued

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents —Continued				
Collectors —Continued				
Alkyl dithiophosphate	405	$352	.021	$0.018
Unspecified dithiophosphate	62	93	.023	.035
Xanthogen formate	48	80	.006	.010
Thionocarbamate	709	1,426	.018	.037
Unspecified sulfide collector	765	560	.028	.020
Fuel oil	2,207	442	.037	.007
Kerosene	55	10	.003	.001
Total	5,346	3,902	XX	XX
Depressants:				
Phosphorus pentasulfide	1,926	573	1.068	.318
Cyanide salt	3,652	1,543	.680	.287
Sulfide salt	19,649	3,587	6.874	1.255
Sodium silicate	102	20	1.720	.344
Total	25,329	5,723	XX	XX
Activators: Sodium sulfide or hydrosulfide	14,613	6,576	.677	.305
pH regulators:				
Sulfuric acid	2,263	7	7.040	.021
Caustic soda (NaOH)	3	1	.057	.020
Lime	357,129	12,158	2.839	.09
Total	359,395	12,166	XX	XX
Frothers:				
Aliphatic alcohol	2,936	1,532	.051	.02
Pine oil	227	77	.012	.004
Phenol	777	505	.036	.023
Polyglycol ether	219	133	.006	.004
Unspecified polyol	587	232	.021	.008
Total	4,746	2,479	XX	XX
Flocculants:				
Anionic polyacrylamide	157	110	.006	.004
Nonionic polyacrylamide	52	122	.003	.007
Polyacrylate	374	250	.010	.007
Unspecified polymer	66	58	.113	.099
Total	649	540	XX	XX
Dispersants:				
Sodium silicate	51	10	.160	.032
Polyphosphate	273	169	.016	.010
Total	324	179	XX	XX
Effluent treatment: pH regulators: Sulfuric acid	352	1	1.056	.003
Flocculants:				
Anionic polyacrylamide	6	13	.020	.043
Unspecified polyacrylamide	211	183	.011	.009
Unspecified polymer	46	34	.002	.002
Total	263	230	XX	XX
Filtering aids:				
Nonionic surfactants	701	513	.700	.512
Unspecified polymer	15	8	.255	.135
Total	716	521	XX	XX

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.

Table 29.—Froth flotation of lead-zinc in 1985

OPERATING DATA

Plants:	
Number	9
Design capacity[1] thousand short tons	4,824
Ore treated:[1]	
Quantity do	3,580
Grade:	
Lead percent	5.87
Silver troy ounce per ton	1.976
Gold do	0.059
Zinc percent	3.34
Water used, gallons:	
Total millions	1,860
New or makeup do	1,602
Reclaimed do	257
Per ton	520
Energy used, kilowatt-hours:	
Total millions	63
Per ton	17.7
Rod consumption, pounds:	
Total thousands	258
Per ton[2]	0.090
Ball consumption, pounds:	
Total thousands	1,792
Per ton[2]	0.511
Liner consumption, pounds:	
Steel total thousands	152
Per ton[2]	0.054
Rubber total thousands	17
Per ton[2]	0.170

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)	Grade (percent)	Recovery (percent)	Byproducts: Type	Byproducts: Grade (percent or troy ounce per ton)	Byproducts: Recovery (percent)
Lead	271	74.21	96	Silver	20.700	78
				Zinc	5.18	4
				Gold	1.065	78
				Copper	1.30	62
Zinc	188	55.28	90	Gold	.073	10
				Silver	2.330	3
				Lead	9.75	8
				Copper	1.20	18

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Ethylxanthate	123	$96	0.137	$0.107
Amylxanthate	6	7	.900	1.017
Isopropylxanthate	219	136	.082	.051
Alkyl dithiophosphate	47	39	.080	.067
Aryl dithiophosphate	17	27	.046	.074
Thionocarbamate	1	1	.100	.200
Unspecified sulfide collector	29	25	.095	.082
Total	442	331	XX	XX
Depressants:				
Cyanide salt	86	73	.027	.023
Zinc sulfate	607	180	.215	.064
Total	693	253	XX	XX
Activators:				
Copper salt	624	370	.185	.110
Sodium sulfide or hydrosulfide	60	15	.102	.026
Total	684	385	XX	XX
pH regulators:				
Lime	934	35	.367	.014
Soda ash	47	5	.906	.091
Total	981	40	XX	XX
Frothers:				
Aliphatic alcohol	199	119	.058	.035
Polyglycol ether	17	14	.053	1.761
Petroleum-based blends	1	1	.020	.013
Total	217	134	XX	XX
Flocculants:				
Anionic polyacrylamide	1	1	.100	.102
Nonionic polyacrylamide	1	3	.011	.027
Total	2	4	XX	XX

See footnotes at end of table.

Table 29.—Froth flotation of lead-zinc in 1985 —Continued

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Effluent treatment:				
pH regulators:				
Sulfuric acid	108	$3	.500	$0.016
Lime	2,767	106	2.582	.099
Total	2,875	109	XX	XX
Flocculants:				
Anionic polyacrylamide	101	78	.315	.242
Unspecified polyacrylamide	1	2	.009	.025
Total	102	80	XX	XX
Filtering aids:				
Nonionic surfactants	246	130	.108	.057
Polyacrylamides	--	--	.001	.001
Total	246	130	XX	XX

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.

Table 30.—Froth flotation of molybdenum in 1985

OPERATING DATA

Plants:		Energy used, kilowatt-hours:	
Number	4	Total millions	255
Design capacity[1] thousand short tons	36,923	Per ton	16.0
Ore treated:[1]		Ball consumption, pounds:	
Quantity do	24,054	Total thousands	27,701
		Per ton[2]	1.736
Grade: Molybdenum percent	0.20	Steel liner consumption, pounds:	
Water used, gallons:		Total thousands	5,320
Total millions	7,066	Per ton[2]	0.221
New or makeup do	2,847		
Reclaimed do	4,219		
Per ton	294		

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)	Grade (percent)	Recovery (percent)
Molybdenum	67	61.73	85

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Petroleum derivative	9,397	$8,457	.811	.730
Fuel oil	2,854	319	.228	.026
Other	610	73	.140	.017
Total	12,861	8,849	XX	XX
Depressants:				
Phosphorus pentasulfide	890	450	.068	.035
Cyanide salt	15	13	.050	.044
Sulfide salt	41	8	.005	.001
Unspecified depressant	101	105	.023	.024
Total	1,047	576	XX	XX

See footnotes at end of table.

Table 30.—Froth flotation of molybdenum in 1985 —Continued

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents —Continued				
pH regulators:				
Caustic soda (NaOH)	1,500	$135	.270	$0.024
Lime	8,000	367	.443	.020
Total	9,500	502	XX	XX
Frothers:				
Aliphatic alcohol	563	314	.045	.025
Pine oil	488	190	.048	.019
Polyglycol ether	210	193	.036	.033
Unspecified polyol	80	32	.019	.007
Total	1,341	729	XX	XX
Dispersants: Sodium silicate	32	6	.516	.103

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.

Table 31.—Froth flotation of zinc in 1985

OPERATING DATA

Plants:		Energy used, kilowatt-hours:	
Number	4	Total ... millions	34
Design capacity[1] ... thousand short tons	5,655	Per ton	13.4
Ore treated:[1]		Rod consumption, pounds:	
Quantity ... do	3,310	Total ... thousands	212
		Per ton[2]	0.214
Grade: Zinc ... percent	3.8	Ball consumption, pounds:	
Water used, gallons:		Total ... thousands	545
Total ... millions	1,233	Per ton[2]	0.132
New or makeup ... do	77	Steel liner consumption, pounds:	
Reclaimed ... do	1,156	Total ... thousands	6
Per ton	581	Per ton[2]	0.010

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)	Grade (percent)	Recovery (percent)
Zinc	185	63.52	93

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Amylxanthate	3	$3	0.004	$0.004
Alkyl dithiophosphate	126	105	.047	.039
Mercaptobenzothiazole	38	35	.070	.063
Total	167	143	XX	XX
Activators: Copper salt	1,371	509	.614	.228
Frothers: Polyglycol ether	118	99	.052	.043
Flocculants: Nonionic polyacrylamide	49	89	.065	.117

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Ore treated may have been previously upgraded by other concentration methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.

Table 32.—Froth flotation of iron in 1985

OPERATING DATA

Plants:		Energy used, kilowatt-hours:	
Number	4	Total ... millions	2,045
Design capacity[1] ... thousand short tons	39,989	Per ton	40.1
Ore treated:[1]		Rod consumption, pounds:	
Quantity ... do	24,205	Total ... thousands	7,179
		Per ton[2]	0.669
Grade: Iron ... percent	56.21	Ball consumption, pounds:	
Water used, gallons:		Total ... thousands	9,853
Total ... millions	210,370	Per ton[2]	0.918
New or makeup ... do	14,406	Liner consumption, pounds:	
Reclaimed ... do	195,963	Steel total ... thousands	6,865
Per ton	3,965	Per ton[2]	0.129
		Rubber total ... thousands	10
		Per ton[2]	0.005

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)	Grade (percent)	Recovery (percent)
Iron	19,428	66.23	95

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Diamine	150	$164	0.018	$0.020
Unspecified amine	493	641	.150	.195
Amine salt	4,866	2,919	.270	.162
Fatty acid ester	186	279	.150	.225
Total	5,695	4,003	XX	XX
Depressants: Starches, celluloses, derivatives	33,638	6,728	1.870	.374
Activators: Acetic acid	76	14	.023	.004
pH regulators:				
Carbon dioxide	14,846	1,485	.830	.083
Caustic soda (NaOH)	46,449	4,180	2.590	.233
Total	61,295	5,665	XX	XX
Frothers: Aliphatic alcohol	408	131	.035	.015
Flocculants:				
Anionic polyacrylamide	151	121	.001	.001
Polyethylene oxides	21	17	.001	.001
Unspecified polymer	1,099	857	.880	.686
Total	1,271	995	XX	XX
Dispersants:				
Sodium silicate	1,810	362	.100	.020
Polyphosphate	629	390	.040	.025
Total	2,439	752	XX	XX
Effluent treatment:				
pH regulators: Lime	20,330	1,626	1.130	.090
Flocculants:				
Aluminum salts	7,294	1,021	.410	.057
Unspecified polymer	11,018	8,247	.358	.268
Total	18,312	9,268	XX	XX
Filtering aids: Nonionic surfactants	5,231	3,714	.290	.206

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.

Table 33.—Froth flotation of limestone-magnesite in 1985

OPERATING DATA

Plants:		Energy used, kilowatt-hours:	
Number	4	Total .... millions	1
Design capacity[1] thousand short tons	370	Per ton	6.3
Ore treated[1] .... do	194	Rod consumption, pounds:	
Water used, gallons:		Total .... thousands	66
Total .... millions	224	Per ton[2]	0.331
New or makeup .... do	3	Ball consumption, pounds:	
Reclaimed .... do	221	Total .... thousands	91
Per ton	555	Per ton[2]	0.923

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)
Limestone-magnesite	238

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Amine derivative	6	$6	1.000	$1.000
Amine salt	73	88	.566	.684
Fatty and rosin acids and soaps	4	4	.500	.397
Fatty acid derivative	188	55	2.120	.615
Fuel oil	377	45	4.240	.509
Total	648	198	XX	XX
Depressants:				
Sodium silicate	35	3	2.600	.216
Other	124	6	9.000	.414
Total	159	9	XX	XX
pH regulators: Sulfuric acid	6	--	.700	.028
Frothers:				
Pine oil	25	14	.330	.185
Polyglycol ether	([3])	([3])	.030	.021
Total	25	14	XX	XX
Flocculants:				
Aluminum salts	61	7	5.200	.562
Unspecified polymer	16	17	.700	.749
Total	77	24	XX	XX
Effluent treatment:				
Flocculants: Polyacrylate	5	14	.070	.186
Grinding aids: Sodium hexametaphosphate	7	4	.500	.300

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.
[3]Less than 1/2 unit.

Table 34.—Froth flotation of feldspar-mica-quartz in 1985

OPERATING DATA

Plants:	
Number	10
Design capacity[1] thousand short tons	2,920
Ore treated[1] do	2,084
Water used, gallons:	
Total millions	10,356
New or makeup do	2,033
Reclaimed do	8,323
Per ton	4,429
Engery used, kilowatt-hours:	
Total millions	83
Per ton	44.5
Rod consumption, pounds:	
Total thousands	2,709
Per ton[2]	1.159
Ball consumption, pounds:	
Total thousands	160
Per ton[2]	0.257
Liner consumption pounds:	
Steel total thousands	346
Per ton[2]	0.200
Rubber total thousands	6
Per ton[2]	0.011

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)
Quartz	258
Feldspar	607
Mica	67
Lithium dioxide	W

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Unspecified amine	125	$117	.483	.454
Amine salt	287	252	.333	.292
Fatty and rosin acids and soaps	1,000	350	1.500	.525
Fatty acid derivative	251	107	.877	.373
Petroleum sulfonates	210	133	.234	.148
Fuel oil	886	96	.668	.072
Total	2,759	1,055	XX	XX
Depressants:				
Hydrofluoric acid	525	202	1.144	.441
Lignin derivative	35	1	.300	.006
Total	560	203	XX	XX
Activators: Hydrofluoric acid	599	271	.813	.368
pH regulators:				
Sulfuric acid	1,743	56	1.543	.049
Caustic soda (NaOH)	797	91	.598	.068
Total	2,540	147	XX	XX
Frothers:				
Aliphatic alcohol	40	21	.101	.055
Pine oil	39	24	.037	.022
Polyglycol	8	1	.060	.004
Polyglycol ether	35	25	.095	.067
Petroleum-based blends	48	34	.334	.237
Total	170	105	XX	XX
Flocculants:				
Aluminum salts	351	10	.140	.004
Unspecified polymer	33	36	.040	.043
Total	384	46	XX	XX
Effluent treatment:				
pH regulators:				
Caustic soda (NaOH)	719	14	3.420	.068
Lime	1,299	55	2.421	.103
Total	2,018	69	XX	XX

See footnotes at end of table.

Table 34.—Froth flotation of feldspar-mica-quartz in 1985—Continued

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Effluent treatment—Continued				
Flocculants:				
Unspecified polyacrylamide	5	$6	0.040	$0.050
Polyacrylate	55	52	.253	.239
Polyethyleneimines	11	9	.800	.696
Unspecified polymer	29	38	.009	.012
Total	100	105	XX	XX

W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.

Table 35.—Froth flotation of glass sand in 1985

OPERATING DATA

Plants:		Rod consumption, pounds:	
Number	8	Total ... thousands	341
Design capacity[1] ... thousand short tons	4,467	Per ton	0.324
Ore treated[1] ... do	2,774	Ball consumption, pounds:	
Water used, gallons:		Total ... thousands	265
Total ... millions	5,593	Per ton[2]	1.104
New or makeup ... do	383		
Reclaimed ... do	5,210		
Per ton	1,464		

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)
Glass sand	2,379

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Diamine	91	$76	0.140	$0.116
Fatty and rosin acids and soaps	2,639	812	1.18	.363
Petroleum sulfonates	143	35	.420	.104
Petroleum derivative	596	70	.885	.104
Total	3,469	993	XX	XX
Depressants: Sodium silicate	20	--	.100	.001
Activators: Sodium hydroxide	36	3	.730	.058
pH regulators:				
Sulfuric acid	1,922	95	2.465	.122
Caustic soda (NaOH)	1,885	173	1.425	.130
Total	3,807	268	XX	XX
Frothers:				
Pine oil	4	2	.007	.004
Polyglycol	15	13	.150	.129
Petroleum-based blends	3	3	8.400	7.727
Total	22	18	XX	XX
Dispersants: Sodium silicate	344	24	3.440	.237
Effluent treatment:				
pH regulators: Sulfuric acid	210	7	.563	.018
Flocculants: Unspecified polymer	20	17	1.150	.978

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Weighted average only for respondents reporting this data.

Table 36.—Froth flotation of phosphate in 1985

OPERATING DATA

Plants:		Energy used, kilowatt-hours:	
Number	22	Total ___ millions	1,849
Design capacity[1] ___ thousand short tons	160,087	Per ton	11.3
Ore treated:[1]		Rod consumption, pounds:	
Quantity ___ do	120,687	Total ___ thousands	304
Grade:		Per ton[2]	0.008
P_2O_5 ___ percent	9.94	Ball consumption, pounds:	
Water used, gallons:		Total ___ thousands	540
Total ___ millions	565,852	Per ton[2]	0.491
New or makeup ___ do	58,487		
Reclaimed ___ do	507,364		
Per ton	3,164		

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)	Grade (percent)	Recovery (percent)
P_2O_5	27,081	31.21	70

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Secondary amine	4,847	$1,600	0.223	$0.074
Unspecified amine	4,800	2,880	1.200	.720
Amine derivative	6,885	2,444	.221	.078
Amine salt	6,080	2,356	.337	.131
Quarternary ammonium salt	1,644	553	.319	.107
Fatty and rosin acids and soaps	151,447	23,015	1.419	.216
Fatty acid derivative	10,770	1,389	.794	.102
Petroleum sulfonates	110	50	.300	.135
Petroleum derivative	676	68	.074	.007
Fuel oil[3]	130,943	12,521	1.268	.121
Kerosene	8,863	1,025	.170	.020
Total	275,410	47,950	XX	XX
Depressants:				
Sodium silicate	1,740	139	.190	.015
Starches, celluloses, derivatives	374	52	.350	.049
Total	2,114	191	XX	XX
pH regulators:				
Sulfuric acid	134,866	3,398	1.320	.033
Caustic soda (NaOH)	5,649	455	.526	.042
Ammonia or ammonium hydroxide	28,362	2,626	.294	.027
Total	168,877	6,479	XX	XX
Frothers:				
Polyglycol ether	82	41	.019	.009
Unspecified polyol	13	11	.400	.330
Petroleum-based blends	50	32	.200	.128
Total	145	84	XX	XX
Flocculants: Anionic polyacrylamide	19	17	.003	.003
Dispersants: Sodium silicate	126	19	.009	.001
Effluent treatment:				
pH regulators: Sulfuric acid	8,440	228	7.910	.214
Flocculants: Anionic polyacrylamide	1,655	2,188	.742	.981

XX Not applicable.

[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).

[2]Weighted average only for respondents reporting this data.

[3]Includes fuel oil used as an extender or activator.

Table 37.—Froth flotation of potash in 1985

OPERATING DATA

Plants:		Water used, gallons:	
Number	5	Total ------ millions	793
Design capacity[1] — thousand short tons	15,850	New or makeup ------ do	278
Ore treated:[1]		Reclaimed ------ do	514
Quantity ------ do	11,100	Per ton	71
		Energy used, kilowatt-hours:	
Grade: K_2O ------ percent	11.30	Total ------ millions	121
		Per ton	10.9

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)	Grade (percent)	Recovery (percent)
K_2O	1,669	59.15	79

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Primary amine	675	$454	0.138	$0.093
Quarternary ammonium salt	230	83	.069	.025
Fatty and rosin acids and soaps	990	198	.350	.070
Petroleum derivative	26	10	.060	.024
Fuel oil	1,953	213	.425	.046
Total	3,874	958	XX	XX
Depressants: Gums and dextrans	1,732	332	.208	.040
pH regulators: Hydrochloric acid	156	6	.059	.002
Frothers:				
Aliphatic alcohol	525	294	.054	.030
Polyglycol ether	1	1	.002	.002
Petroleum-based blends	246	39	.112	.018
Total	772	334	XX	XX
Flocculants:				
Anionic polyacrylamide	46	42	.008	.007
Unspecified polyacrylamide	17	31	.009	.016
Unspecified polymer	424	215	.192	.097
Total	487	288	XX	XX

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).

Table 38.—Froth flotation of bituminous coal in 1985

OPERATING DATA

Plants:		Water used, gallons:	
Number	75	Total ... millions	38,886
Design capacity[1] ... thousand short tons	36,114	New or makeup ... do	4,095
Raw coal treated ... do	27,666	Reclaimed ... do	34,791
Energy used, kilowatt-hours:		Per ton	326
Total ... millions	399		
Per ton	6.5		

CONCENTRATES PRODUCED

Type	Quantity (thousand short tons)
Clean coal	19,509

REAGENT CONSUMPTION

Function and type	Total: Quantity (thousand pounds)	Total: Value (thousands)	Per ton: Quantity (pounds)	Per ton: Value
Flotation reagents:				
Collectors:				
Fatty acid derivative	11	$17	0.043	$0.065
Petroleum derivative	306	249	.191	.155
Unspecified nonsulfide collectors	90	125	.057	.079
Phosphorus derivatives	18	3	.060	.009
Fuel oil	5,062	3,025	.372	.222
Kerosene	423	55	.742	.096
Total	5,910	3,474	XX	XX
pH regulators:				
Caustic soda (NaOH)	738	63	.526	.045
Lime	11	1	.014	.001
Ammonia or ammonium hydroxide	30	7	.640	.154
Total	779	71	XX	XX
Frothers:				
Aliphatic alcohol	688	671	.127	.12
Polyglycol	8	5	.080	.052
Polyglycol ether	906	674	.233	.173
Unspecified polyol	161	36	.038	.009
Petroleum-based blends	1,979	1,456	.174	.128
Total	3,742	2,842	XX	XX
Flocculants:				
Aluminum salts	12	2	.055	.007
Anionic polyacrylamide	1,274	1,726	.408	.553
Cationic polyacrylamide	166	87	.026	.013
Unspecified polyacrylamide	180	146	.033	.027
Polyacrylate	63	54	--	--
Polyacrylonitrile	486	243	2.499	1.250
Unspecified polymer	628	502	.204	.163
Total	2,809	2,760	XX	XX
Effluent treatment:				
pH regulators:				
Caustic soda (NaOH)	1,019	128	3.040	.382
Lime	5	(2)	.019	.001
Total	1,024	128	XX	XX
Flocculants:				
Starch-cellulose	1	3	.004	.007
Anionic polyacrylamide	854	716	.056	.047
Cationic polyacrylamide	853	507	.275	.164
Nonionic polyacrylamide	9	5	.195	.107
Unspecified polyacrylamide	56	46	.127	.104
Polyamide	26	17	.320	.211
Unspecified polymer	24	24	.109	.108
Total	1,823	1,318	XX	XX

See footnotes at end of table.

Table 38.—Froth flotation of bituminous coal in 1985 —Continued

Function and type	Total		Per ton	
	Quantity (thousand pounds)	Value (thousands)	Quantity (pounds)	Value
Filtering aids:				
Polyacrylamides	36	$29	0.031	$0.024
Polyamines	844	584	.261	.181
Unspecified polymer	767	559	.270	.197
Total	1,647	1,172	XX	XX

XX Not applicable.
[1]These values are for the flotation section only and would exclude material processed by other separation methods. Other operating data are for the entire plant (grinding mill and concentrator).
[2]Less than 1/2 unit.

Statistical Summary

By Sarah P. Guerrino[1]

This chapter summarizes data on crude nonfuel mineral production for the United States, its island possessions, and the Commonwealth of Puerto Rico. Included also are the tables that show the principal nonfuel mineral commodities exported from and imported into the United States and that compare world and U.S. mineral production. The detailed data from which these tables were derived are contained in the individual commodity chapters of Volume I and in the State chapters of Volume II of this edition of the Minerals Yearbook.

Although crude mineral production may be measured at any of several stages of extraction and processing, the stage of measurement used in this chapter is what is normally termed "mine output." It usually refers to minerals or ores in the form in which they are first extracted from the ground, but customarily includes the output from auxiliary processing at or near the mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. For copper, gold, lead, silver, tin, and zinc, the quantities are recorded on a mine basis (as the recoverable content of ore sold or treated). However, the values assigned to these quantities are based on the average selling price of refined metal, not the mine value. Mercury is measured as recovered metal and valued at the average New York price for the metal.

The weight or volume units shown are those customarily used in the particular industries producing the commodities. Values shown are in current dollars, with no adjustments made to compensate for changes in the purchasing power of the dollar.

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[1]Mineral data specialist, Division of Ferrous Metals. The author was assisted in preparation of this chapter by Barbara M. Carrico, mineral data specialist, Division of Nonferrous Metals; Barbara E. Gunn, mineral data assistant, Division of Industrial Minerals; Wanda West, program assistant, Division of State Activities; and William L. Zajac, mineral data specialist, Division of International Minerals.

Table 1.—Nonfuel mineral production[1] in the United States

Mineral	1983		1984		1985	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS						
Antimony ore and concentrate short tons, antimony content	838	W	557	W	W	W
Bauxite thousand metric tons, dried equivalent	679	$11,309	856	$15,643	674	$12,855
Copper (recoverable content of ores, etc.) metric tons	1,038,098	1,751,476	[r]1,102,613	[r]1,625,116	1,105,758	1,632,483
Gold (recoverable content of ores, etc.) troy ounces	[r]2,002,526	[r]849,071	[r]2,084,615	[r]751,833	2,475,436	786,345
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	44,295	1,938,496	W	W	W	W
Iron oxide pigments, crude short tons	41,875	2,427	53,017	2,819	46,585	2,826
Lead (recoverable content of ores, etc.) metric tons	[r]449,295	[r]214,745	[r]322,677	[r]181,745	413,955	174,008
Manganiferous ore (5% to 35% Mn) short tons, gross weight	33,523	216	88,423	860	19,882	W
Mercury 76-pound flasks	25,070	W	19,048	W	16,530	W
Molybdenum (content of ore and concentrate) thousand pounds	48,805	166,612	102,405	326,780	111,936	347,812
Nickel (content of ore and concentrate) short tons	--	--	14,540	W	6,127	W
Silver (recoverable content of ores, etc.) thousand troy ounces	[r]43,431	[r]496,850	[r]44,592	[r]368,006	39,357	241,740
Tungsten ore and concentrate metric tons, contained W	1,016	10,528	1,173	13,409	983	9,143
Vanadium (recoverable in ore and concentrate) short tons	2,171	30,675	1,617	24,551	W	W
Zinc (recoverable content of ores, etc.) metric tons	275,294	251,204	252,768	270,833	226,545	201,607
Combined value of beryllium concentrates, magnesium chloride for magnesium metal, rare-earth metal concentrate, tin, titanium concentrate (ilmenite and rutile), zircon concentrate, and values indicated by symbol W	XX	133,220	XX	2,427,624	XX	2,212,104
Total	XX	[r]5,857,000	XX	[r]6,004,000	XX	5,621,000
INDUSTRIAL MINERALS (EXCEPT FUELS)						
Abrasive stones[2] short tons	1,101	482	1,290	602	1,157	515
Asbestos metric tons	69,906	27,866	57,422	24,238	57,457	20,485
Barite thousand short tons	754	29,203	775	25,445	739	21,501
Boron minerals do	1,303	439,181	1,367	456,687	1,269	404,775
Bromine[e] thousand pounds	370,000	91,000	385,000	95,000	320,000	80,000
Calcium chloride short tons	W	W	[e]838,000	[e]93,000	W	W
Cement:						
Masonry thousand short tons	2,921	186,240	3,281	219,877	3,187	213,096
Portland do	67,183	3,315,690	74,376	3,810,446	74,250	3,817,335
Clays do	40,858	931,091	[r]43,702	[r]1,032,127	44,974	1,011,377
Diatomite do	619	114,279	627	120,926	635	127,030
Feldspar short tons	710,000	22,500	710,000	23,500	700,000	22,800
Fluorspar do	[e]61,000	[e]10,000	[e]72,000	W	66,000	W
Garnet (abrasive) do	29,767	2,533	29,647	[e]2,487	36,727	2,973
Gem stones[e]	NA	7,425	NA	7,450	NA	7,425
Gypsum thousand short tons	12,884	101,361	14,319	113,671	14,726	114,229
Helium (Grade-A) million cubic feet	[3]1,299	[3]45,465	[r]1,642	[r]61,575	1,865	69,938
Lime thousand short tons	14,867	757,611	15,922	811,183	15,690	809,000
Magnesium compounds short tons	618,227	182,495	W	W	W	W
Mica (scrap) thousand short tons	140	6,479	161	7,139	138	6,330
Peat do	725	18,667	814	19,907	882	21,892
Perlite short tons	474,000	15,664	498,000	16,638	507,000	17,160
Phosphate rock thousand metric tons	42,573	1,021,095	49,197	1,182,244	50,835	1,203,265
Potassium salts (K_2O equivalent) do	1,513	220,800	1,639	241,800	1,266	178,400

See footnotes at end of table.

Table 1.—Nonfuel mineral production[1] in the United States —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
INDUSTRIAL MINERALS (EXCEPT FUELS) —Continued						
Pumice ---- thousand short tons--	449	$4,486	502	$4,929	508	$4,553
Salt ---------------- do----	34,573	597,081	39,225	675,099	39,484	741,799
Sand and gravel:						
Construction --------- do----	e655,100	e1,935,000	773,900	2,244,000	e800,100	e2,438,000
Industrial ----------- do----	26,620	335,200	29,380	377,200	29,430	374,070
Sodium sulfate (natural) ---- do----	423	39,425	435	40,125	389	35,860
Stone:[4]						
Crushed ------------- do----	861,600	3,327,000	e956,000	e3,755,600	1,000,800	4,053,000
Dimension ----------- do----	1,090	147,843	e1,157	e154,949	1,121	171,667
Sulfur, Frasch process thousand metric tons--	4,111	414,210	5,001	546,106	4,678	573,570
Talc and pyrophyllite thousand short tons--	1,066	20,280	r1,127	r23,167	1,269	29,188
Tripoli ------------ short tons--	111,020	649	124,482	699	W	W
Vermiculite -- thousand short tons--	282	27,170	315	31,500	314	32,400
Combined value of aplite, asphalt (native), emery, graphite (1983-84), helium (crude), iodine, kyanite, lithium minerals, magnesite, marl (greensand), olivine, pyrites, sodium carbonate (natural), staurolite, wollastonite, and values indicated by symbol W --	XX	867,486	XX	r937,900	XX	1,007,903
Total ----------------	XX	15,263,000	XX	r17,157,000	XX	17,612,000
Grand total ------------	XX	r21,120,000	XX	r23,161,000	XX	23,232,000

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Combined value" figure. XX Not applicable.

[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2]Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

[3]Excludes output in New Mexico; withheld to avoid disclosing company proprietary data; included with industrial minerals "Combined value" figure for 1983.

[4]Excludes abrasive stone and bituminous limestone and sandstone; all included elsewhere in table.

Table 2.—Nonfuel minerals produced in the United States and principal producing States in 1985

Mineral	Principal producing States, in order of quantity	Other producing States
Antimony ore and concentrate	Idaho.	
Aplite	Va.	
Asbestos	Calif. and Vt.	
Asphalt (native)	Tex. and Utah.	
Barite	Nev., Ga., Mo., Mont	Ill., Tenn., Wash.
Bauxite	Ark. and Ala.	
Beryllium concentrate	Utah and S. Dak.	
Boron minerals	Calif.	
Bromine	Ark. and Mich.	
Calcium chloride	Mich., Calif., Wash.	
Cement	Tex., Calif., Pa., Mich	All other States except Conn., Del., Mass., Minn., N.H., N.J., N.C., N. Dak., R.I., Vt.
Clays	Ga., Tex., N.C., Wyo	All other States except Alaska, Del., Hawaii, R.I., Vt., Wis.
Copper (mine)	Ariz., N. Mex., Utah, Mont	Calif., Colo., Idaho, Ill., Mich., Mo., Nev., Tenn.
Diatomite	Calif., Nev., Wash., Oreg.	
Emery	N.Y.	
Feldspar	N.C., Conn., Ga., Calif	Okla. and S. Dak.
Fluorspar	Ill., Nev., Tex.	
Garnet, abrasive	Idaho, Maine, N.Y.	
Gold (mine)	Nev., S. Dak., Calif., Mont	Alaska, Ariz., Colo., Idaho, Mich., N. Mex., Oreg., S.C., Utah, Wash.
Gypsum	Tex., Mich., Iowa, Okla	Ariz., Ark., Calif., Colo., Ind., Kans., La., Mont., Nev., N. Mex., N.Y., Ohio, S. Dak., Utah, Va., Wash., Wyo.
Helium	Kans., Tex., N. Mex.	
Iodine	Okla. and Mich.	
Iron ore	Minn., Mich., Mo., Tex	Calif., Colo., Mont., Nev.
Iron oxide pigments (crude)	Mich., Ga., Mo., Va.	
Kyanite	Va. and Ga.	
Lead (mine)	Mo., Idaho, Colo., N.Y	Ariz., Ill., Mont., Nev., N. Mex., Tenn.
Lime	Ohio, Ky., Mo., Pa	All other States except Alaska, Conn., Del., Ga., Kans., Maine, Miss., N.H., N.J., N. Mex., N.C., R.I., S.C., Vt.
Lithium minerals	N.C. and Nev.	
Magnesite	Nev.	
Magnesium chloride	Tex.	
Magnesium compounds	Mich., Calif., Utah, Del	Tex.
Manganiferous ore	S.C.	
Marl, greensand	N.J. and Del.	
Mercury	Nev.	
Mica (scrap)	N.C., N. Mex., S.C., Ga	Conn., Pa., S. Dak., Tex.
Molybdenum	Colo., Ariz., Idaho, N. Mex	Calif., Nev., Utah.
Nickel	Oreg.	
Olivine	N.C. and Wash.	
Peat	Mich., Fla., Ind., Ill	Calif., Colo., Ga., Iowa, Md., Mass., Minn., Mont., N.J., N.Y., N.C., N. Dak., Ohio, Pa., S.C., Wash., Wis.
Perlite	N. Mex., Calif., Ariz., Nev	Colo. and Idaho.
Phosphate rock	Fla., N.C., Idaho, Tenn	Mont. and Utah.
Potassium salts	N. Mex., Utah, Calif.	
Pumice	Oreg., N. Mex., Calif., Idaho	Ariz., Hawaii, Kans., Okla.
Pyrites, ore and concentrate	Tenn., Colo., Ariz.	
Rare-earth metal concentrate	Calif. and Fla.	
Salt	La., Tex., N.Y., Ohio	Ala., Calif., Kans., Mich., Nev., N. Mex., N. Dak., Okla., Utah, W. Va.
Sand and gravel:		
Construction	Calif., Tex., Mich., Ariz	All other States.
Industrial	Ill., Mich., N.J., Calif	All other States except Alaska, Del., Hawaii, Iowa, Maine, N.H., N. Mex., N. Dak., Oreg., S. Dak., Vt., Wyo.
Silver (mine)	Idaho, Nev., Ariz., Mont	Alaska, Calif., Colo., Ill., Mich., Mo., N. Mex., N.Y., S.C., S. Dak., Tenn., Utah, Wash.
Sodium carbonate (natural)	Wyo. and Calif.	
Sodium sulfate (natural)	Calif., Tex., Utah.	
Staurolite	Fla.	
Stone:		
Crushed	Tex., Fla., Pa., Ga	All other States except Del.
Dimension	Ind., Ga., Vt	All other States except Alaska, Del., Fla., Hawaii, Ky., La., Miss., Neb., Nev., N.J., N. Dak., R.I., W. Va., Wyo.
Sulfur (Frasch)	Tex. and La.	
Talc and pyrophyllite	Mont., Tex., Vt., N.Y	Ark., Calif., Ga., N.C., Oreg., Va.
Tin	Alaska and Colo.	
Titanium concentrate	Fla.	
Tripoli	Ill. and Okla.	
Tungsten ore and concentrate	Calif. and Colo.	
Vanadium	Idaho and Ark.	
Vermiculite	Mont., S.C., Va.	
Wollastonite	N.Y.	
Zinc (mine)	Tenn., Mo., N.Y., N.J	Colo., Idaho, Ill., Ky.
Zircon concentrate	Fla.	

Table 3.—Value of nonfuel mineral production in the United States and principal nonfuel minerals produced in 1985

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$405,915	20	1.75	Cement, stone (crushed), lime, sand and gravel (construction).
Alaska	89,969	42	.39	Sand and gravel (construction), gold, stone (crushed), tin.
Arizona	1,550,085	4	6.68	Copper, sand and gravel (construction), cement, molybdenum.
Arkansas	256,697	29	1.11	Bromine, cement, stone (crushed), sand and gravel (construction).
California	2,094,796	1	9.02	Cement, sand and gravel (construction), boron minerals, stone (crushed).
Colorado	408,178	19	1.76	Molybdenum, cement, sand and gravel (construction), stone (crushed).
Connecticut	72,386	43	.31	Stone (crushed), sand and gravel (construction), feldspar, sand and gravel (industrial).
Delaware	[1]4,029	50	.02	Magnesium compounds, sand and gravel (construction), marl.
Florida	1,559,266	3	6.71	Phosphate rock, stone (crushed), cement, sand and gravel (construction).
Georgia	946,075	7	4.07	Clays, stone (crushed), cement, stone (dimension).
Hawaii	53,272	44	.23	Stone (crushed), cement, sand and gravel (construction), lime.
Idaho	348,154	22	1.50	Silver, phosphate rock, molybdenum, lead.
Illinois	459,920	17	1.98	Stone (crushed), cement, sand and gravel (construction), sand and gravel (industrial).
Indiana	302,954	25	1.30	Cement, stone (crushed), sand and gravel (construction), lime.
Iowa	228,017	32	.98	Stone (crushed), cement, sand and gravel (construction), gypsum.
Kansas	322,170	23	1.39	Cement, salt, stone (crushed), helium (Grade-A).
Kentucky	267,558	27	1.15	Stone (crushed), lime, cement, sand and gravel (construction).
Louisiana	522,268	15	2.25	Sulfur (Frasch), salt, sand and gravel (construction), cement.
Maine	41,108	46	.18	Sand and gravel (construction), cement, stone (crushed), garnet.
Maryland	258,274	28	1.11	Stone (crushed), cement, sand and gravel (construction), clays.
Massachusetts	117,205	38	.50	Sand and gravel (construction), stone (crushed), stone (dimension), lime.
Michigan	1,347,853	6	5.80	Iron ore, cement, magnesium compounds, stone (crushed).
Minnesota	1,547,958	5	6.66	Iron ore, sand and gravel (construction), stone (crushed), sand and gravel (industrial).
Mississippi	102,793	40	.44	Sand and gravel (construction), clays, cement, stone (crushed).
Missouri	734,960	9	3.16	Cement, stone (crushed), lead, lime.
Montana	200,272	34	.86	Gold, sand and gravel (construction), silver, copper.
Nebraska	99,970	41	.43	Cement, sand and gravel (construction), stone (crushed), clays.
Nevada	630,883	12	2.72	Gold, diatomite, cement, silver.
New Hampshire	32,900	47	.14	Sand and gravel (construction), stone (dimension), stone (crushed), clays.
New Jersey	177,576	35	.76	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), zinc.
New Mexico	656,889	11	2.83	Copper, potassium salts, molybdenum, cement.
New York	657,308	10	2.83	Stone (crushed), cement, salt, sand and gravel (construction).
North Carolina	432,756	18	1.86	Stone (crushed), phosphate rock, lithium compounds, sand and gravel (construction).
North Dakota	24,184	48	.10	Sand and gravel (construction), lime, salt, clays.
Ohio	607,127	13	2.61	Salt, stone (crushed), sand and gravel (construction), cement.
Oklahoma	251,607	30	1.08	Stone (crushed), cement, sand and gravel (construction), sand and gravel (industrial).
Oregon	130,296	36	.56	Stone (crushed), sand and gravel (construction), cement, lime.
Pennsylvania	804,474	8	3.46	Stone (crushed), cement, lime, sand and gravel (construction).
Rhode Island	12,192	49	.05	Stone (crushed), sand and gravel (construction), sand and gravel (industrial).
South Carolina	275,929	26	1.19	Cement, stone (crushed), clays, sand and gravel (industrial).
South Dakota	207,339	33	.89	Gold, cement, stone (dimension), sand and gravel (construction).
Tennessee	472,287	16	2.03	Stone (crushed), zinc, cement, pyrites.
Texas	1,733,359	2	7.46	Cement, sulfur (Frasch), stone (crushed), sand and gravel (construction).
Utah	312,359	24	1.34	Cement, copper, gold, sand and gravel (construction).
Vermont	49,854	45	.21	Stone (dimension), stone (crushed), sand and gravel (construction), talc.
Virginia	381,276	21	1.64	Stone (crushed), cement, sand and gravel (construction), lime.
Washington	243,670	31	1.05	Cement, sand and gravel (construction), gold, stone (crushed).

See footnotes at end of table.

Table 3.—Value of nonfuel mineral production in the United States and principal nonfuel minerals produced in 1985 —Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
West Virginia	$105,409	39	.45	Stone (crushed), cement, sand and gravel (industrial), salt.
Wisconsin	125,110	37	.54	Stone (crushed), sand and gravel (construction), lime, sand and gravel (industrial).
Wyoming	552,463	14	2.38	Sodium carbonate, clays, cement (portland), sand and gravel (construction).
Total	23,232,000	XX	100.00	

XX Not applicable.
[1]Incomplete total.

Table 4.—Value of nonfuel mineral production per capita and per square mile in 1985, by State

State	Area (square miles)	Population (thousands)	Value of mineral production: Total (thousands)	Per square mile: Dollars	Per square mile: Rank	Per capita: Dollars	Per capita: Rank
Alabama	51,705	4,021	$405,915	7,851	24	101	20
Alaska	591,004	521	89,969	152	50	173	10
Arizona	114,000	3,187	1,550,085	13,597	11	486	3
Arkansas	53,187	2,359	256,697	4,826	31	109	18
California	158,706	26,365	2,094,796	13,199	13	79	24
Colorado	104,091	3,231	408,178	3,921	35	126	16
Connecticut	5,018	3,174	72,386	14,425	9	23	47
Delaware	2,044	622	[1]4,029	1,971	44	6	50
Florida	58,664	11,366	1,559,266	26,580	1	137	14
Georgia	58,910	5,976	946,075	16,060	7	158	11
Hawaii	6,471	1,054	53,272	8,232	21	51	37
Idaho	83,564	1,005	348,154	4,166	33	346	6
Illinois	56,345	11,535	459,920	8,163	23	40	39
Indiana	36,185	5,499	302,954	8,372	20	55	35
Iowa	56,275	2,884	228,017	4,052	34	79	25
Kansas	82,277	2,450	322,170	3,916	36	131	15
Kentucky	40,409	3,726	267,558	6,621	25	72	27
Louisiana	47,751	4,481	522,268	10,937	15	117	17
Maine	33,265	1,164	41,108	1,236	48	35	42
Maryland	10,460	4,392	258,274	24,692	2	59	32
Massachusetts	8,284	5,822	117,205	14,148	10	20	48
Michigan	58,527	9,088	1,347,853	23,030	3	148	12
Minnesota	84,402	4,193	1,547,958	18,340	5	369	5
Mississippi	47,689	2,613	102,793	2,155	43	39	40
Missouri	69,697	5,029	734,960	10,545	16	146	13
Montana	147,046	826	200,272	1,362	45	242	8
Nebraska	77,355	1,606	99,970	1,292	47	62	31
Nevada	110,561	936	630,883	5,706	27	674	2
New Hampshire	9,279	998	32,900	3,546	40	33	44
New Jersey	7,787	7,562	177,576	22,804	4	23	46
New Mexico	121,593	1,450	656,889	5,402	29	453	4
New York	49,108	17,783	657,308	13,385	12	37	41
North Carolina	52,669	6,255	432,756	8,217	22	69	28
North Dakota	70,703	685	24,184	342	49	35	43
Ohio	41,330	10,744	607,127	14,690	8	57	33
Oklahoma	69,956	3,301	251,607	3,597	38	76	26
Oregon	97,073	2,687	130,296	1,342	46	48	38
Pennsylvania	45,308	11,853	804,474	17,756	6	68	29
Rhode Island	1,212	968	12,192	10,059	17	13	49
South Carolina	31,113	3,347	275,929	8,869	19	82	23
South Dakota	77,116	708	207,339	2,689	41	293	7
Tennessee	42,144	4,762	472,287	11,207	14	99	21
Texas	266,807	16,370	1,733,359	6,497	26	106	19
Utah	84,899	1,645	312,359	3,679	37	190	9
Vermont	9,614	535	49,854	5,186	30	93	22
Virginia	40,767	5,706	381,276	9,353	18	67	30
Washington	68,138	4,409	243,670	3,576	39	55	34
West Virginia	24,231	1,936	105,409	4,350	32	54	36
Wisconsin	56,153	4,775	125,110	2,228	42	26	45
Wyoming	97,809	509	552,463	5,648	28	1,085	1
Total[2] or average	3,618,701	238,114	23,232,000	6,416	XX	98	XX

XX Not applicable.
[1]Incomplete total.
[2]Excludes Washington, DC (which has no mineral production), with an area of 69 square miles and a population of 626,000.

Table 5.—Nonfuel mineral production[1] in the United States, by State

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
ALABAMA						
Cement:						
Masonry thousand short tons	210	$13,417	259	$17,247	268	$18,113
Portland do.	3,279	150,255	3,656	167,191	3,721	165,972
Clays[2] do.	1,863	20,758	1,906	30,500	1,873	13,139
Gem stones	NA	1	NA	1	NA	1
Lime thousand short tons	981	41,149	1,163	50,560	1,216	52,295
Sand and gravel:						
Construction do.	[e]8,600	[e]23,500	10,348	26,188	[e]11,000	[e]32,000
Industrial do.	418	3,256	442	3,600	524	4,533
Stone:						
Crushed do.	20,558	95,374	[e]22,000	[e]98,500	25,853	109,176
Dimension do.	7	2,661	[e]8	[e]2,674	11	2,881
Combined value of bauxite, clays (bentonite), phosphate rock (1983), and salt	XX	10,956	XX	13,380	XX	7,805
Total	XX	361,327	XX	409,841	XX	405,915
ALASKA						
Gem stones	NA	$60	NA	$60	NA	$60
Gold (recoverable content of ores, etc.) troy ounces	39,523	16,758	[r]19,433	[r]7,009	44,733	14,210
Sand and gravel (construction) thousand short tons	[e]45,200	[e]97,200	30,861	66,883	[e]29,000	[e]63,000
Silver (recoverable content of ores, etc.) thousand troy ounces	4	47	[r](3)	[r]1	W	W
Stone (crushed) thousand short tons	1,981	9,460	[e]2,500	[e]10,800	1,907	8,535
Combined value of cement (portland, 1984-85), copper (1983), lead (1983), tin, and values indicated by symbol W	XX	971	XX	[r]2,543	XX	4,164
Total	XX	124,496	XX	[r]87,296	XX	89,969
ARIZONA						
Clays thousand short tons	151	$1,425	138	$819	186	$1,503
Copper (recoverable content of ores, etc.) metric tons	678,216	1,144,285	746,453	1,100,182	796,556	1,175,995
Gem stones	NA	2,800	NA	2,700	NA	2,700
Gold (recoverable content of ores, etc.) troy ounces	61,991	26,284	[r]54,897	[r]19,799	52,053	16,535
Gypsum thousand short tons	265	1,929	261	2,332	251	1,926
Lead (recoverable content of ores, etc.) metric tons	[r]234	[r]112	W	W	581	244
Lime thousand short tons	340	16,700	359	17,304	476	21,226
Molybdenum (content of concentrate) thousand pounds	23,934	80,210	24,013	76,112	24,125	63,389
Pumice thousand short tons	2	15	2	21	W	2
Sand and gravel (construction) do.	[e]23,200	[e]75,000	30,439	101,959	[e]37,000	[e]118,000
Silver (recoverable content of ores, etc.) thousand troy ounces	4,492	51,383	[r]4,247	[r]34,570	4,885	30,007
Stone:						
Crushed thousand short tons	4,755	24,079	[e]5,200	[e]27,300	5,929	23,111
Dimension do.	(3)	1	[e](3)	[e](3)	W	W
Combined value of cement, perlite, pyrites, salt (1984), sand and gravel (industrial), tin (1984), and values indicated by symbol W	XX	87,449	XX	102,839	XX	95,447
Total	XX	[r]1,511,672	XX	[r]1,485,937	XX	1,550,085
ARKANSAS						
Clays thousand short tons	879	$9,956	1,019	$7,838	1,052	$10,769
Gem stones	NA	200	NA	200	NA	200
Sand and gravel:						
Construction thousand short tons	[e]6,900	[e]19,600	8,334	23,786	[e]8,500	[e]24,400
Industrial do.	386	4,796	459	6,207	412	5,414
Stone:						
Crushed do.	13,448	51,267	[e]15,200	[e]59,800	14,815	60,874
Dimension do.	9	573	--	--	5	305
Talc do.	7	66	W	W	W	W
Combined value of abrasives, bauxite, bromine, cement, gypsum, lime, tripoli (1983-84), vanadium (1984-85), and values indicated by symbol W	XX	159,972	XX	174,797	XX	154,735
Total	XX	246,430	XX	272,628	XX	256,697

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
CALIFORNIA						
Boron minerals thousand short tons	1,303	$439,181	1,367	$456,687	1,269	$404,775
Cement, portland do	7,567	420,949	8,715	520,026	9,462	601,506
Clays[2] do	1,816	18,255	2,100	23,868	2,203	26,600
Gem stones	NA	300	NA	500	NA	550
Gold (recoverable content of ores, etc.) troy ounces	38,443	16,300	85,858	30,965	165,101	52,446
Gypsum thousand short tons	1,213	10,668	1,382	12,443	1,332	12,201
Lime do	358	22,994	406	26,827	367	24,733
Peat do	13	612	W	W	W	W
Pumice do	65	1,582	80	1,600	78	1,491
Sand and gravel:						
Construction do	e91,000	e308,700	102,420	360,427	e112,800	e430,000
Industrial do	2,150	34,066	2,281	39,176	2,255	37,434
Silver (recoverable content of ores, etc.) thousand troy ounces	27	308	W	W	115	709
Stone:						
Crushed thousand short tons	35,582	146,289	e38,600	e158,000	41,199	174,395
Dimension do	20	2,839	e22	e2,990	23	2,449
Talc and pyrophyllite do	71	1,289	74	1,642	100	2,493
Combined value of asbestos, calcium chloride, cement (masonry), clays (fire clay), copper, diatomite, feldspar, iron ore, lead (1984), magnesium compounds, molybdenum (1984-85), perlite, potassium salts, rare-earth metal concentrates, salt, sodium carbonate, sodium sulfate, tungsten ore and concentrate, wollastonite (1983-84), and values indicated by symbol W	XX	359,218	XX	r360,085	XX	323,014
Total	XX	1,783,550	XX	r1,995,236	XX	2,094,796
COLORADO						
Clays thousand short tons	459	$2,650	308	$2,111	303	$1,743
Gem stones	NA	80	NA	80	NA	80
Gold (recoverable content of ores, etc.) troy ounces	63,063	26,739	60,010	21,643	43,301	13,755
Gypsum thousand short tons	W	W	291	W	233	1,800
Sand and gravel:						
Construction do	e21,200	e81,600	28,024	87,324	e27,500	e88,000
Industrial do	212	3,233	149	2,213	W	W
Silver (recoverable content of ores, etc.) thousand troy ounces	2,146	24,546	2,200	17,909	549	3,370
Stone:						
Crushed thousand short tons	6,790	22,749	e7,200	e26,200	7,037	25,930
Dimension do	1	86	e1	e87	2	204
Combined value of cement, copper, iron ore, lead, lime, molybdenum, peat, perlite, pyrites (1984-85), salt (1984), tin (1984-85), tungsten ore and concentrate, vanadium (1983-84), zinc, and values indicated by symbol W	XX	175,969	XX	r278,609	XX	273,296
Total	XX	337,652	XX	r436,176	XX	408,178
CONNECTICUT						
Clays thousand short tons	86	$515	99	$565	106	$632
Lime do	5	400	W	W	--	--
Sand and gravel (construction) do	e5,000	e17,900	6,718	22,817	e6,000	e21,000
Stone:						
Crushed do	7,692	45,890	e8,300	e49,400	7,277	43,937
Dimension do	18	1,028	e18	e1,080	20	1,285
Combined value of feldspar, gem stones, mica (scrap), sand and gravel (industrial), and value indicated by symbol W	XX	5,480	XX	5,834	XX	5,532
Total	XX	71,213	XX	79,696	XX	72,386
DELAWARE						
Marl (greensand) thousand short tons	--	--	1	$18	2	$29
Sand and gravel (construction) do	e1,400	e$3,200	1,003	2,795	e1,300	e4,000
Total[4]	XX	3,200	XX	2,813	XX	4,029

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983		1984		1985	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
FLORIDA						
Cement:						
Masonry ----- thousand short tons--	313	$19,557	383	$24,624	316	$17,137
Portland ----------do----	3,329	164,048	3,564	172,548	3,282	148,908
Clays ----------do----	684	31,566	772	34,048	672	33,074
Gem stones----------	NA	6	NA	6	NA	6
Lime --------- thousand short tons--	W	13,881	171	9,379	W	W
Peat ----------do----	114	1,999	263	5,454	243	5,333
Sand and gravel:						
Construction----------do----	[e]14,900	[e]31,500	21,032	48,494	[e]22,500	[e]49,500
Industrial ----------do----	329	3,447	1,533	9,815	2,123	12,642
Stone (crushed) ----------do----	57,282	235,700	[e]68,500	[e]290,000	69,266	287,237
Combined value of magnesium compounds, phosphate rock, rare-earth metal concentrates, staurolite, titanium concentrates (ilmenite and rutile), zircon concentrates, and value indicated by symbol W ------	XX	774,122	XX	915,996	XX	1,005,429
Total----------	XX	1,275,826	XX	1,510,364	XX	1,559,266
GEORGIA						
Clays --------- thousand short tons--	7,859	$560,005	8,679	$600,029	8,671	$575,097
Gem stones----------	NA	20	NA	20	NA	20
Sand and gravel:						
Construction--- thousand short tons--	[e]3,800	[e]9,400	5,347	13,623	[e]5,000	[e]13,400
Industrial ----------do----	539	7,298	478	6,795	571	6,675
Stone:						
Crushed----------do----	41,100	186,193	[e]45,900	[e]220,000	52,062	256,588
Dimension ----------do----	183	21,019	[e]202	[e]20,007	185	19,466
Talc ----------do----	14	101	15	104	16	111
Combined value of barite, bauxite (1983-84), cement, feldspar, iron oxide pigments (crude), kyanite, mica (scrap), and peat---	XX	65,536	XX	79,914	XX	74,718
Total----------	XX	849,572	XX	940,492	XX	946,075
HAWAII						
Cement:						
Masonry ----- thousand short tons--	6	$641	5	$792	7	$588
Portland ----------do----	216	20,673	186	18,282	16	16,050
Sand and gravel (construction) thousand short tons--	[e]440	[e]1,000	436	2,031	[e]500	[e]2,100
Stone:						
Crushed----------do----	5,532	29,703	[e]5,400	[e]29,700	5,627	34,183
Dimension ----------do----	([3])	3	--	--	--	--
Combined value of other industrial minerals	XX	391	XX	442	XX	351
Total----------	XX	52,411	XX	51,247	XX	53,272
IDAHO						
Antimony ore and concentrate, antimony content----------short tons--	585	W	557	W	W	W
Clays --------- thousand short tons--	6	$91	[5]1	W	[2]2	W
Copper (recoverable content of ores, etc.) metric tons--	3,556	6,000	3,701	$5,455	3,551	$5,242
Gem stones----------	NA	100	NA	150	NA	175
Gold (recoverable content of ores., etc.) troy ounces--	W	W	W	W	44,306	14,074
Lead (recoverable content of ores, etc.) metric tons--	25,893	12,376	W	W	33,707	14,169
Lime --------- thousand short tons--	85	7,686	87	5,616	93	5,803
Phosphate rock -- thousand metric tons--	W	W	4,722	126,586	3,784	102,430
Sand and gravel (construction) thousand short tons--	[e]3,000	[e]9,800	4,725	13,509	[e]4,000	[e]11,400
Silver (recoverable content of ores, etc.) thousand troy ounces--	17,684	202,308	18,869	153,608	18,828	115,645
Stone (crushed) --- thousand short tons--	1,935	7,480	[e]1,800	[e]7,100	2,019	6,977

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
IDAHO—Continued						
Combined value of cement, clays (bentonite and fire clay, 1984-85; fuller's earth, 1985) garnet (abrasive), gypsum (1984), molybdenum (1984-85), perlite, pumice, sand and gravel (industrial), stone (dimension), tungsten ore and concentrate (1983), vanadium (1984-85), zinc, and values indicated by symbol W	XX	$169,318	XX	[r]$100,326	XX	$72,239
Total	XX	415,159	XX	[r]412,350	XX	348,154
ILLINOIS						
Cement (portland) thousand short tons	1,857	$74,975	1,997	$82,622	2,101	$86,211
Clays[2] do	717	3,360	253	940	265	876
Gem stones	NA	15	NA	15	NA	15
Peat thousand short tons	W	W	49	W	W	W
Sand and gravel:						
Construction do	[e]21,100	[e]58,400	25,969	72,477	[e]26,600	[e]77,000
Industrial do	4,060	42,871	4,100	52,197	4,056	56,915
Stone:						
Crushed do	42,761	166,860	[e]48,500	[e]191,600	41,044	164,117
Dimension do	2	71	--	--	2	107
Combined value of barite, cement (masonry), clays (fuller's earth), copper (1985), fluorspar, lead, lime, silver, tripoli, zinc, and values indicated by symbol W	XX	60,355	XX	72,010	XX	74,679
Total	XX	406,907	XX	471,861	XX	459,920
INDIANA						
Clays thousand short tons	[2]558	[2]$1,421	[2]653	[2]$2,085	740	$2,776
Gem stones	NA	1	NA	1	NA	1
Peat thousand short tons	81	1,973	61	1,358	54	W
Sand and gravel:						
Construction do	[e]14,400	[e]37,900	16,071	44,744	[e]18,600	[e]55,800
Industrial do	W	W	194	1,129	182	1,209
Stone:						
Crushed do	24,051	82,782	[e]26,700	[e]99,400	[e]23,384	[e]81,119
Dimension do	144	11,015	[e]159	[e]14,269	188	20,186
Combined value of abrasives (natural), cement, clays (fire clay, 1983-84), gypsum, lime, stone (crushed marl, 1985), and values indicated by symbol W	XX	115,450	XX	130,250	XX	141,863
Total	XX	250,542	XX	293,236	XX	302,954
IOWA						
Cement:						
Masonry thousand short tons	37	$3,425	42	$3,260	39	$3,372
Portland do	1,644	87,836	1,730	92,699	1,618	77,890
Clays do	576	3,258	623	2,695	503	2,450
Gem stones	NA	1	NA	W	NA	1
Gypsum thousand short tons	1,612	13,518	1,527	12,421	1,639	13,682
Peat do	W	W	11	400	11	415
Sand and gravel (construction) do	[e]11,800	[e]32,800	13,882	37,027	[e]12,000	[e]30,500
Stone (crushed) do	24,844	101,097	[e]23,800	[e]100,000	23,657	94,496
Combined value of lime, stone (dimension, 1983, 1985), and values indicated by symbol W	XX	5,425	XX	4,943	XX	5,211
Total	XX	247,360	XX	253,445	XX	228,017
KANSAS						
Clays thousand short tons	718	$3,921	918	$5,537	878	$5,326
Gem stones	NA	1	NA	1	NA	1
Helium:						
Crude million cubic feet	188	3,572	402	8,844	W	W
Grade-A do	775	27,125	1,015	38,063	W	W
Salt[7] thousand short tons	1,719	67,195	1,712	71,558	1,790	71,970

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983		1984		1985	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
KANSAS—Continued						
Sand and gravel:						
Construction ___ thousand short tons__	[e]12,400	[e]$26,600	11,796	$26,358	[e]13,200	[e]$31,800
Industrial _______________do____	199	2,184	W	W	134	1,124
Stone (crushed) ______________do____	12,687	45,121	[e]13,600	[e]48,500	15,653	57,155
Combined value of cement, gypsum, lime (1983-84), pumice, salt (brine), stone (dimension), and values indicated by symbol W __	XX	91,866	XX	113,149	XX	154,794
Total____________________	XX	267,585	XX	312,010	XX	322,170
KENTUCKY						
Clays _________ thousand short tons__	[2]669	[2]$2,142	[r] [2]662	[r] [2]$2,533	775	$6,487
Gem stones____________________	NA	1	NA	1	NA	1
Sand and gravel:						
Construction ___ thousand short tons__	[e]5,500	[e]13,000	7,839	18,252	[e]7,600	[e]19,000
Industrial _______________do____	10	124	W	W	W	W
Stone (crushed) ______________do____	33,399	117,842	[e]37,300	[e]133,000	[8]38,022	[8]134,978
Combined value of cement, clays (ball clay, 1983-84, fire clay, 1983), lime, stone (crushed sandstone, 1985), zinc, and values indicated by symbol W _______________	XX	91,408	XX	[r]103,422	XX	107,092
Total____________________	XX	224,517	XX	[r]257,208	XX	267,558
LOUISIANA						
Clays _________ thousand short tons__	[2]505	$10,793	547	[2]$10,858	334	$7,017
Gem stones____________________	NA	1	NA	1	NA	1
Salt ___________ thousand short tons__	11,544	100,936	13,101	112,142	12,325	138,955
Sand and gravel:						
Construction______________do____	[e]14,200	[e]46,600	17,040	54,664	[e]15,000	[e]48,000
Industrial _______________do____	291	4,252	266	3,757	267	3,838
Stone (crushed) ______________do____	5,758	25,702	[e]4,100	[e]19,500	[9]4,820	[9]25,956
Sulfur (Frasch) __ thousand metric tons__	1,643	W	2,007	W	1,698	W
Combined value of cement, clays (bentonite, 1984), gypsum, lime, stone (crushed miscellaneous, 1985), and values indicated by symbol W ____________________	XX	258,477	XX	310,548	XX	298,501
Total____________________	XX	446,761	XX	511,470	XX	522,268
MAINE						
Clays _________ thousand short tons__	43	$93	43	$97	50	$100
Gem stones____________________	NA	W	NA	400	NA	400
Sand and gravel (construction) thousand short tons__	[e]4,800	[e]12,100	7,885	19,228	[e]7,200	[e]18,000
Stone (crushed) ______________do____	848	2,851	[e]1,300	[e]4,400	1,459	5,114
Combined value of cement, garnet (abrasive), peat (1983-84), and stone (dimension) ____	XX	11,319	XX	[r]13,814	XX	17,494
Total____________________	XX	26,363	XX	37,939	XX	41,108
MARYLAND						
Clays[2] _________ thousand short tons__	484	$1,747	347	$1,484	336	$1,647
Gem stones____________________	NA	2	NA	2	NA	2
Lime _________ thousand short tons__	7	383	7	419	10	608
Peat ____________________do____	4	W	5	W	W	W
Sand and gravel (construction) ____do____	[e]10,600	[e]37,800	14,234	46,671	[e]17,000	[e]58,000
Stone:						
Crushed________________do____	19,284	80,429	[e]22,100	[e]94,000	24,406	98,584
Dimension _______________do____	12	682	[e]17	[e]864	18	1,218
Combined value of cement, clays (ball clay), sand and gravel (industrial, 1984-85), and values indicated by symbol W______	XX	78,366	XX	98,261	XX	98,215
Total____________________	XX	199,409	XX	241,701	XX	258,274

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
MASSACHUSETTS						
Clays thousand short tons	237	$1,298	240	$1,212	265	$1,388
Lime do	156	10,671	171	12,426	159	10,935
Sand and gravel (construction) do	[e]10,400	[e]36,200	14,168	42,139	[e]14,900	[e]47,500
Stone:						
Crushed do	7,740	36,002	[e]8,400	[e]39,000	9,354	42,881
Dimension do	51	10,488	[e]57	[e]11,657	73	13,724
Combined value of gem stones, peat, and sand and gravel (industrial)	XX	1,016	XX	898	XX	777
Total	XX	95,675	XX	107,332	XX	117,205
MICHIGAN						
Clays thousand short tons	1,199	$5,693	1,321	$5,052	1,477	$5,514
Gem stones	NA	15	NA	15	NA	15
Gypsum thousand short tons	1,097	8,104	1,534	10,304	1,772	11,883
Iron ore (usable) thousand long tons, gross weight	10,713	W	13,263	W	12,629	W
Lime thousand short tons	503	23,142	622	30,092	535	24,790
Peat do	215	4,286	227	4,341	282	5,414
Salt do	1,355	93,306	1,491	93,860	991	75,030
Sand and gravel:						
Construction do	[e]23,000	[e]52,300	36,071	76,540	[e]38,000	[e]93,000
Industrial do	3,545	27,577	3,400	33,060	3,345	25,469
Stone:						
Crushed do	24,763	82,152	[e]28,100	[e]92,000	30,685	95,953
Dimension do	4	112	[e]4	[e]129	4	113
Combined value of bromine, calcium chloride, cement, copper (1985), gold (1985), iodine, iron oxide pigments (crude), magnesium compounds, silver (1985), and values indicated by symbol W	XX	882,239	XX	1,063,214	XX	1,010,672
Total	XX	1,178,926	XX	1,408,607	XX	1,347,853
MINNESOTA						
Gem stones	NA	$5	NA	$5	NA	$5
Iron ore (usable) thousand long tons, gross weight	30,699	1,342,455	35,602	1,561,516	34,977	1,430,353
Manganiferous ore short tons	11,314	W	68,019	W	--	--
Peat thousand short tons	W	W	24	W	34	1,720
Sand and gravel:						
Construction do	[e]24,600	[e]53,000	22,612	49,087	[e]25,000	[e]55,500
Industrial do	685	12,932	W	W	884	16,910
Stone:						
Crushed do	8,580	25,320	[e]8,900	[e]25,800	7,756	22,601
Dimension do	28	11,365	[e]39	[e]13,369	37	13,598
Combined values of clays, lime, and values indicated by symbol W	XX	9,953	XX	26,470	XX	7,271
Total	XX	1,455,030	XX	1,676,247	XX	1,547,958
MISSISSIPPI						
Clays thousand short tons	1,446	$23,846	[r 2]1,274	[r 2]$10,366	1,558	$34,864
Sand and gravel (construction) do	[e]11,000	[e]34,600	12,205	34,955	[e]13,400	[e]42,000
Stone (crushed) do	1,651	4,377	[e]2,000	[e]5,800	1,582	4,282
Combined value of cement, clays (ball clay and fuller's earth, 1984), and sand and gravel (industrial)	XX	26,882	XX	[r]42,016	XX	21,647
Total	XX	89,705	XX	[r]93,137	XX	102,793
MISSOURI						
Barite thousand short tons	W	W	W	W	47	$2,791
Cement:						
Masonry do	146	$7,339	143	$7,033	139	6,630
Portland do	3,499	157,249	3,981	178,225	3,669	159,757
Clays[2] do	1,418	11,848	1,575	14,666	1,545	10,271
Copper (recoverable content of ores, etc.) metric tons	7,725	13,033	5,818	8,575	13,410	19,797
Gem stones	NA	10	NA	10	NA	10
Iron ore (usable) thousand long tons, gross weight	877	27,054	1,370	W	1,110	W
Lead (recoverable content of ores, etc.) metric tons	409,280	195,620	278,329	156,766	371,008	155,955

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
MISSOURI—Continued						
Sand and gravel:						
Construction ___ thousand short tons__	[e]7,700	[e]$17,700	7,967	$19,364	[e]7,500	[e]$20,000
Industrial ______________do____	600	7,541	614	8,129	535	7,330
Silver (recoverable content of ores, etc.) thousand troy ounces__	2,021	23,124	1,401	11,406	1,635	10,044
Stone (crushed) ___ thousand short tons__	39,454	120,700	[e]41,600	[e]137,000	50,646	162,097
Zinc (recoverable content of ores, etc.) metric tons__	57,044	52,052	45,458	48,707	49,340	43,908
Combined value of clays (fuller's earth), iron oxide pigments (crude), lime, stone (dimension), and values indicated by symbol W __	XX	92,598	XX	142,016	XX	136,370
Total____________________	XX	725,868	XX	731,897	XX	734,960
MONTANA						
Antimony _____________short tons__	253	W	--	--	--	--
Barite_________ thousand short tons__	10	$750	W	W	W	W
Clays ___________________do____	194	6,205	[r]229	[r]$5,642	279	$8,296
Copper (recoverable content of ores, etc.) metric tons__	33,337	56,245	W	W	15,092	22,281
Gem stones______________________	NA	300	NA	450	NA	400
Gold (recoverable content of ores, etc.) troy ounces__	161,436	68,449	181,190	65,348	160,262	50,909
Lead (recoverable content of ores, etc.) metric tons__	1,163	556	W	W	846	356
Lime _________ thousand short tons__	86	W	89	5,097	W	W
Sand and gravel (construction) ____do____	[e]5,000	[e]10,200	7,776	21,269	[e]9,000	[e]26,000
Silver (recoverable content of ores, etc.) thousand troy ounces__	5,708	65,299	5,653	46,018	4,010	24,630
Stone (crushed) ___ thousand short tons__	872	2,320	[e]950	[e]2,400	[10]1,730	[10]5,044
Combined value of cement, graphite (1983-84), gypsum, iron ore, molybdenum (1983), peat, phosphate rock, sand and gravel (industrial), stone (crushed traprock, 1985), stone (dimension), talc, vermiculite, and values indicated by symbol W ____________	XX	81,644	XX	[r]93,811	XX	62,356
Total____________________	XX	291,968	XX	[r]240,035	XX	200,272
NEBRASKA						
Clays _________ thousand short tons__	164	$501	180	$556	244	$718
Gem stones______________________	NA	W	NA	W	NA	10
Sand and gravel:						
Construction___ thousand short tons__	[e]10,100	[e]25,000	11,839	27,791	[e]11,600	[e]28,800
Industrial ______________do____	4	W	W	W	W	W
Stone (crushed) ______________do____	4,442	22,612	[e]4,500	[e]23,400	4,175	19,134
Combined value of cement, lime, and values indicated by symbol W ____________	XX	39,296	XX	48,621	XX	51,308
Total____________________	XX	87,409	XX	100,368	XX	99,970
NEVADA						
Barite_________ thousand short tons__	663	$21,736	615	$14,924	590	$10,904
Clays ___________________do____	58	2,348	[2]20	[2]1,191	[2]80	[2]3,776
Gem stones______________________	NA	1,200	NA	1,300	NA	1,300
Gold (recoverable content of ores, etc.) troy ounces__	[r]960,657	[r]407,319	[r]1,020,546	[r]368,068	1,276,114	405,369
Gypsum________ thousand short tons__	998	7,896	1,192	8,860	1,207	8,942
Lead (recoverable content of ores, etc.) metric tons__	14	7	W	W	(3)	(3)
Mercury __________ 76-pound flasks__	25,070	W	19,048	W	16,530	W
Sand and gravel:						
Construction___ thousand short tons__	[e]7,500	[e]16,200	8,202	20,505	[e]9,500	[e]24,800
Industrial ______________do____	W	W	489	W	479	W
Silver (recoverable content of ores, etc.) thousand troy ounces__	[r]5,179	[r]59,252	6,477	52,727	4,947	30,383
Stone (crushed) ___ thousand short tons__	1,269	5,358	[e]1,100	[e]4,700	1,334	6,218
Combined value of cement (portland), clays (fuller's earth and kaolin, 1984-85), copper, diatomite, fluorspar, iron ore, lime, lithium compounds, magnesite, molybdenum, perlite, salt, tungsten ore and concentrate (1984), and values indicated by symbol W _	XX	111,178	XX	151,787	XX	139,191
Total____________________	XX	[r]632,494	XX	[r]624,062	XX	630,883

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
NEW HAMPSHIRE						
Sand and gravel (construction) thousand short tons	e4,000	e$12,100	5,637	$16,054	e6,300	e$19,800
Stone:						
Crushed do	946	2,853	e850	e2,700	1,612	6,434
Dimension do	58	4,032	e59	e4,198	79	6,532
Combined value of other industrial minerals	XX	101	XX	160	XX	134
Total	XX	19,086	XX	23,112	XX	32,900
NEW JERSEY						
Clays thousand short tons	62	$596	r62	$611	130	$2,050
Gem stones	NA	1	NA	1	NA	1
Peat thousand short tons	W	W	5	128	W	311
Sand and gravel:						
Construction do	e10,800	e34,300	9,545	$31,878	e10,600	e36,700
Industrial do	2,386	31,819	2,712	32,287	2,820	31,119
Stone (crushed)	12,301	70,421	e13,500	e75,000	15,692	94,339
Zinc (recoverable content of ores, etc.) metric tons	16,475	15,033	W	W	W	W
Combined value of magnesium compounds (1983), marl (greensand), stone (dimension, 1983-84), and values indicated by symbol W	XX	2,445	XX	16,331	XX	13,056
Total	XX	154,615	XX	156,236	XX	177,576
NEW MEXICO						
Clays thousand short tons	50	$115	67	$143	60	$161
Gem stones	NA	200	NA	200	NA	200
Gold (recoverable content of ores, etc.) troy ounces	W	W	W	W	45,045	14,309
Gypsum thousand short tons	169	1,016	318	1,622	350	1,570
Lead (recoverable content of ores, etc.) metric tons	258	123	--	--	W	W
Lime thousand short tons	17	W	--	--	--	--
Perlite do	394	13,297	416	14,115	419	14,521
Potassium salts thousand metric tons	1,278	174,700	1,418	204,100	1,120	156,000
Pumice thousand short tons	110	1,070	132	1,269	152	1,114
Sand and gravel (construction) do	e7,000	e20,000	8,363	22,389	e8,400	e22,800
Stone:						
Crushed do	4,730	15,118	e4,700	e17,000	3,641	15,232
Dimension do	18	141	e19	e149	20	277
Combined value of cement, copper, helium (Grade-A), mica (scrap), molybdenum, salt, silver, tungsten ore and concentrate (1984), and values indicated by symbol W	XX	291,411	XX	r374,855	XX	430,705
Total	XX	517,191	XX	r635,842	XX	656,889
NEW YORK						
Clays thousand short tons	2371	2$869	2543	2$2,435	700	$3,129
Gem stones	NA	30	NA	30	NA	30
Lead (recoverable content of ores, etc.) metric tons	1,299	621	W	W	W	W
Peat thousand short tons	18	W	W	W	W	W
Salt do	4,859	100,119	5,644	123,755	6,928	142,318
Sand and gravel:						
Construction do	e18,700	e54,200	25,968	80,866	e28,000	e88,500
Industrial do	W	W	25	260	W	W
Silver (recoverable content of ores, etc.) thousand troy ounces	33	379	W	W	W	W
Stone:						
Crushed thousand short tons	31,991	134,752	e33,100	e135,000	35,139	165,136
Dimension do	24	4,310	e15	e4,271	16	3,666
Zinc (recoverable content of ores, etc.) metric tons	56,748	51,783	W	W	W	W
Combined value of cement, clays (ball clay, 1983-84), emery, garnet (abrasive), gypsum, lime, talc, titanium concentrate (ilmenite, 1983-84), wollastonite, and values indicated by symbol W	XX	156,351	XX	265,873	XX	254,529
Total	XX	503,414	XX	612,490	XX	657,308

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
NORTH CAROLINA						
Clays ---- thousand short tons--	[2]2,068	[2]$6,681	2,327	$8,987	2,688	$10,477
Feldspar ---- short tons--	508,641	13,610	510,275	13,994	490,993	13,351
Gem stones----	NA	50	NA	50	NA	50
Mica (scrap) ---- thousand short tons--	69	4,266	79	3,762	80	3,726
Sand and gravel:						
Construction ---- do----	[e]5,600	[e]16,900	6,312	18,159	[e]6,100	[e]19,500
Industrial ---- do----	1,066	11,689	1,158	12,864	1,294	13,086
Stone:						
Crushed ---- do----	33,694	145,001	[e]38,100	[e]168,000	41,771	194,818
Dimension ---- do----	87	8,267	W	W	35	6,132
Talc and pyrophyllite ---- do----	89	1,452	87	1,587	85	1,604
Combined value of cement (1983), clays (kaolin, 1983), lithium compounds, olivine, peat, phosphate rock, and value indicated by symbol W ----	XX	190,641	XX	224,077	XX	170,012
Total----	XX	398,557	XX	451,480	XX	432,756
NORTH DAKOTA						
Gem stones----	NA	$2	NA	$2	NA	$2
Lime ---- thousand short tons--	57	6,798	60	5,912	56	5,562
Sand and gravel (construction) ---- do----	[e]3,800	[e]15,000	6,426	11,351	[e]6,900	[e]13,800
Combined value of clays, peat, salt, and stone (crushed, 1985) ----	XX	3,570	XX	4,529	XX	4,820
Total----	XX	25,370	XX	21,794	XX	24,184
OHIO						
Cement:						
Masonry ---- thousand short tons--	97	$7,454	101	$8,092	110	$10,412
Portland ---- do----	1,575	71,599	1,525	69,810	1,769	84,929
Clays ---- do----	1,716	8,061	1,960	10,473	2,114	10,581
Gem stones----	NA	W	NA	W	NA	10
Lime ---- thousand short tons--	1,906	84,928	1,859	87,951	1,730	84,142
Peat ---- do----	W	W	13	345	16	413
Salt ---- do----	2,565	85,988	W	W	4,783	143,949
Sand and gravel:						
Construction ---- do----	[e]27,200	[e]84,600	31,748	104,709	[e]33,000	[e]109,000
Industrial ---- do----	1,226	17,848	1,506	20,829	1,312	21,945
Stone:						
Crushed ---- do----	32,937	114,059	[e]38,500	[e]139,000	38,310	136,544
Dimension ---- do----	49	2,923	[e]37	[e]3,454	53	3,661
Combined value of abrasives, gypsum, and values indicated by symbol W ----	XX	1,684	XX	108,240	XX	1,541
Total----	XX	479,144	XX	552,903	XX	607,127
OKLAHOMA						
Cement:						
Masonry ---- thousand short tons--	45	$3,074	49	$3,506	43	$2,854
Portland ---- do----	1,719	83,685	1,732	84,701	1,589	72,583
Clays ---- do----	862	2,288	979	2,498	997	2,338
Gem stones----	NA	2	NA	2	NA	2
Gypsum ---- thousand short tons--	1,351	11,571	1,549	13,485	1,595	12,548
Pumice ---- do----	1	W	W	W	W	W
Sand and gravel:						
Construction ---- do----	[e]7,500	[e]17,300	10,984	26,582	[e]12,600	[e]32,300
Industrial ---- do----	1,184	13,221	W	W	W	W
Stone:						
Crushed ---- do----	23,865	76,941	[e]25,500	[e]86,000	31,173	98,811
Dimension ---- do----	10	737	[e]12	[e]771	11	836
Combined value of feldspar, iodine, lime, salt, tripoli, and values indicated by symbol W ----	XX	17,367	XX	28,187	XX	29,335
Total----	XX	226,186	XX	245,732	XX	251,607

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State—Continued

Mineral	1983		1984		1985	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
OREGON						
Clays thousand short tons	188	$275	189	$288	188	$285
Gem stones	NA	600	NA	400	NA	350
Gold (recoverable content of ores, etc.) troy ounces	322	137	W	W	W	W
Nickel (content of ores and concentrates) short tons	--	--	14,540	W	6,127	W
Sand and gravel (construction) thousand short tons	[e]11,000	[e]37,000	12,776	37,117	[e]12,500	[e]36,800
Silver (recoverable content of ores, etc.) thousand troy ounces	1	10	W	W	--	--
Stone (crushed) thousand short tons	13,089	39,873	[e]12,500	[e]37,500	15,336	54,244
Talc and soapstone do	([3])	123	([3])	66	([3])	30
Combined value of cement, copper (1983), diatomite, lead (1983), lime, pumice, sand and gravel (industrial, 1983), stone (dimension, 1983 and 1985), and values indicated by symbol W	XX	32,922	XX	45,031	XX	38,587
Total	XX	110,940	XX	120,402	XX	130,296
PENNSYLVANIA						
Cement:						
Masonry thousand short tons	262	$17,095	298	$20,849	303	$20,970
Portland do	5,154	218,539	5,735	281,590	5,535	288,036
Clays[2] do	916	4,311	963	4,050	1,142	5,293
Gem stones	NA	5	NA	5	NA	5
Lime thousand short tons	1,507	81,682	1,620	90,182	1,492	85,269
Peat do	22	628	24	693	21	602
Sand and gravel:						
Construction do	[e]11,800	[e]52,000	14,472	64,285	[e]17,000	[e]74,000
Industrial do	W	W	W	W	693	9,846
Stone:						
Crushed do	51,523	226,948	[e]56,200	[e]228,000	64,765	310,859
Dimension do	53	5,799	[e]44	[e]6,001	51	8,214
Zinc (recoverable content of ores, etc.) metric tons	16,792	15,322	--	--	--	--
Combined value of clays (kaolin), mica (scrap), and values indicated by symbol W	XX	12,812	XX	12,701	XX	1,380
Total	XX	635,141	XX	708,356	XX	804,474
RHODE ISLAND						
Sand and gravel (construction) thousand short tons	[e]1,000	[e]$2,400	1,483	$5,282	[e]1,200	[e]$4,600
Stone (crushed) do	971	5,507	[e]1,000	[e]5,800	[10]1,135	[10]7,016
Combined value of gem stones, sand and gravel (industrial, 1984-85), and stone (crushed traprock, 1985)	XX	23	XX	486	XX	576
Total	XX	7,930	XX	11,568	XX	12,192
SOUTH CAROLINA						
Cement, portland thousand short tons	W	W	2,319	$103,891	2,207	$104,705
Clays[2] do	1,813	$34,830	1,834	36,809	1,896	37,695
Gem stones	NA	10	NA	10	NA	10
Manganiferous ore thousand short tons	22	W	20	W	20	W
Peat do	W	W	5	W	W	173
Sand and gravel:						
Construction do	[e]5,200	[e]15,000	5,845	17,097	[e]4,900	[e]14,000
Industrial do	842	13,169	882	14,889	794	14,092
Stone:						
Crushed do	15,786	61,054	[e]17,900	[e]72,500	17,079	72,520
Dimension do	17	1,165	[e]16	[e]1,092	8	541
Combined value of cement (masonry), clays (fuller's earth), gold (1985), mica (scrap), silver (1985), vermiculite, and values indicated by symbol W	XX	105,366	XX	29,562	XX	32,193
Total	XX	230,594	XX	275,850	XX	275,929

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
SOUTH DAKOTA						
Cement:						
Masonry thousand short tons	4	$359	5	$283	4	W
Portland do	603	37,435	619	30,773	655	W
Clays[2] do	123	353	119	343	117	$309
Feldspar short tons	7,109	107	7,219	124	13,721	W
Gem stones	NA	70	NA	70	NA	70
Gold (recoverable content of ores, etc.) troy ounces	309,784	131,348	310,527	111,994	356,103	113,119
Gypsum thousand short tons	W	W	W	W	34	269
Sand and gravel (construction) do	e5,100	e11,500	5,786	12,168	e6,400	e16,000
Silver (recoverable content of ores, etc.) thousand troy ounces	62	713	50	407	63	388
Stone:						
Crushed thousand short tons	3,906	12,982	e3,800	e12,800	4,071	14,412
Dimension do	42	15,794	e60	e18,642	W	W
Combined value of beryllium, clays (bentonite), lime, mica (scrap), and values indicated by symbol W	XX	11,432	XX	r11,265	XX	62,772
Total	XX	222,093	XX	r198,869	XX	207,339
TENNESSEE						
Clays thousand short tons	1,066	$26,516	r 2 1,165	r 2 $21,690	2 1,244	2 $25,913
Gem stones	NA	5	NA	5	NA	5
Phosphate rock thousand metric tons	1,193	29,073	1,368	33,275	1,233	27,600
Sand and gravel:						
Construction thousand short tons	e6,100	e18,700	6,304	19,830	e7,200	e22,000
Industrial do	483	5,455	650	6,903	569	6,156
Stone:						
Crushed do	30,578	111,573	e36,200	e138,000	9 37,939	9 155,760
Dimension do	7	1,161	e7	e1,097	5	773
Zinc (recoverable content of ores, etc.) metric tons	109,958	100,336	116,526	124,854	104,471	92,971
Combined value of barite, cement, clays (fuller's earth, 1985), copper, lead (1984-85), lime, pyrites, silver, and stone (crushed granite, 1985)	XX	114,493	XX	r131,918	XX	141,109
Total	XX	407,312	XX	r477,572	XX	472,287
TEXAS						
Cement:						
Masonry thousand short tons	276	$19,704	291	$24,409	263	$22,114
Portland do	9,760	534,298	10,423	557,421	10,242	532,494
Clays do	3,955	22,575	r 2 3,517	r 2 17,091	4,107	28,059
Gem stones	NA	225	NA	175	NA	175
Gypsum thousand short tons	2,049	16,357	2,166	19,431	1,981	17,299
Helium (Grade-A) million cubic feet	524	18,340	W	W	W	W
Lime thousand short tons	1,067	60,193	1,157	61,214	1,192	65,927
Salt do	8,028	65,670	8,184	69,672	8,390	80,434
Sand and gravel:						
Construction do	e58,500	e208,000	62,389	199,461	e57,800	e198,000
Industrial do	1,788	29,637	2,028	29,282	1,968	29,095
Stone:						
Crushed do	76,328	239,187	e89,200	e300,000	85,764	306,821
Dimension do	50	11,071	e47	e11,236	37	11,760
Sulfur (Frasch) thousand metric tons	2,468	W	2,994	W	2,979	W
Talc and pyrophyllite thousand short tons	250	3,933	r240	r4,125	261	5,245
Combined value of asphalt (native, 1984-85), clays (fuller's earth and kaolin, 1984), fluorspar, helium (crude), iron ore, magnesium chloride, magnesium compounds, mica (scrap, 1984-85), sodium sulfate, and values indicated by symbol W	XX	279,291	XX	r419,861	XX	435,936
Total	XX	1,508,481	XX	r1,713,378	XX	1,733,359

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
UTAH						
Beryllium concentrate ______ short tons__	W	W	6,030	$6	5,738	$6
Clays ________ thousand short tons__	[2]227	[2]$1,569	[2]315	[2]2,223	332	2,509
Copper (recoverable content of ores, etc.) metric tons__	169,751	286,403	W	W	W	W
Gem stones____________________	NA	80	NA	80	NA	80
Gold (recoverable content of ores, etc.) troy ounces__	238,459	101,107	W	W	135,489	43,039
Gypsum________ thousand short tons__	305	2,736	277	2,671	413	4,033
Lime ___________________do____	315	16,771	297	16,471	225	11,912
Salt ___________________do____	936	23,184	1,246	28,651	1,189	28,468
Sand and gravel:						
Construction_____________do____	e9,800	e19,800	15,217	34,507	e14,000	e36,400
Industrial _____________do____	24	W	11	W	W	W
Silver (recoverable content of ores, etc.) thousand troy ounces__	4,567	52,242	W	W	W	W
Stone (crushed) ___ thousand short tons__	4,407	14,636	e5,200	e16,400	4,657	14,180
Combined value of asphalt (native), cement, clays (fuller's earth, 1983-84), iron ore (usable, 1983), lead (1984), magnesium compounds, molybdenum, perlite (1983), phosphate rock, potassium salts, sodium sulfate, stone (dimension, 1983 and 1985), vanadium (1983-84), zinc (1984), and values indicated by symbol W ___________	XX	138,051	XX	r424,323	XX	171,732
Total____________________	XX	656,579	XX	r525,332	XX	312,359
VERMONT						
Sand and gravel (construction) thousand short tons__	e3,000	e$6,200	3,802	$8,071	e2,700	e$7,000
Stone:						
Crushed________________do____	1,339	5,579	e1,800	e7,000	1,689	7,468
Dimension ______________do____	116	19,995	e116	e20,462	116	26,346
Combined value of talc and other industrial minerals____________________	XX	10,355	XX	9,565	XX	9,040
Total____________________	XX	42,129	XX	45,098	XX	49,854
VIRGINIA						
Clays ________ thousand short tons__	784	$5,467	712	$6,004	814	$6,977
Gem stones____________________	NA	20	NA	20	NA	20
Iron oxide pigments, crude ___short tons__	W	W	W	W	2,280	W
Lime ________ thousand short tons__	557	24,637	562	24,799	633	28,103
Sand and gravel (construction)____do____	e7,200	e30,800	8,860	37,359	e10,200	e42,000
Stone:						
Crushed________________do____	37,959	159,553	e47,200	e196,000	51,686	221,900
Dimension ______________do____	93	2,238	e22	e3,052	10	3,136
Combined value of aplite, cement, gypsum, kyanite, sand and gravel (industrial), talc (soapstone), vermiculite, and values indicated by symbol W ______________	XX	66,629	XX	74,355	XX	79,140
Total____________________	XX	289,344	XX	341,589	XX	381,276
WASHINGTON						
Clays ________ thousand short tons__	[2]282	[2]$1,715	292	r [2]$1,598	243	$1,402
Gem stones____________________	NA	200	NA	200	NA	200
Peat_________ thousand short tons__	W	W	W	W	12	292
Sand and gravel:						
Construction_____________do____	e15,800	e50,300	23,369	61,070	e22,700	e62,300
Industrial _____________do____	337	4,581	356	5,201	322	5,589
Stone:						
Crushed________________do____	10,451	29,607	e10,400	e31,700	9,543	31,052
Dimension ______________do____	1	37	--	--	1	53
Combined value of barite, calcium chloride (natural, 1985), cement, clays (fire clay, 1983-84) diatomite, gold, gypsum, lime, olivine, silver, talc (1983-84), and values indicated by symbol W ___________	XX	101,025	XX	r102,855	XX	142,782
Total____________________	XX	187,465	XX	202,624	XX	243,670

See footnotes at end of table.

Table 5.—Nonfuel mineral production[1] in the United States, by State —Continued

Mineral	1983		1984		1985	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
WEST VIRGINIA						
Clays ---------- thousand short tons--	[2]249	[2]$532	381	$3,410	331	$3,342
Salt ----------------------do----	1,026	W	1,004	W	895	W
Sand and gravel (construction) ----do----	[e]700	[e]3,400	976	3,198	[e]900	[e]3,000
Stone (crushed) -------------do----	9,439	37,962	[e]9,100	[e]37,300	9,393	38,348
Combined value of cement, clays (fire clay, 1983), lime, sand and gravel (industrial), and values indicated by symbol W------	XX	62,079	XX	68,279	XX	60,719
Total--------------------	XX	103,973	XX	112,187	XX	105,409
WISCONSIN						
Lime ---------- thousand short tons--	319	$17,624	373	$19,892	341	$19,001
Peat ----------------------do----	9	W	9	W	10	W
Sand and gravel:						
Construction--------------do----	[e]14,200	[e]28,800	17,785	38,245	[e]16,000	[e]36,000
Industrial --------------do----	621	7,208	1,060	11,821	1,197	14,624
Stone:						
Crushed-----------------do----	14,252	39,896	[e]15,800	[e]45,000	14,496	42,380
Dimension ---------------do----	24	2,884	[e]24	[e]2,863	22	2,733
Combined value of abrasive stone, cement, and values indicated by symbol W------	XX	4,779	XX	11,527	XX	10,372
Total---------------------	XX	101,191	XX	129,348	XX	125,110
WYOMING						
Clays ---------- thousand short tons--	2,140	$49,059	[r]2,628	[r]$67,921	2,302	$64,146
Gem stones--------------------	NA	250	NA	225	NA	225
Gypsum--------- thousand short tons--	382	2,963	376	2,618	576	4,488
Sand and gravel (construction) ----do----	[e]2,400	[e]8,000	4,586	13,372	[e]3,500	[e]11,000
Stone (crushed) -------------do----	2,019	7,769	[e]1,900	[e]7,600	[9]2,030	[9]7,329
Combined value of beryllium concentrate (1983), cement (portland), iron ore (1983), lime, sodium carbonate, and stone (crushed granite, 1985) ------------------	XX	561,860	XX	458,187	XX	465,275
Total--------------------	XX	629,901	XX	[r]549,923	XX	552,463

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Excludes certain clays; value included with "Combined value" figure.
[3]Less than 1/2 unit.
[4]Partial total, excludes the values of magnesium compounds, which must be concealed to avoid disclosing company proprietary data.
[5]Excludes bentonite and fire clay.
[6]Excludes marl; value included with "Combined value" figure.
[7]Excludes salt in brines; value included with "Combined value" figure.
[8]Excludes sandstone; value included with "Combined value" figure.
[9]Excludes other stone; data included with "Combined value" figure.
[10]Excludes traprock; data included with "Combined value" figure.

Table 6.—Mineral production[1] in the islands administered by the United States

(Thousand short tons and thousand dollars)

Area and mineral	1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value
American Samoa: Stone ------------------	NA	NA	NA	NA	([2])	1
Guam: Stone ------------------------	329	2,192	[e]345	[e]2,280	548	3,731
Virgin Islands: Stone --------------------	237	2,305	[e]249	[e]2,397	214	2,405

[e]Estimated. NA Not available.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Less than 1/2 unit.

Table 7.—Mineral production[1] in the Commonwealth of Puerto Rico

(Thousand short tons and thousand dollars)

Mineral	1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value
Cement (portland)	931	82,509	997	87,568	962	72,602
Clays	125	251	128	266	118	264
Lime	35	3,885	35	4,531	23	3,249
Sand and gravel	NA	NA	43	W	--	--
Stone:						
Crushed	5,536	26,611	e5,813	e27,675	5,493	25,799
Dimension	W	W	e35	e455	--	--
Total[2]	XX	113,256	XX	120,495	XX	101,914

eEstimated. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.
[1]Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2]Total does not include value of items not available or withheld.

Table 8.—U.S. exports of principal minerals and products, excluding mineral fuels

Mineral	1984		1985	
	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS				
Aluminum:				
Ingots, slabs, crude ---metric tons	259,598	$396,798	347,292	$441,598
Scrap ---do	258,404	275,686	374,646	350,669
Plates, sheets, bars, etc ---do	198,399	496,841	167,874	411,337
Castings and forgings ---do	11,590	69,845	12,408	74,498
Aluminum sulfate ---do	2,789	1,185	5,698	1,178
Other aluminum compounds ---do	37,616	31,700	32,390	27,829
Antimony, metals and alloys, crude ---short tons	511	915	362	876
Bauxite including bauxite concentrate thousand metric tons	82	12,735	56	6,407
Beryllium ---pounds	39,315	2,562	119,428	6,375
Bismuth, metals and alloys ---do	311,511	1,091	268,669	603
Cadmium metal ---metric tons	106	208	86	342
Chromium:				
Ore and concentrate:				
Exports ---thousand short tons	55	2,957	101	4,600
Reexports ---do	4	864	4	670
Ferrochromium ---do	15	10,542	10	7,688
Cobalt (content) ---thousand pounds	670	7,661	627	7,355
Copper:				
Ore, concentrate, composition metal, unrefined (copper content) ---metric tons	74,528	91,558	168,024	175,307
Scrap ---do	80,810	96,266	134,300	132,386
Refined copper and semimanufactures ---do	135,885	351,999	101,121	448,227
Other copper manufactures ---do	13,817	30,438	7,883	17,522
Ferroalloys not elsewhere listed:				
Ferrophosphorus ---short tons	39,603	5,279	49,674	5,776
Ferroalloys, n.e.c ---do	27,485	16,158	14,498	24,581
Gold:				
Ore and base bullion ---troy ounces	1,498,617	528,284	1,078,369	334,331
Bullion, refined ---do	3,482,473	1,284,718	2,888,309	919,433
Iron ore ---thousand long tons	4,993	239,257	5,033	240,557
Iron and steel:				
Pig iron ---short tons	56,674	5,685	31,614	3,543
Iron and steel products (major):				
Steel mill products ---do	977,284	904,011	929,954	855,078
Other steel products ---do	261,246	513,942	200,387	465,672
Iron and steel scrap: Ferrous scrap including rerolling materials, ships, boats, other vessels for scrapping thousand short tons	9,840	938,402	10,191	940,416
Lead:				
Ore and concentrate ---metric tons	11,858	4,760	9,987	4,503
Pigs, bars, anodes, sheets, etc ---do	7,445	15,214	27,342	20,977
Scrap ---do	45,097	11,575	59,949	12,963
Magnesium, metal and alloys, scrap, semimanufactured forms, n.e.c ---short tons	48,337	136,661	40,322	113,600
Manganese:				
Ore and concentrate ---do	237,606	15,643	56,040	4,286
Ferromanganese ---do	6,764	4,397	6,927	4,762
Silicomanganese ---do	5,333	2,237	3,089	1,359
Metal ---do	4,082	5,915	5,162	7,242

Table 8.—U.S. exports of principal minerals and products, excluding mineral fuels —Continued

Mineral	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
METALS —Continued				
Molybdenum:				
Ore and concentrate (molybdenum content) thousand pounds	63,366	$242,770	63,859	$247,690
Metal and alloys, crude and scrap do	306	1,209	574	2,365
Wire do	474	5,954	546	6,130
Semimanufactured forms, n.e.c. do	257	6,368	408	8,390
Powder do	461	3,272	369	2,298
Ferromolybdenum do	650	1,567	1,262	2,698
Compounds do	26,602	56,453	23,769	46,109
Nickel:[1]				
Primary (unwrought commercially pure, anodes, ferronickel, powder and flakes) short tons	35,807	131,480	24,354	96,503
Wrought (bars, rods, angles, shapes, sections; plates, sheets, strip; tubes, pipes, blanks, fittings, hollow bar; wire) do	6,857	75,219	8,155	89,289
Compound catalysts and waste and scrap do	15,861	38,722	18,920	49,516
Platinum-group metals:				
Ore and scrap troy ounces	r563,345	123,349	362,384	76,993
Palladium, rhodium, iridium, osmiridium, ruthenium, osmium (metal and alloys including scrap) do	r377,802	74,748	339,254	56,116
Platinum (metal and alloys) do	220,885	76,749	187,013	54,052
Rare-earth metals: Ferrocerium and alloys short tons	34	309	29	317
Selenium kilograms	122,929	1,587	154,122	1,431
Silicon:				
Ferrosilicon short tons	29,364	21,135	12,969	12,671
Silicon carbide, crude and in grains (including reexports) do	6,023	8,613	5,186	7,446
Silver:				
Ore, concentrate, waste, sweepings thousand troy ounces	14,108	119,965	12,145	79,086
Bullion, refined do	10,340	86,339	12,611	81,746
Tantalum:				
Ore, metal, other forms thousand pounds	508	24,603	491	19,265
Powder do	151	17,026	143	15,188
Tin:				
Ingots, pigs, bars, etc.: Exports metric tons	1,429	14,409	1,478	16,744
Tinplate and terneplate do	154,679	93,033	155,119	85,000
Titanium:				
Ore and concentrate short tons	8,651	1,936	27,759	6,953
Unwrought and scrap metal do	4,484	9,359	6,992	17,475
Intermediate mill shapes and mill products, n.e.c do	2,849	61,502	3,395	70,423
Pigments and oxides do	108,247	102,828	103,201	112,870
Tungsten (tungsten content):				
Ore and concentrate metric tons	129	1,240	124	831
Carbide powder do	448	12,415	661	15,734
Alloy powder do	816	17,329	1,449	33,331
Vanadium:				
Ore and concentrate (vanadium content) thousand pounds	24	109	5	9
Pentoxide, etc do	7,423	14,514	3,053	6,300
Ferrovanadium do	938	5,205	908	4,791
Zinc:				
Slabs, pigs, or blocks metric tons	760	975	1,011	1,525
Sheets, plates, strips, other forms, n.e.c do	975	2,421	776	1,973
Waste, scrap, dust (zinc content) do	42,079	23,871	45,984	22,080
Semifabricated forms, n.e.c do	1,428	2,349	2,674	3,500
Ore and concentrate do	30,579	13,353	23,264	8,216
Zirconium:				
Ore and concentrate short tons	9,528	2,647	16,855	3,965
Oxide do	422	1,263	1,048	3,332
Metals, alloys, other forms do	808	42,523	1,153	51,558
INDUSTRIAL MINERALS				
Abrasives (includes reexports):				
Industrial diamond, natural or synthetic:				
Powder or dust thousand carats	47,992	74,337	51,593	81,806
Other do	3,301	30,441	3,291	29,530
Diamond grinding wheels do	536	5,141	553	6,603
Other natural and artificial metallic abrasives and products	XX	[2]99,719	XX	[2]89,716
Asbestos:				
Exports:				
Unmanufactured metric tons	39,779	18,221	45,075	16,366
Products	XX	162,690	XX	193,476
Reexports:				
Unmanufactured metric tons	140	125	581	123
Products	XX	657	XX	289
Barite: Natural barium sulfate short tons	1,449	574	5,876	692

See footnotes at end of table.

Table 8.—U.S. exports of principal minerals and products, excluding mineral fuels —Continued

Mineral	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
INDUSTRIAL MINERALS —Continued				
Boron:				
Boric acid short tons	44,728	$24,402	49,457	$21,598
Sodium borates, refined do	r576,231	134,000	623,375	151,000
Bromine compounds thousand pounds	53,200	16,200	61,000	23,400
Calcium:				
Other calcium compounds including precipitated calcium carbonate short tons	37,000	17,000	49,000	25,000
Chloride do	34,062	20,568	26,143	6,343
Dicalcium phosphate do	40,000	33,000	58,600	43,000
Cement: Hydraulic and clinker do	80,007	13,496	97,897	21,478
Clays:				
Kaolin or china clay thousand short tons	1,418	170,137	1,381	174,204
Bentonite do	563	45,375	640	44,973
Other do	718	80,221	759	90,694
Diatomite do	127	29,461	120	28,519
Feldspar, leucite, nepheline syenite short tons	10,080	920	9,280	680
Fluorspar do	12,266	1,292	9,671	1,063
Gem stones (including reexports):				
Diamond thousand carats	2,273	574,719	2,378	571,300
Pearls	XX	8,265	XX	3,600
Other	XX	98,150	XX	56,500
Graphite, natural short tons	7,096	2,807	10,159	3,830
Gypsum:				
Crude, crushed or calcined thousand short tons	131	12,711	83	13,021
Manufactured, wallboard and plaster articles	XX	17,141	XX	13,398
Helium million cubic feet	392	21,461	439	25,316
Lime short tons	24,714	6,805	19,383	5,155
Lithium compounds:				
Lithium carbonate thousand pounds	18,069	24,487	13,916	19,006
Lithium hydroxide do	8,198	14,108	7,853	13,709
Other lithium compounds do	5,430	9,765	5,608	12,453
Magnesium compounds:				
Magnesite, dead-burned short tons	17,275	3,641	24,805	5,529
Magnesite, crude, caustic-calcined, lump or ground do	32,053	14,026	21,567	9,773
Mica:				
Waste, scrap, ground thousand pounds	15,306	2,038	17,378	2,370
Block, film, splittings do	348	549	82	159
Manufactured, cut or stamped, built-up do	NA	4,519	NA	5,103
Mineral-earth pigments, iron oxide, natural and synthetic short tons	32,428	31,832	29,720	27,574
Nitrogen compounds (major) thousand short tons	10,439	1,635,430	10,799	1,553,387
Phosphate rock thousand metric tons	r11,316	r392,032	10,284	281,515
Phosphatic fertilizers:				
Phosphoric acid do	r867	r181,055	716	141,162
Superphosphates do	2,847	r149,150	5,524	176,515
Diammonium phosphates do	6,346	1,200,579	6,131	1,048,322
Elemental phosphorus metric tons	14,852	22,375	17,131	27,024
Pigments and compounds: Zinc oxide (metal content) do	288	627	359	1,005
Potash:				
Potassium chloride do	621,820	57,200	699,770	NA
Potassium sulfate do	67,320	13,940	91,000	NA
Quartz, crystal:				
Cultured thousand pounds	277	11,021	185	3,723
Natural do	42	234	60	290
Salt:				
Crude and refined thousand short tons	820	15,299	904	15,988
Shipments to noncontiguous territories do	r18	2,301	23	5,196
Sand and gravel:				
Construction:				
Sand do	1,210	8,094	997	6,212
Gravel do	635	2,231	516	2,723
Industrial sand do	1,193	27,656	866	22,580
Sodium compounds:				
Sodium carbonate do	1,648	160,774	1,771	186,064
Sodium sulfate do	76	9,587	119	11,899
Stone:				
Crushed do	2,378	23,970	2,372	29,347
Dimension do	NA	r23,007	NA	13,835
Sulfur, crude thousand metric tons	1,334	156,067	1,365	189,248
Talc, crude and ground thousand short tons	256	16,162	237	14,282
Total	XX	r13,988,499	XX	13,065,121

rRevised. NA Not available. XX Not applicable.
[1]Not comparable to prior years owing to regrouping of nickel forms.
[2]Silicon carbide (crude and refined) has been deducted and is shown separately elsewhere in this table.

Table 9.—U.S. imports for consumption of principal minerals and products, excluding mineral fuels

Mineral	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
METALS				
Aluminum:				
Metal ---- metric tons	881,956	$1,292,724	868,674	$1,017,453
Scrap ---- do	137,675	145,748	127,501	108,625
Plates, sheets, bars, etc ---- do	457,562	1,027,631	423,769	847,476
Aluminum oxide (alumina) thousand metric tons	4,466	976,364	3,979	809,664
Antimony:				
Ore and concentrate (antimony content) short tons	4,299	6,798	6,638	12,381
Sulfide including needle or liquated ---- do	72	157	167	256
Metal ---- do	3,898	8,037	5,129	10,983
Oxide ---- do	17,884	26,348	10,620	20,765
Arsenic:				
White (As_2O_3 content) ---- do	13,985	9,454	16,472	14,059
Metallic ---- do	304	2,127	407	2,150
Bauxite, crude ---- thousand metric tons	r10,228	NA	7,944	NA
Beryllium ore ---- short tons	1,332	1,177	1,646	1,427
Bismuth, metals and alloys (gross weight) ---- pounds	1,948,394	5,892	1,998,865	10,172
Cadmium metal ---- metric tons	1,889	5,133	1,988	4,122
Calcium metal ---- pounds	248,973	670	492,244	1,395
Cesium compounds and chloride ---- do	53,652	1,552	50,537	1,595
Chromium:				
Ore and concentrate (Cr_2O_3 content) thousand short tons	134	15,477	176	20,170
Ferrochromium (gross weight) ---- do	426	183,451	331	156,546
Ferrochromium-silicon ---- do	8	3,736	4	2,085
Metal ---- do	5	24,073	4	19,615
Cobalt:				
Metal ---- thousand pounds	23,316	202,954	16,613	181,379
Oxide (gross weight) ---- do	706	5,285	246	2,258
Salts and compounds (gross weight) ---- do	2,284	5,371	1,413	4,431
Columbium ore ---- do	3,265	6,030	2,899	4,673
Copper (copper content):				
Ore and concentrate ---- metric tons	11,056	9,863	2,869	1,739
Matte ---- do	2,094	2,586	3,997	6,997
Blister ---- do	38,949	52,950	12,979	15,529
Refined in ingots, etc ---- do	444,699	620,674	377,725	491,798
Scrap ---- do	23,005	28,925	23,014	25,680
Ferroalloys not elsewhere listed, including spiegeleisen short tons	5,321	27,304	5,225	25,969
Gallium ---- kilograms	9,669	4,050	7,961	3,447
Germanium ---- do	116,719	7,539	14,841	8,829
Gold:				
Ore and base bullion ---- troy ounces	1,837,052	653,307	1,865,022	587,002
Bullion, refined ---- do	6,031,550	2,293,606	6,360,977	2,109,475
Hafnium ---- short tons	1	115	1	185
Indium ---- thousand troy ounces	1,022	4,577	980	3,480
Iron ore ---- thousand long tons	17,187	529,065	15,771	452,240
Iron and steel:				
Pig iron ---- short tons	702,355	83,985	338,258	50,619
Iron and steel products (major):				
Steel mill products ---- do	r26,169,048	r10,201,074	24,278,482	9,565,642
Other products ---- do	r1,146,133	r1,155,386	1,211,146	1,308,921
Scrap including tinplate ---- thousand short tons	572	46,946	601	45,620
Lead:				
Ore, flue dust, matte (lead content) ---- metric tons	29,888	11,923	2,649	979
Base bullion (lead content) ---- do	43	57	760	398
Pigs and bars (lead content) ---- do	161,489	86,189	131,353	53,864
Reclaimed scrap, etc. (lead content) ---- do	5,026	2,029	3,168	1,212
Sheets, pipes, shot ---- do	1,667	4,044	1,981	2,517
Magnesium:				
Metal and scrap ---- short tons	5,296	12,260	4,866	10,303
Alloys (magnesium content) ---- do	3,596	10,791	3,651	12,774
Sheets, tubing, ribbons, wire, other forms (magnesium content) ---- do	489	2,620	754	2,010
Manganese:				
Ore (35% or more contained manganese) ---- do	338,094	16,024	386,859	22,561
Ferromanganese ---- do	409,310	117,678	366,874	104,389
Ferrosilicon-manganese (manganese content) do	91,339	44,746	109,719	51,423
Metal ---- do	13,314	12,978	8,566	9,052
Mercury:				
Compounds ---- pounds	r249,083	r1,111	329,889	1,625
Metal ---- 76-pound flasks	25,327	7,274	18,890	5,337

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products, excluding mineral fuels —Continued

Mineral	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
METALS —Continued				
Molybdenum:				
Ore and concentrate (molybdenum content) thousand pounds	28	$183	112	$566
Waste and scrap (gross weight) do	NA	2,565	NA	2,830
Metal:				
Unwrought (molybdenum content) do	142	2,170	145	2,370
Wrought (gross weight) do	132	3,023	94	2,301
Ferromolybdenum (gross weight) do	2,086	4,438	1,424	3,721
Material in chief value molybdenum (molybdenum content) do	5,266	19,441	2,239	7,329
Compounds (gross weight) do	3,437	6,251	3,815	6,678
Nickel:				
Pigs, ingots, shot, cathodes short tons	103,017	461,371	97,779	446,009
Plates, bars, etc do	8,650	58,120	10,100	89,660
Slurry do	82,509	116,956	68,210	101,101
Scrap do	6,199	20,542	5,552	16,430
Powder and flakes do	15,829	78,736	12,753	67,717
Ferronickel do	43,048	68,429	36,528	60,253
Oxide do	5,526	22,413	5,079	20,722
Platinum-group metals:				
Unwrought:				
Grains and nuggets (platinum) troy ounces	19,786	5,647	20,827	6,807
Sponge (platinum) do	1,527,841	617,888	1,464,645	542,133
Sweepings, waste, scrap do	526,738	61,920	530,724	62,342
Iridium do	18,225	7,472	20,972	9,615
Palladium do	1,795,939	273,222	1,396,810	174,333
Rhodium do	155,671	83,979	201,028	173,310
Ruthenium do	198,257	16,652	162,887	16,474
Other platinum-group metals do	10,602	3,796	15,701	4,707
Semimanufactured:				
Platinum do	60,140	22,682	78,206	23,946
Palladium do	158,012	24,192	84,492	9,532
Rhodium do	2,389	516	145	73
Other platinum-group metals do	506	122	13,157	2,422
Rare-earth metals:				
Ferrocerium and other cerium alloys kilograms	138,128	1,651	113,385	1,302
Monazite metric tons	5,661	2,202	5,694	1,984
Metals including scandium and yttrium kilograms	4,316	619	3,185	285
Rhenium:				
Metal including scrap pounds	1,962	450	4,943	1,225
Ammonium perrhenate (rhenium content) do	r4,754	1,052	3,325	669
Selenium and selenium compounds (selenium content) kilograms	376,946	8,054	400,658	8,358
Silicon:				
Metal (over 96% silicon content) short tons	25,221	55,381	51,801	83,367
Ferrosilicon do	143,651	72,874	155,421	74,019
Silver:				
Ore and base bullion thousand troy ounces	13,018	105,587	3,533	20,180
Bullion, refined do	93,546	784,838	137,398	855,550
Sweepings, waste, doré do	8,402	72,772	11,671	76,218
Tantalum ore thousand pounds	2,199	19,054	737	8,187
Tellurium (tellurium content) kilograms	r35,383	725	30,050	871
Thallium pounds	2,964	96	2,655	50
Tin:				
Concentrate (tin content) metric tons	3,272	20,862	1,636	10,659
Dross, skimmings, scrap, residue, tin alloys, n.s.p.f. do	1,211	1,318	877	2,804
Tinfoil, powder, flitters, etc	XX	3,292	XX	3,290
Tin compounds metric tons	838	5,301	827	5,164
Titanium:				
Ilmenite[1] short tons	619,444	43,846	798,632	66,821
Rutile do	180,508	44,910	179,663	43,967
Metal do	5,533	35,469	5,479	39,408
Ferrotitanium and ferrosilicon titanium do	579	861	483	982
Pigments do	193,501	186,952	196,213	206,809
Tungsten ore and concentrate (tungsten content) metric tons	5,807	51,715	4,746	36,706
Vanadium (vanadium content):				
Ferrovanadium thousand pounds	2,341	11,839	1,557	7,757
Pentoxide do	297	1,269	22	180
Vanadium-bearing materials do	1,266	552	605	535
Zinc:				
Ore (zinc content) metric tons	86,172	29,186	90,186	33,626
Blocks, pigs, slabs do	639,228	635,940	610,900	508,003
Sheets, etc do	850	1,308	3,559	2,757
Fume (zinc content) do	314	171	--	--
Waste and scrap do	6,259	3,940	3,247	1,848
Dross and skimmings do	5,027	3,161	4,942	2,419
Dust, powder, flakes do	7,572	9,505	8,681	10,781
Manufactured	XX	927	XX	713

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products, excluding mineral fuels —Continued

Mineral	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
METALS —Continued				
Zirconium:				
Ore including zirconium sand ------- short tons--	66,436	$7,548	43,787	$4,599
Metal, scrap, compounds ------------ do----	1,844	20,330	4,202	24,962
INDUSTRIAL MINERALS				
Abrasives:				
Diamond (industrial) -------- thousand carats--	43,710	113,632	46,222	127,191
Other ----------------------------	XX	268,062	XX	255,686
Asbestos --------------------- metric tons--	209,963	64,749	142,431	44,093
Barite:				
Crude and ground ------- thousand short tons--	1,776	74,945	2,127	82,913
Witherite ------------------- short tons--	226	153	142	74
Chemicals ---------------------- do----	35,208	20,524	32,907	19,978
Boron:				
Boric acid (contained boron oxide) ------ do----	r4,000	3,449	6,000	5,121
Colemanite (contained boron oxide) thousand short tons--	20,000	12,123	33,000	24,620
Ulexite ------------------------ do----	47,000	10,202	31,000	11,120
Bromine (contained in compounds) - thousand pounds--	16,080	10,996	17,079	11,065
Calcium chloride ---------------- short tons--	22,078	1,817	77,736	10,967
Cement: Hydraulic and clinker - thousand short tons--	8,846	r294,207	14,487	437,429
Clays ----------------------- short tons--	31,585	4,868	40,902	5,981
Cryolite ---------------------- do----	22,722	13,124	16,596	10,003
Feldspar:				
Crude ------------------------- do----	2	1	936	1,126
Ground and crushed --------------- do----	23	14	16	25
Fluorspar --------------------- do----	703,711	65,241	552,959	49,639
Gem stones:				
Diamond ------------- thousand carats--	r8,228	2,905,317	8,151	3,006,762
Emeralds -------------------- do----	4,410	154,644	2,741	139,000
Other ----------------------------	XX	591,555	XX	534,113
Graphite, natural ------------- short tons--	58,246	14,579	52,737	16,186
Gypsum:				
Crude, ground, calcined---- thousand short tons--	8,915	74,357	9,924	64,331
Manufactured -----------------------	XX	95,310	XX	91,091
Iodine, crude ------------- thousand pounds--	5,067	r24,803	4,971	26,761
Lime:				
Hydrated ------------------ short tons--	59,906	3,669	48,827	3,407
Other ------------------------ do----	187,579	9,722	145,230	8,810
Lithium:				
Ore --------------------------- do----	r150	r33	4,716	1,277
Compounds --------------------- do----	462	2,313	1,402	5,774
Magnesium compounds:				
Crude magnesite ----------------- do----	r758	232	1,350	332
Lump or ground caustic-calcined magnesia -- do----	r54,893	9,594	65,709	10,407
Refractory magnesia, dead-burned, fused magnesite, dead-burned dolomite ------------ do----	155,162	r26,186	179,207	32,075
Compounds --------------------- do----	46,153	10,036	36,751	10,085
Mica:				
Waste, scrap, ground ------- thousand pounds--	23,198	3,251	20,057	2,920
Block, film, splittings ------------- do----	1,480	644	1,684	1,080
Manufactured, cut or stamped, built-up ---- do----	856	2,836	978	3,154
Mineral-earth pigments, iron oxide:				
Ocher, crude and refined ---------- short tons--	7	31	26	22
Siennas, crude and refined ----------- do----	160	72	270	49
Umber, crude and refined ----------- do----	6,401	1,012	4,921	795
Vandyke brown ------------------ do----	659	244	404	140
Other natural and refined ----------- do----	996	444	1,026	561
Synthetic --------------------- do----	30,015	19,720	33,151	20,999
Nepheline syenite:				
Crude ------------------------ do----	410	17	920	62
Ground, crushed, etc ------------- do----	377,535	14,201	331,684	11,373
Nitrogen compounds (major) including urea thousand short tons--	8,476	984,524	8,544	880,348
Peat:				
Fertilizer-grade -------------- short tons--	453,387	53,491	452,018	54,244
Poultry- and stable-grade ------------ do----	31,685	4,318	25,370	3,606
Phosphates, crude and apatite - thousand metric tons--	9	274	34	1,593
Phosphatic fertilizers:				
Fertilizer and fertilizer materials -------- do----	119	7,536	30	5,929
Elemental phosphorus -------------- do----	r4	6,482	2	3,530
Other ------------------------- do----	11	1,550	3	492

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products, excluding mineral fuels —Continued

Mineral	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
INDUSTRIAL MINERALS —Continued				
Pigments and salts:				
Lead pigments and compounds ______ metric tons__	19,081	$15,022	16,272	$12,468
Zinc pigments and compounds__________do____	52,432	48,178	52,310	48,244
Potash__________________________do____	7,947,700	658,100	7,570,900	499,100
Pumice:				
Crude or unmanufactured _________short tons__	16,703	402	781	198
Wholly or partly manufactured__________do____	[r]192	[r]48	357	103
Manufactured, n.s.p.f_____________________	XX	148	XX	218
Quartz crystal (Brazilian lascas) __ thousand pounds__	569	373	173	99
Salt_________________ thousand short tons__	7,545	74,100	6,207	65,593
Sand and gravel:				
Industrial sand____________________do____	26	926	81	1,513
Other sand and gravel ______________do____	151	1,603	246	1,572
Sodium compounds:				
Sodium carbonate __________________do____	17	2,301	56	8,089
Sodium sulfate ____________________do____	265	21,198	194	14,492
Stone:				
Crushed ___________________________do____	2,923	15,071	2,725	10,209
Dimension ___________________________	XX	[r]223,150	XX	295,094
Calcium carbonate fines ___ thousand short tons__	292	2,471	281	1,432
Strontium:				
Minerals___________________short tons__	48,852	4,293	37,552	3,321
Compounds _________________________do____	4,755	3,386	7,403	5,586
Sulfur and compounds, sulfur ore and other forms, n.e.s _______________ thousand metric tons__	[r]2,557	[r]200,189	2,104	199,240
Talc, unmanufactured ______ thousand short tons__	45	9,156	47	9,532
Total_________________________	XX	[r]31,497,367	XX	29,450,174

[r]Revised. NA Not available. XX Not applicable.
[1]Includes titanium slag averaging about 70% TiO_2. For details, see "Titanium" chapter.

Table 10.—Comparison of world and U.S. production of selected nonfuel mineral commodities

(Thousand short tons unless otherwise specified)

Mineral	1984 World production[1]	1984 U.S. production	1984 U.S. percent of world production	1985[p] World production[1]	1985[p] U.S. production	1985[p] U.S. percent of world production
METALS, MINE BASIS						
Antimony (content of ore and concentrate) short tons__	60,396	557	1	60,621	W	NA
Arsenic trioxide[2] ______metric tons__	44,099	6,800	15	45,030	2,200	5
Bauxite[3] ____ thousand metric tons__	88,173	856	1	85,133	674	1
Beryl_______________short tons__	9,838	6,030	61	9,688	5,738	59
Bismuth________ thousand pounds__	8,415	W	NA	9,175	W	NA
Chromite ______________________	10,312	--	--	10,951	--	--
Cobalt (content of ore and concentrate) short tons__	35,869	--	--	39,867	--	--
Columbium-tantalum concentrate (gross weight) _______ thousand pounds__	78,827	--	--	83,857	--	--
Copper (content of ore and concentrate) thousand metric tons__	7,986	1,103	14	8,114	1,106	14
Gold (content of ore and concentrate) thousand troy ounces__	46,408	2,085	4	48,217	2,475	5
Iron ore (gross weight) thousand long tons__	817,428	51,269	6	845,251	48,751	6
Lead (content of ore and concentrate) thousand metric tons__	3,256	334	10	3,392	424	12
Manganese ore gross weight) ________	26,027	--	--	26,922	--	--
Mercury___ thousand 76-pound flasks__	195	19	10	196	17	9
Molybdenum (content of ore and concentrate) ________ thousand pounds__	214,506	103,664	48	215,139	108,409	50
Nickel (content of ore and concentrate) __	833	15	2	857	6	1
Platinum-group metals[2] thousand troy ounces__	7,648	15	([4])	7,951	W	NA

See footnotes at end of table.

Table 10.—Comparison of world and U.S. production of selected nonfuel mineral commodities —Continued

(Thousand short tons unless otherwise specified)

Mineral	1984			1985[p]		
	World production[1]	U.S. production	U.S. percent of world production	World production[1]	U.S. production	U.S. percent of world production
METALS, MINE BASIS —Continued						
Silver (content of ore and concentrate) thousand troy ounces	415,239	44,592	11	412,273	39,357	10
Tin (content of ore and concentrate) metric tons	198,432	W	NA	191,103	W	NA
Titanium concentrates (gross weight):						
Ilmenite	3,402	W	NA	3,654	W	NA
Rutile	388	W	NA	402	W	NA
Tungsten ore and concentrate (contained tungsten) metric tons	46,478	1,203	3	46,989	996	2
Vanadium (content of ore and concentrate) short tons	34,291	1,617	5	33,665	W	NA
Zinc (content of ore and concentrate) thousand metric tons	6,564	278	4	6,676	252	4
METALS, SMELTER BASIS						
Aluminum (primary only) do	15,664	4,099	26	15,289	3,500	23
Cadmium metric tons	19,171	1,686	9	18,662	1,603	9
Cobalt short tons	25,608	--	--	28,217	--	--
Copper smelter (primary and secondary)[5] thousand metric tons	8,344	1,183	14	8,331	1,138	14
Iron, pig	546,317	51,961	10	555,222	49,963	9
Lead, smelter (primary and secondary)[6] thousand metric tons	5,494	1,072	20	5,569	1,124	20
Magnesium (primary)	360	159	44	361	150	42
Nickel[7]	771	45	6	782	36	5
Selenium[8] kilograms	1,350,702	253,598	19	1,122,835	W	NA
Steel, raw	782,008	[9]92,528	12	788,119	[9]88,259	11
Tellurium[8] kilograms	99,594	W	NA	98,500	W	NA
Tin metric tons	199,669	[10]4,000	2	193,715	[10]3,000	2
Zinc (primary and secondary) thousand metric tons	6,463	331	5	6,567	312	5
INDUSTRIAL MINERALS						
Asbestos do	4,106	57	1	4,111	57	1
Barite	6,352	[11]775	12	6,671	[11]739	11
Boron minerals	2,775	1,367	49	2,679	1,269	47
Bromine thousand pounds	873,550	[11]385,000	44	835,090	[11]320,000	38
Cement, hydraulic	1,045,468	[12]78,699	8	1,071,225	[12]78,859	7
Clays:						
Bentonite[8]	6,493	[11]3,438	53	6,245	[11]3,195	51
Fuller's earth[8]	2,528	[11]1,899	75	2,704	[11]2,059	76
Kaolin[2]	23,354	[11]7,953	34	23,361	[11]7,793	33
Corundum short tons	16,265	--	--	16,805	--	--
Diamond thousand carats	63,517	--	--	66,371	--	--
Diatomite	1,933	627	32	1,951	635	33
Feldspar	4,167	710	17	4,294	700	16
Fluorspar	5,270	72	1	5,268	66	1
Graphite short tons	685,507	W	NA	676,740	W	NA
Gypsum	86,767	14,319	17	89,220	14,726	17
Iodine, crude thousand pounds	27,419	W	NA	27,141	W	NA
Lime	125,630	[11,12]15,956	13	123,531	[11,12]15,713	13
Magnesite	13,121	W	NA	13,208	W	NA
Mica (including scrap and ground) thousand pounds	608,700	322,000	53	537,792	275,100	51
Nitrogen, N content of ammonia	93,029	13,368	14	94,302	13,238	14
Peat	282,719	800	([4])	283,106	839	([4])
Perlite	1,808	[11]498	28	1,798	[11]507	28
Phosphate rock (gross weight) thousand metric tons	152,488	49,197	32	151,363	50,835	34
Potash (K_2O equivalent) do	29,348	1,564	5	28,618	1,296	5
Pumice[8]	12,662	[11]502	4	12,110	[11]508	4
Salt	188,699	[11,12]39,256	21	187,693	[11,12]39,519	21

See footnotes at end of table.

Table 10.—Comparison of world and U.S. production of selected nonfuel mineral commodities —Continued

(Thousand short tons unless otherwise specified)

Mineral	1984			1985[p]		
	World production[1]	U.S. production	U.S. percent of world production	World production[1]	U.S. production	U.S. percent of world production
INDUSTRIAL MINERALS —Continued						
Sodium compounds, natural and manufactured:						
Sodium carbonate	31,126	8,511	27	31,628	8,597	27
Sodium sulfate	4,697	872	19	4,647	827	18
Strontium[8] short tons	137,236	--	--	138,700	--	--
Sulfur, all forms thousand metric tons	52,607	10,652	20	54,856	11,609	21
Talc and pyrophyllite	8,351	1,127	14	8,305	1,269	15
Vermiculite[8]	545	315	58	556	314	56

[p]Preliminary. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]For those commodities for which U.S. data are withheld to avoid disclosing company proprietary data, the world total excludes U.S. output and the U.S. percent of world production cannot be reported.
[2]World total does not include an estimate for output in China.
[3]U.S. figures represent dried bauxite equivalent of crude ore; to the extent possible, individual country figures that are included in the world total are also on the dried bauxite equivalent basis, but for some countries, available data are insufficient to permit this adjustment.
[4]Less than 0.5%.
[5]Primary and secondary blister and anode copper, including electrowon refined copper that is not included as blister or anode.
[6]Includes bullion.
[7]Refined nickel plus nickel content of ferronickel, and nickel oxide.
[8]World total does not include estimates for output in the U.S.S.R. or China.
[9]Data from American Iron and Steel Institute. Excludes production of castings by companies that do not report steel ingot.
[10]Includes tin content of alloys made directly from ore.
[11]Quantity sold or used by producers.
[12]Includes Puerto Rico.

Abrasive Materials

By Bureau of Mines Staff

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The combined production value of natural abrasives, which consist of tripoli, special silica stone, garnet, and emery, decreased in 1985. Shipments of processed tripoli increased slightly in quantity but decreased 6% in value. Production of garnet, an abundant iron-aluminum silicate, increased 24% in quantity and 20% in value. There was an 11% increase in the quantity and a 7% increase in the value of refined garnet shipped when compared with 1984 shipments, a new record high. Production of crude special silica stone decreased 10% in quantity and 14% in value, and shipments of finished special silica stone products decreased 35% in quantity and 63% in value. Both the quantity and value of special silica stone finished products sold or used were the lowest since 1981. Production of emery, an impure aluminum oxide, decreased 56% in quantity and 61% in value of product mined and shipped.

Table 1.—Salient U.S. abrasives statistics

		1981	1982	1983	1984	1985
Natural abrasives production by producers:						
Tripoli (crude)	short tons	107,330	112,928	111,020	124,482	W
Value	thousands	$617	$653	$649	$699	W
Special silica stone[1]	short tons	2,501	1,285	1,101	1,290	1,157
Value	thousands	$1,096	$553	$482	$602	$515
Garnet[2]	short tons	25,451	27,303	29,767	29,647	36,727
Value	thousands	$2,059	$2,321	$2,533	$2,487	$2,973
Emery	short tons	W	W	W	W	W
Value	thousands	W	W	W	W	W
Manufactured abrasives[3]	short tons	[4]586,915	418,224	[4]418,153	[4]531,264	[4]478,897
Value	thousands	[4]$225,503	$167,471	[4]$167,430	[4]$203,231	[4]$171,974
Foreign trade (natural and artificial abrasives):						
Exports (value)	do	$189,719	$174,126	$192,794	$191,003	$191,272
Reexports (value)	do	$27,758	$22,650	$24,111	$27,248	$23,845
Imports for consumption (value)	do	$301,695	$245,048	$289,865	$381,694	$382,877

W Withheld to avoid disclosing company proprietary data.
[1]Includes grindstones, oilstones, and whetstones. Excludes grinding pebbles and tube-mill liners.
[2]Primary garnet; denotes first marketable product.
[3]Includes Canadian production of crude silicon carbide and fused aluminum oxide and shipments of metallic abrasives by producers.
[4]Excludes U.S. and Canadian production and value of aluminum-zirconium oxide.

The nonmetallic manufactured abrasives industry, which consisted of crude silicon carbide and fused aluminum oxide, experienced a 10% decrease in shipments and a 20% decrease in value. The average unit values of these shipments, including high-purity fused aluminum oxide, dropped from those of 1984.

The metallic abrasives industry, which consisted of primary producers of steel, chilled and annealed shot and grit, plus cut wire shot manufacturers, reported a 9% decrease in quantity and an 8% decrease in value shipped from those of 1984 shipments.

U.S. exports of diamond grit and powder reached a new record high at 50 million carats, a 5% increase over 1984 exports.

Total imports of abrasive materials increased slightly in value. Imports of industrial diamond increased 6% in value and 12% in quantity. Imported stone increased 14% in quantity and 21% in value with an average price of $8.52 per carat, a 6% increase from that of 1984. Imports of synthetic grit, powder, and dust from Ireland increased slightly in quantity but accounted for 75% of the imports in this category. The average value of the synthetic grit, powder, and dust imported from Ireland increased from $1.44 to $1.49 per carat. Total exports plus reexports of abrasive materials decreased slightly in value.

Domestic Data Coverage.—Domestic production data for abrasive materials are developed by the Bureau of Mines from six separate, voluntary surveys. Of the 51 operations canvassed, producing natural and manufactured abrasives, all responded, representing 100% of the total production shown in tables 1, 5, 6, 8, 15, 16, and 17.

FOREIGN TRADE

Exports plus reexports of industrial diamonds, loose, increased 7% in volume to 54.9 million carats, and 6% in value to $111.3 million. This was a record high quantity. The diamond content in diamond wheels, exported and reexported, was 553,000 carats, a slight increase; the declared value was $6.6 million, an increase of 28.4%. The value of imported diamond wheels increased 28% to $10.5 million.

The value of imported abrasive materials was essentially unchanged from that of 1984, and exports plus reexports decreased slightly in value. Net imports were valued at $167.8 million.

Table 2.—U.S. exports of abrasive materials, by kind

(Thousands)

Kind	1984 Quantity	1984 Value	1985 Quantity	1985 Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust _ carats	47,213	$72,484	49,725	$78,235
Industrial diamond, natural or synthetic, other _ do	859	6,626	1,556	10,227
Emery, natural corundum, pumice in blocks _ pounds	3,783	947	1,918	833
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) _ do	24,588	15,329	24,531	15,004
Silicon carbide, crude or in grains _ do	11,365	8,086	10,004	7,147
Carbide abrasives, n.e.c. _ do	911	1,250	1,420	1,005
Other refined abrasives _ do	29,939	17,078	21,152	12,364
Grinding and polishing wheels and stones:				
Diamond _ carats	532	5,085	552	6,544
Polishing stones, whetstones, oilstones, hones, similar stone number	827	2,360	726	2,208
Wheels and stones, n.e.c _ pounds	3,465	20,171	3,445	19,343
Abrasive paper and cloth, coated with natural or artificial abrasive materials _ do	11,915	36,045	10,405	33,576
Grit and shot including wire pellets _ do	18,313	5,542	16,172	4,786
Total	XX	191,003	XX	191,272

XX Not applicable.

Table 3.—U.S. reexports of abrasive materials, by kind

(Thousands)

Kind	1984 Quantity	1984 Value	1985 Quantity	1985 Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust __ carats__	779	$1,853	1,868	$3,571
Industrial diamond, natural or synthetic, other __do____	2,442	23,815	1,735	19,303
Emery, natural corundum, pumice in blocks __pounds__	227	230	30	13
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) __do____	282	126	57	40
Silicon carbide, crude or in grains __do____	680	527	367	299
Carbide abrasives, n.e.c __do____	10	71	--	--
Grinding and polishing wheels and stones:				
Diamond __ carats__	4	56	1	59
Polishing stones, whetstones, oilstones, hones, similar stone __ number__	--	--	7	16
Wheels and stones, n.e.c __pounds__	32	200	55	266
Abrasive paper and cloth, coated with natural or artificial abrasive materials __do____	109	370	45	278
Total	XX	27,248	XX	23,845

XX Not applicable.

Table 4.—U.S. imports for consumption of abrasive materials (natural and artificial), by kind

(Thousands)

Kind	1984 Quantity	1984 Value	1985 Quantity	1985 Value
Emery, flint, rottenstone, tripoli, crude or crushed __short tons__	20	$421	24	$475
Silicon carbide, crude __do____	64	29,992	56	22,854
Aluminum oxide, crude __do____	175	75,755	152	60,444
Other crude artificial abrasives __do____	8	3,513	14	4,570
Abrasives, ground, grains, pulverized or refined:				
Rottenstone and tripoli __do____	--	--	--	--
Silicon carbide __do____	7	9,343	6	9,007
Aluminum oxide __do____	21	17,140	18	13,982
Emery, corundum, flint, garnet, other, including artificial abrasives __do____	3	5,475	2	5,343
Papers, cloths, other materials wholly or partly coated with natural or artificial abrasives	(1)	71,525	(1)	78,219
Hones, whetstones, oilstones, polishing stones __ number__	2,191	1,154	7,102	1,757
Abrasive wheels and millstones:				
Burrstones manufactured or bound up into millstones short tons__	(2)	49	(2)	14
Solid natural stone wheels __ number__	291	165	429	300
Diamond __do____	229	8,207	420	10,477
Abrasive wheels bonded with resins __pounds__	9,662	16,469	11,208	16,891
Other	(1)	12,313	(1)	16,299
Articles not specifically provided for:				
Emery or garnet	(1)	250	(1)	554
Natural corundum or artificial abrasive materials	(1)	8,886	(1)	8,367
Other n.s.p.f	(1)	4,494	(1)	4,094
Grit and shot, including wire pellets __pounds__	18,759	2,385	6,757	1,478
Diamond, natural and synthetic:				
Diamond dies __ number__	12	526	14	561
Crushing bort __ carats__	219	291	390	568
Natural industrial diamond stones __do____	7,125	58,838	8,174	74,433
Miners' diamond __do____	[3]1,157	7,690	[3]1,271	6,019
Powder and dust, synthetic __do____	28,381	38,684	29,633	38,860
Powder and dust, natural __do____	6,828	8,129	6,754	7,311
Total	XX	381,694	XX	382,877

XX Not applicable.
[1]Quantity not reported.
[2]Less than 1/2 unit.
[3]Includes 43,000 carats of synthetic miners' diamond in 1984 and 111,000 carats in 1985.

Industrial diamond imports totaled 46.2 million carats of loose material valued at $127.2 million, an increase of 6% in quantity and 12% in value. Imports of synthetic powder and dust increased to 29.6 million carats with an average value of $1.31 per carat compared with 28.4 million carats at $1.36 per carat in 1984. Imports from Ireland increased 3% in this category and accounted for 46% of the synthetic powder and dust increase. Industrial diamond stone imports increased 1.2 million carats, while the value increased $0.49 per carat to $8.52. Ireland, the largest U.S. source of industrial diamonds in terms of quantity, shipped to the United States a total of 25.8 million carats, mostly synthetic, valued at $43.1 million. Although the quantity increased slightly, the value increased 8%, primarily because of increases in the unit prices of all categories except miners' diamond. Of the 25.8 million carats from Ireland, 22.3 million carats was synthetic powder and dust with an average value of $1.49 per carat. The share of imports of industrial diamond from Ireland was 56% of total quantity and 34% of total value.

The Republic of South Africa, the largest U.S. source of imported industrial diamonds in terms of value, shipped to the United States a total of 4.7 million carats valued at $45.9 million, a decrease of 41% in quantity and 8% in value. The share of imports from the Republic of South Africa was 10% of the total quantity and 36% of the total value. Of the 4.7 million carats, 3.9 million carats were industrial stones with an average value of $11.49 per carat, a 47% increase from that of 1984.

TRIPOLI

Fine-grained, porous silica materials are grouped together under the category tripoli because they have similar properties and end uses. Processed tripoli, sold or used, increased slightly in quantity and decreased slightly in value; most of the increase in quantity was for filler material, and the value decreases occurred in both abrasive and filler end uses.

Because tripoli grains lack distinct edges and corners, they were used as mild abrasives in toothpaste and industrial soaps and as buffing and polishing compounds in lacquer finishing in the automobile industry. The mineral was also used as a filler and extender in paint, plastic, rubber, and enamels.

The five tripoli producers were Malvern Minerals Co., Garland County, AR, which produced crude and finished material; American Tripoli Co., which produced crude material in Ottawa County, OK, and finished material in Newton County, MO; Illinois Minerals Co. and Tammsco Inc., both in Alexander County, IL, which produced crude and finished amorphous (microcrystalline) silica; and Keystone Filler and Manufacturing Co., in Northumberland County, PA, which processed rottenstone, a decomposed fine-grained siliceous limestone or shale.

Prices quoted in the Engineering and Mining Journal, December 1985, for tripoli and amorphous silica were as follows:

Tripoli, paper bags, carload lots, f.o.b., in cents per pound:	
White, Elco, IL: Air floated through 200 mesh	3.55
Rose and cream, Seneca, MO, and Rogers, AR:	
Once ground	2.90
Double ground	2.90
Air float	3.15
Amorphous silica, 50-pound, paper bags, f.o.b. Elco, IL, in dollars per ton:	
Through 200 mesh, 90% to 95%	$71.00
Through 200 mesh, 96% to 99%	72.00
Through 325 mesh, 90% to 95%	73.00
Through 325 mesh, 96% to 98%	69.50
Through 325 mesh, 98% to 99.4%	78.00
Through 325 mesh, 99.5%	95.00
Through 400 mesh, 99.9%	128.00
Below 15 micrometers, 99%	137.00
Below 10 micrometers, 99%	164.00
Below 8 micrometers, 99%	196.00

Table 5.—Processed tripoli[1] sold or used by producers in the United States, by use[2]

Use		1981	1982	1983	1984	1985
Abrasives	short tons	34,494	35,798	38,073	40,812	40,022
Value	thousands	$2,206	$2,477	$3,203	$3,738	$3,670
Filler	short tons	56,932	55,314	65,138	65,941	68,800
Value	thousands	$4,393	$4,557	$6,077	$6,989	$6,452
Total	short tons	91,426	[3]91,111	103,211	106,753	108,822
Total value	thousands	[3]$6,600	$7,034	$9,280	$10,727	$10,122

[1]Includes amorphous silica and Pennsylvania rottenstone.
[2]Partly estimated.
[3]Data do not add to total shown because of independent rounding.

SPECIAL SILICA STONE PRODUCTS

Production of special silica stone products included oilstones and whetstones from Arkansas and Indiana, grindstones from Ohio, and deburring media from Wisconsin.

Four main grades of whetstones were produced, ranging from the high-quality Arkansas Stone, with porosity of 0.07% and characterized by a waxy luster, down to Washita Stone, with a porosity of 16% and resembling unglazed porcelain. The four main types were as follows:

Trade name	Use
Washita Stone	Rapid sharpening.
Soft Arkansas Stone	General purpose.
Hard Arkansas Stone	Polishing blades to a very fine edge.
Black Hard Arkansas Stone	Polishing the most perfect edge possible.

Table 6.—Special silica stone finished products sold or used in the United States[1]

Year	Quantity (short tons)	Value (thousands)
1981	523	$3,928
1982	713	5,360
1983	602	3,814
1984	683	3,975
1985	443	1,452

[1]Includes grindstones, oilstones, and whetstones. Excludes grinding pebbles and tube-mill liners.

Table 7.—Producers of special silica stone products in 1985

Company and location	Type of operation	Product
Arkansas Oilstone Co.: Hot Springs, AR	Stone cutting and finishing	Whetstones and oilstones.
Arkansas Whetstone Co. Inc.:		
Hot Springs, AR	do	Do.
Do	Quarry	Crude novaculite.
Baraboo Quartzite Co. Inc.:		
Baraboo, WI	Crushing and sizing	Deburring media.
Do	Quarry	Crude silica stone.
Buffalo Stone Corp.: Hot Springs, AR	Tumbling and sizing novaculite.	Metal finishing media and deburring media.
Cleveland Quarries Co.:		
Amherst, OH	Stone cutting and finishing	Grindstones.
Do	Quarry	Crude silica stone.
Dans Whetstone Cutting Co. Inc.:		
Royal, AR	Stone cutting and finishing	Whetstones and oilstones.
Do	Quarry	Crude novaculite.
Halls Arkansas Oilstones Inc.: Pearcy, AR	Stone cutting and finishing	Whetstones and oilstones.
Hindostan Whetstone Co.:		
Bedford, IN	do	Cuticle stones.
Do	Quarry	Crude silica stone.
Hiram A. Smith Whetstone Co. Inc.:		
Hot Springs, AR	Stone cutting and finishing	Whetstones and oilstones.
Do	Quarry	Crude novaculite.
Norton Co. Oilstones, Norton Pike Div.:		
Hot Springs, AR	do	Do.
Littleton, NH	Stone cutting and finishing	Whetstones and oilstones.
Pioneer Whetstone Co.: Hot Springs, AR	do	Do.
Poor Boy Whetstones: Hot Springs, AR (inactive)	do	Do.
Wallis Whetstone Inc.:		
Malvern, AR	do	Do.
Malvern, AR (inactive)	Quarry	Crude novaculite.
Washita Mountain Whetstone Co.: Lake Hamilton, AR	Stone cutting and finishing	Whetstones and oilstones.

Arkansas finished stone production accounted for 78% of both the total value and the total quantity of special stone products sold or used by U.S. producers.

American Trails Whetstone Co., Glenwood, AR, and Poor Boy Whetstones, Hot Springs, AR, remained idle for the second year. Arkansas Oilstone Co., Hot Springs, AR, reported no mining activity but continued production with purchased raw materials.

GARNET

The United States continued to account for an estimated 70% of the world's garnet production; the remainder was produced primarily, in order of size, by India, Australia, China, and the U.S.S.R. Three domestic producers continued to be active, one each in New York, Idaho, and Maine. Barton Mines Corp., Warren County, NY, sold garnet for use in coated abrasives, glass grinding and polishing, and metal lapping. The NYCO Div. of Processed Minerals Inc., Essex County, NY, reported that its byproduct garnet was not recovered in 1985. Emerald Creek Garnet Milling Co. operated two mines in Benewah County, ID, and reported that its garnet was used chiefly in sandblasting and water filtration. Industrial Garnet Extractives Inc. (IGE), near Rangeley in Oxford County, ME, produced almandine garnet and a garnet-containing utility grit concentrate which was used largely in sandblasting and water filtration. The firm doubled its mine capacity by upgrading classification facilities and making additional processing changes. These improvements parallel an improved market demand, especially for sandblasting and water filtration. In addition, IGE installed two new dust collectors at its mine operation.

Production of garnet increased 24% in quantity and 20% in value. There was a significant increase in the quantity and value of refined garnet shipped when compared with that of 1984.

Table 8.—Garnet sold or used by producers in the United States

Year	Quantity (short tons)	Value (thousands)
1981	25,519	$5,204
1982	26,660	5,549
1983	30,300	5,970
1984	27,672	5,677
1985	30,634	6,102

CORUNDUM AND EMERY

Corundum.—There were no imports of abrasive-grade corundum during 1981-85. Demand was met by withdrawal from stocks. In recent years, the domestic supply had consisted almost entirely of material imported from Zimbabwe through the Republic of South Africa by one firm in Massachusetts. Another Massachusetts firm accounted for one-half of the total domestic consumption. Corundum was used in grinding and polishing optical components.

Table 9.—Natural corundum: World production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
India	1,424	1,494	787	487	550
South Africa, Republic of	100	68	54	23	[2]11
U.S.S.R.[e]	9,500	9,500	9,600	9,600	9,600
Uruguay[e]	240	50	55	55	44
Zimbabwe	13,450	9,606	5,644	[r] [e]6,100	6,600
Total	24,714	20,718	16,140	16,265	16,805

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 24, 1986.
[2]Reported figure.

Emery.—One company, John Leardi Emery Mine, continued to operate an emery mine near Peekskill in Westchester County, NY. The crude material, a corundum-containing silicate rock, was processed by two companies—Washington Mills Abrasives Co., North Grafton, MA, and Emeri-Crete Inc., New Castle, NH. Domestic emery was used as a nonslip additive for floors, pavements, and stair treads.

World production of emery was principally from Greece and Turkey. In 1984, production of emery in Greece was reported to be 8,929 short tons, and production in Turkey was reported to be 22,074 tons.

INDUSTRIAL DIAMOND

Domestic production of synthetic industrial diamond was estimated to be 76 million carats, the same as in 1984. The five companies producing synthetic diamond in the United States were E. I. du Pont de Nemours & Co. Inc., Industrial Diamond Div., Gibbstown, NJ; General Electric Co., Specialty Materials Department, Worthington, OH; Megadiamond Industries Inc., Provo, UT; U.S. Synthetics Corp., Orem, UT; and Valdiamant International, a division of Valeron Corp., Ann Arbor, MI. Secondary production of industrial diamond, as salvage from used diamond tools and from wet and dry diamond-containing waste, was estimated to be 1.5 million carats.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the guidelines, industrial diamond stone would be only in tier II with a goal of 7.9 million carats. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The U.S. Government industrial diamond stockpile inventory, as of December 31, was at 22.0 million carats of crushing bort; however, the 12.5 million carats of stone exceeded the current goal for stone of 7.7 million carats. Available for disposal, from enabling legislation effective October 1, 1984, was 5.0 million carats of stone. The inventory of small diamond dies was 25,473 pieces, compared with a goal of 60,000 pieces; however, no purchase authorization has been issued.

The United States remained the largest consumer of natural industrial diamond stones but was totally dependent on foreign sources, importing approximately 9.4 million carats.

Exports plus reexports of industrial diamond dust and powder, including synthetics, was at a record high level for quantity of 51.6 million carats valued at $81.8 million. Exports plus reexports of stone totaled 3.3 million carats valued at $29.5 million.

Table 10.—U.S. imports for consumption of industrial diamond (excluding diamond dies)

(Thousand carats and thousand dollars)

Year	Quantity	Value
1983	24,877	88,617
1984	43,710	113,632
1985	46,222	127,191

Table 11.—U.S. imports for consumption of industrial diamond, by country[1]

(Thousand carats and thousand dollars)

Country	Natural industrial diamond stones (including glazers' and engravers' diamond, unset)				Miners' diamond[2]				Powder and dust, synthetic				Powder and dust, natural			
	1984		1985		1984		1985		1984		1985		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	2	61	1	24	--	--	--	--	1	3	--	--	--	--	--	--
Belgium-Luxembourg	159	2,571	726	13,808	6	86	200	102	227	170	723	151	576	383	572	411
Canada	54	36	144	255	(3)	7	(3)	4	23	21	119	58	214	84	976	250
China	(3)	7	--	--	1	4	--	--	5	18	4	7	--	--	22	11
Congo	194	3,918	14	277	--	--	--	--	--	--	--	--	32	108	--	--
Finland	--	--	--	--	--	--	--	--	118	110	--	--	--	--	--	--
France	(3)	19	1	51	--	--	--	--	--	--	94	45	3	2	--	--
Germany, Federal Republic of	38	1,298	2	98	13	88	(3)	121	398	1,069	579	887	38	74	70	83
Ghana	(3)	7	--	--	1	10	--	--	--	--	--	--	--	--	--	--
Greece	2	5	--	--	--	--	--	--	702	426	676	333	--	--	--	--
Hong Kong	2	5	9	77	--	--	--	--	--	--	13	8	(3)	1	--	--
Ireland	113	218	763	1,622	1,015	5,823	941	4,952	21,766	31,446	22,348	33,380	2,684	2,553	1,702	3,152
Israel	14	49	11	672	--	--	(3)	3	7	19	15	52	16	25	90	30
Japan	8	276	18	616	1	4	--	--	3,040	2,263	2,800	1,604	14	63	158	128
Mexico	--	--	--	--	5	24	5	43	43	19	--	--	6	6	--	--
Netherlands	41	526	94	1,487	20	20	6	97	4	19	(3)	22	86	45	8	8
South Africa, Republic of	5,849	45,877	3,881	44,594	(3)	24	1	42	433	977	49	59	1,601	2,888	749	1,162
Switzerland	6	17	7	261	(3)	60	(3)	116	345	285	341	532	692	827	784	528
U.S.S.R.	(3)	30	--	--	--	--	--	--	73	18	--	--	351	116	442	130
United Kingdom	534	1,591	2,417	8,168	13	83	81	129	743	1,251	1,583	1,297	292	390	445	352
Venezuela	30	1,262	37	1,142	(3)	58	3	134	--	--	--	--	--	--	--	--
Zaire	36	54	--	--	22	118	7	43	51	137	--	5	167	400	583	890
Other Africa, n.e.c	40	941	8	314	2	54	(3)	3	--	--	--	--	8	12	--	--
Other	3	71	40	966	57	1,227	26	230	404	434	289	420	48	153	152	177
Total[4]	7,125	58,838	8,174	74,433	1,157	7,690	1,271	6,019	28,381	38,684	29,633	38,860	6,828	8,129	6,754	7,311

[1]Excludes 219,300 carats of crushing bort from France, Japan, and the United Kingdom in 1984, and 390,400 carats from Belgium-Luxembourg, Canada, Japan, the Republic of South Africa, and the United Kingdom in 1985.
[2]Includes 43,000 carats of synthetic miners' diamond in 1984 and 111,000 carats in 1985.
[3]Less than 1/2 unit.
[4]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

De Beers Consolidated Mines Ltd.'s sales in 1985 through the Central Selling Organization were estimated to be $1.8 billion compared with $1.61 billion in 1984. Sales during the second half of 1985 were unusually strong.

Australia.—Argyle Diamond Mines Joint Venture produced a total of about 17 million carats from its alluvial operation before the operation was closed in October. The second phase, production from the AK-1 kimberlite pipe, commenced on schedule in December. The firm estimated that the AK-1 deposit would produce about 25 million carats per year for about 20 years.[1]

Botswana.—The new Jwaneng Mine expanded its diamond production. Although mining was centered in the middle lobe, stripping proceeded on the northeastern lobe. The ore grade increased by 23% at the Jwaneng Mine, by 30% at the Letlhakane Mine, and by 8% at the Orapa Mine.

Brazil.—Mineração Tejucana S.A., a member of the Union Minière Group, planned an expansion of its current annual output of industrial diamonds from 52,100 carats to 62,500 carats. Coupled with an increase to 540 carats per year of industrial diamonds at the Morro Vermelho plant, Brazilian output of industrial diamonds was anticipated to increase by 10,900 carats.[2]

Burma.—The Ministry of Mines carried out exploration for diamonds by test pitting and drilling. It discovered 68 diamonds with a total weight of 65.31 carats in the period April 1, 1984, to December 31, 1984, mostly industrial diamonds.

Japan.—DEBID (BVI) Ltd. of the British Virgin Islands was reported to have taken a 95% share of the new Japanese company, Debius Industrial Diamond Japan Co.[3] The new company was to deal exclusively with the inspection and sale of imported natural and synthetic industrial diamonds in Japan.

South Africa, Republic of.—The Minister of Finance announced a special temporary surcharge of 5% over and above the 20% surcharge already in effect on taxes paid by all domestic diamond and gold mines. The new surcharge was added in view of mining profits obtained owing to the favorable rand-dollar exchange rate in 1984. The Chamber of Mines, a mining trade association, responded by saying that any additional profits had been absorbed by increased capital expenditure.

De Beers reported about 95% of 1985 South African diamond production, or about 9.7 million carats. Its Finsch Mine, the largest diamond mine in the Republic of South Africa, produced 4.9 million carats, and its Premier Mine produced 2.7 million carats. Other sources indicate that in 1984, 73% of South African production was from Cape Province, 26% from Transvaal, and the balance from the Orange Free State.

The Finsch Mine worked slightly lower grade ore, in accordance with management's plan. The Premier Mine experienced no further collapse of the gabbro sill. Investigations indicated that retreatment of the mine's stored tailings appeared to be feasible, and the processing was scheduled to begin during the year.

Swaziland.—Trans-Hex Ltd. was involved with its joint venture partner, the Swaziland Government, in a $5 million expansion of mining activity at its kimberlite pipe. The open pit extraction of industrial and low-quality gem diamonds, plus smaller amounts of good-quality gems, was expected to last at least 8 years. The expansion in capacity was expected to go on-stream in October 1985.

Zaire.—Société Minière de Bakwanga (MIBA) produced 6,896,000 carats in 1984, and exported 6,902,000 carats worth $57.9 million. MIBA invested $9.7 million in a new hydroelectric power station plus additional funds for geological exploration and research, modernization of workers' housing, and improving the security of the operations.

Table 12.—Diamond (natural): World production, by country and type[1]

(Thousand carats)

Country	1981			1982			1983			1984[p]			1985[e]		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total	Gem[2]	Industrial	Total	Gem[2]	Industrial	Total
Angola	1,050	350	1,400	915	310	1,225	775	259	1,034	[r] [e]750	[r] [e]250	[e]1,000	375	250	625
Australia	21	184	205	[r]274	[r]183	[r]457	3,720	2,480	6,200	3,414	2,276	5,690	[3]4,235	[3]2,824	[3]7,059
Botswana	744	4,217	4,961	1,165	6,604	7,769	4,829	5,902	10,731	5,810	7,104	12,914	5,800	7,100	12,900
Brazil[4]	163	926	1,089	80	450	530	80	450	530	200	550	750	200	800	1,000
Central African Republic	209	103	312	186	91	277	230	65	295	236	101	337	236	101	337
China[e]	190	760	950	200	800	1,000	200	800	1,000	200	800	1,000	200	800	1,000
Ghana	85	751	836	68	616	684	34	306	340	35	315	[e]350	65	585	650
Guinea[e]	12	26	38	13	27	40	23	17	40	34	14	48	105	7	[3]112
Guyana[e]	4	6	10	[r]4	[r]7	11	5	[r]5	[r]10	[r]6	[r]8	[r]14	4	7	11
India	14	2	16	11	2	13	12	2	14	13	2	15	14	2	16
Indonesia[e]	3	12	15	3	12	15	5	22	27	5	22	27	5	22	27
Lesotho	49	4	53	39	3	42	--	--	--	--	--	--	--	--	--
Liberia	132	204	336	170	263	433	132	198	330	108	132	240	108	132	240
Namibia	1,186	62	1,248	963	51	1,014	915	48	963	884	46	930	894	47	941
Sierra Leone	208	97	305	203	87	290	242	103	345	240	105	[e]345	240	105	345
South Africa, Republic of:															
Finsch Mine	1,002	3,463	4,465	847	3,003	3,850	1,765	3,278	5,043	1,714	3,184	4,898	1,770	3,184	[3]4,954
Premier Mine	510	1,530	2,040	615	1,845	2,460	800	1,844	2,644	765	1,785	2,550	820	1,864	[3]2,684
Other De Beers properties[4]	1,603	1,069	2,672	1,359	906	2,265	1,400	569	1,969	1,452	593	2,045	1,500	569	[3]2,069
Other	314	35	349	521	58	579	589	66	655	585	65	650	460	35	495
Total	3,429	6,097	9,526	3,342	5,812	9,154	4,554	5,757	10,311	4,516	5,627	10,143	4,550	5,652	[3]10,202
Swaziland	--	--	--	--	--	--	--	--	--	7	10	17	10	15	25
Tanzania	110	107	217	100	120	220	183	78	261	186	80	266	186	80	266
U.S.S.R.[e]	2,100	8,500	10,600	2,100	8,500	10,600	3,700	7,000	10,700	4,300	6,400	10,700	4,400	6,400	10,800
Venezuela	102	388	490	99	394	[e]493	45	234	279	40	232	272	35	163	198
Zaire	[r]360	[r]6,801	[r]7,161	[r] [e]308	[r] [e]5,856	[r] [e]6,164	3,355	8,627	11,982	5,169	13,290	18,459	5,493	14,124	19,617
World total	[r]10,171	[r]29,597	[r]39,768	[r]10,243	[r]30,188	[r]40,431	23,039	32,353	55,392	26,153	37,364	63,517	27,155	39,216	66,371

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 3, 1986. Total diamond output (gem plus industrial) for each country is actually reported except where indicated by a footnote to be estimated. In contrast, the detailed separate production data for gem diamond and industrial diamond are Bureau of Mines estimates in the case of every country except Australia (1981-85), the Central African Republic (1981, 1983, 1984, 1985), Guinea (1984), Liberia (1981, 1984), Sierra Leone (1981), and Venezuela (1981), for which source publications give details on grade as well as totals. The estimated distribution of total output between gem and industrial diamond is conjectural and, for most countries, is based on the best available data at time of publication.

[2]Includes near-gem and cheap-gem qualities.

[3]Reported figure.

[4]Other De Beers Group output from the Republic of South Africa includes Kimberley Pool, Koffiefontein Mine, and the Namaqualand Mines.

TECHNOLOGY

A Japanese firm developed a process for mass producing large size industrial-grade diamonds. Graphite material was subjected to pressures of 50,000 to 60,000 atmospheres and temperatures of 1,400° to 1,600° C for 100 hours. Diamonds with diameters of 6 millimeters were produced in a single cycle. Current mass production techniques were limited to the synthesis of diamonds with diameters no larger than 0.8 millimeter.[4]

A British company developed new furnace techniques, which improved general production and permitted the introduction of new drill bit matrices. These improvements were accomplished through the use of a special atmospherically controlled ceramic-tube radiant furnace. Diamond grit drill bits produced using this technique reportedly outperformed previous designs drilling hard-rock formations.[5]

MANUFACTURED ABRASIVES

Superior Graphite Co. began production of ceramic grades of beta-silicon carbide at its facility in Hopkinsville, KY. A continuous, proprietary high-temperature processing technology is being employed that produces a free-flowing inexpensive grain that can be used as is or can be further processed to finer grits. Silicon carbide is currently made by batch processes and pulverized to meet abrasive, metallurgical, or refractory industry specification. The main markets targeted for the new line of silicon carbide are the newly emerging high-tech ceramic and advanced refractories fields. In the United Kingdom, TAC Engineering Materials, a subsidiary of Turner and Newell Ltd., established a research and development unit for engineering small production runs and prototypes using sintered silicon nitrides and selected oxide ceramics at Trafford Park, Manchester, England.[6] The company was aiming for markets in the metal extrusion, welding, textile, automotive, and other related industries.

In mergers, closures, and acquisition, Norton Canada Inc., Hamilton, Ontario, Canada, and Carborundum Abrasives Inc. have agreed in principle for Norton Canada to acquire and operate the coated abrasives business of Carborundum Abrasives Canada's Sand Papers Div. in Plattsville, Ontario, Canada. The agreement also included a provision for Norton Canada to produce and market Carborundum's bonded abrasives line.[7] Satellite Alloy Corp., a U.S. producer of silicon carbide, closed its Springfield, PA, production facility in March. The plant was sold and dismantled.

TECHNOLOGY

A technical article encompassing a wide range of fused materials employed in abrasives, refractories, and foundry markets was published.[8] The article highlighted the international fused aluminum oxide industry with special emphasis on the North American producers. The industry production and processing flowsheets were discussed in detail along with the physical chemistry of the fusion reactions required to produce high-quality white and brown fused aluminum oxides. The paper also featured the individual company operations and the marketing areas served. The scientific rationale for the use of sintered alpha-silicon carbide (SASiC) as an advanced material for the chemical processing industries was postulated.[9] The physical, mechanical, and corrosion-resisting properties of SASiC along with high-density and high-temperature performance were compared with those of conventional alloy and ceramics and shown to be superior. Special features of the article were the tables comparing the corrosion resistance of selected materials in liquid media with SASiC and another table listing the range of uses for SASiC in six industries: oil and gas production, chemical processing, papermaking, heat treating and furnacing steel, nuclear, and mining and mineral processing. The latter table also lists the environments to be expected, the primary benefits to be derived, and processing applications.

Several noteworthy techniques and products were announced for the rapidly growing advanced ceramics and/or high-tech material fields that are silicon carbide and nitride related. De Beers Industrial Diamond Ltd. reported that cubic boron nitride, harder than either cemented carbides or ceramics, was being successfully used in machining where diamond tooling is precluded because of the reaction between the tool and the workpiece.[10] In another development, silicon carbide and nitride components, formed by hot isostatic pressing, tested favorably when compared with typical cast metal products.[11] If continuing research proves equally successful on improving high-temperature fabrication techniques, it could result in material with sufficient strength to justify use in turbine blades. A joint study by Kubota and the

Agency for Industrial Science (Japan) has resulted in a unique silicon nitride which is stronger at elevated temperatures (above 1,000° C) than at ambient temperatures.[12] The successful transfer of this physical property to a polycrystalline fabricated part could accelerate the development of high-performance ceramic motors and turbine blades. Rare earth oxides, such as lanthanum and praeseodymium, reportedly are used as the sintering additives. Lastly, a new technique was advanced for "welding" ceramic materials.[13] Initial research and development studies centered on silicon carbide and nitride ceramics.

The proprietary joining process employs an adhesive material sandwiched between the ceramic faces and then rapidly fused together electrically into a monolithic shape. By altering the composition of the special adhesive material, most ceramic materials should be amenable to this forming technique. The successful development of this method should lead to a wide variety of intricate and inexpensive ceramic components for both traditional and high-tech uses.

A West German firm developed a fully automated three-station precision honing machine which employs a single-stick bronze-bonded cubic boron nitride tooled honing facility for hydraulic boring. The machine averaged 35 seconds per bore in a cast iron valve block for bores 50 millimeters in diameter and 100 millimeters long.[14]

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[1]Industrial Minerals (London). World of Minerals. No. 220, Jan. 1986, p. 8.
[2]———. Company News and Mineral Notes. No. 213, June 1985, p. 72.
[3]———. Company News and Mineral Notes. No. 219, Dec. 1985, p. 91.
[4]———. Synthetic Diamond Breakthrough. No. 213, June 1985, p. 10.
[5]———. New Craelius KS and KM Diamond Impregnated Diamond Bits. No. 215, Aug. 1985, p. 67.
[6]———. Company News and Mineral Notes. No. 218, Nov. 1985, p. 81.
[7]Brick and Clay Record. Refractories News—Norton Canada Buys Carborundum Abrasives. V. 187, No. 5, Nov. 1985, p. 13.
[8]Power, T. Fused Minerals—the High Purity High Performance Oxides. Ind. Miner. (London), No. 214, July 1985, pp. 37-57.
[9]Lashway, R. W. Sintered Alpha-Silicon Carbide: An Advanced Material for CPI Applications. Chem. Eng., v. 92, No. 25, Dec. 1985, pp. 121-122.
[10]Industrial Minerals (London). Company News and Mineral Notes. No. 214, July 1985, p. 76.
[11]———. Company News and Mineral Notes. No. 213, June 1985, p. 79.
[12]———. Company News and Mineral Notes. No. 213, June 1985, p. 73.
[13]———. Company News and Mineral Notes. No. 219, Dec. 1985, p. 93.
[14]———. Company News and Mineral Notes. Diamond and CBN Provide Complete Honing System. No. 209, Feb. 1985, p. 68.

Table 13.—Crude artificial abrasives manufacturers in 1985

Company	Location	Product
The Exolon-ESK Co	Hennepin, IL	Silicon carbide.
Do	Thorold, Ontario, Canada	Fused aluminum oxide (regular) and silicon carbide.
General Abrasives, a division of Dresser Industries Inc.	Niagara Falls, NY	Fused aluminum oxide (regular and high-purity).
Do	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular) and silicon carbide.
Norton Co	Huntsville, AL	Fused aluminum oxide (high-purity) and aluminum-zirconium oxide.
Do	Worcester, MA	General abrasive processing.
Do	Cap-de-la-Madeleine, Quebec, Canada	Silicon carbide.
Do	Chippewa, Ontario, Canada	Fused aluminum oxide (regular and high-purity) and aluminum-zirconium oxide.
Sohio Electro Minerals Co	Niagara Falls, NY	Fused aluminum oxide (high-purity).
Do	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
Do	Shawinigan, Quebec, Canada	Silicon carbide.
Washington Mills Abrasives Co	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).

Table 14.—Producers[1] of metallic abrasives in 1985

Company	Location	Product (shot and/or grit)
Abrasive Materials Inc	Hillsdale, MI	Cut wire.
Durasteel Co	Pittsburgh, PA	Steel.
Ervin Industries Inc	Adrian, MI	Do.
Do	Butler, PA	Do.
Globe Steel Abrasives Co	Mansfield, OH	Do.
Jumbo Manufacturing Inc	Tippecanoe, IN	Chilled and annealed iron.
Metaltec Steel Abrasives Co	Canton, MI	Steel.
National Metal Abrasive Co	Wadsworth, OH	Do.
The Pangborn Co	Butler, PA	Do.
Pellets Inc	Tonawanda, NY	Cut wire.
Steel Abrasives Inc	Fairfield, OH	Chilled iron.
Wheelabrator-Frye Inc	Bedford, VA	Steel.

[1]Excludes secondary (salvage) producers.

Table 15.—Crude manufactured abrasives produced in the United States and Canada, by kind

(Thousand short tons and thousand dollars)

Kind	1981	1982	1983	1984	1985
Silicon carbide[1]	156	112	109	137	113
Value	$68,839	$54,507	$52,016	$57,125	$42,563
Aluminum oxide (abrasive grade)[1]	203	132	137	177	169
Value	$73,712	$45,975	$50,565	$63,818	$54,061
Aluminum-zirconium oxide	W	8	W	W	W
Value	W	$4,600	W	W	W
Metallic abrasives[2]	228	166	172	217	197
Value	$82,952	$62,389	$64,849	$82,288	$75,349
Total	[3]587	418	[3]418	[3]531	[3]479
Total value	[3]$225,503	$167,471	[3]$167,430	[3]$203,231	[3 4]$171,974

W Withheld to avoid disclosing company proprietary data.
[1]Includes material used for refractories and other nonabrasive purposes.
[2]Shipments for U.S. plants only.
[3]Excludes U.S. and Canadian production and value of aluminum-zirconium oxide.
[4]Data do not add to total shown because of independent rounding.

Table 16.—End uses of crude silicon carbide and aluminum oxide (abrasive grade) in the United States and Canada, as reported by producers

Use	1984			1985		
	Quantity (short tons)	Value (thousands)	Yearend stocks (short tons)	Quantity (short tons)	Value (thousands)	Yearend stocks (short tons)
SILICON CARBIDE						
Abrasives	50,946	$22,217	6,704	46,664	$18,451	6,245
Metallurgical	71,140	28,718	6,140	53,433	19,018	5,448
Refractories and other	14,509	6,190	3,036	12,508	5,094	1,703
Total	136,595	57,125	15,880	112,605	42,563	13,396
ALUMINUM OXIDE						
Regular: Abrasives plus refractories[1]	156,814	53,740	9,175	152,401	46,705	16,993
High purity	19,856	10,078	1,950	16,422	7,356	1,769
Total	176,670	63,818	11,125	168,823	54,061	18,762

[1]Abrasives combined with refractories to avoid disclosing company proprietary data.

Table 17.—Production, shipments, and annual capacities of metallic abrasives in the United States, by product[1]

Product	Production		Shipments		Annual capacity[2] (short tons)
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	
1984:					
Chilled iron shot and grit	W	W	W	W	W
Annealed iron shot and grit	W	W	W	W	W
Steel shot and grit	196,921	$69,653	197,946	$74,368	274,500
Other[3]	20,427	8,015	20,053	7,920	41,500
Total	217,348	77,668	217,999	82,288	XX
1985:					
Chilled iron shot and grit	W	W	W	W	W
Annealed iron shot and grit	W	W	W	W	W
Steel shot and grit	182,655	54,404	187,381	70,647	237,000
Other[3]	17,713	7,584	10,088	4,702	41,100
Total	200,368	61,988	197,469	75,349	XX

W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable.

[1]Excludes secondary (recycle) producers.

[2]Total quantity of the various types of metallic abrasives that a plant could have produced during the year, working three 8-hour shifts per day, 7 days per week, allowing for usual interruptions, and assuming adequate fuel, labor, and transportation.

[3]Includes cut wire, aluminum, stainless steel shot, and items indicated by symbol W.

Aluminum[1]

By Frank X. McCawley[2]

World production decreased in 1985 as many of the world's major producing countries slowed production in response to high inventories and low metal prices. The largest decrease was in the United States, where production decreased 15% from that of 1984. U.S. annual capacity decreased owing to the closure of three facilities. A major innovation to the domestic aluminum industry was the introduction of alumina tolling into metal by independent companies for major foreign and domestic metal corporations. Despite low prices and an oversupply of metal, new smelters came onstream and production increased in Australia, Brazil, and Canada. Foreign sources of aluminum continued to supply a large share of the U.S. market. Although U.S. exports of aluminum increased substantially, the United States remained a net importer of aluminum.

Domestic Data Coverage.—Domestic production data for aluminum are developed by the Bureau of Mines from two separate, voluntary surveys of U.S. operations. Typical of these surveys is the "Aluminum" survey. Of the 11 companies to which monthly survey requests were sent, all responded, representing 100% of the total primary aluminum production shown in tables 1, 6, and 14.

Table 1.—Salient aluminum statistics

(Thousand metric tons and thousand dollars unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Primary production	4,489	3,274	3,353	4,099	3,500
Value	$7,520,841	$5,485,121	$5,754,298	$7,319,844	$6,249,614
Price: Producer list, ingot, average cents per pound	76.0	76.0	77.8	81.0	81.0
Secondary recovery	1,394	1,466	1,564	[1]1,760	[1]1,762
Exports (crude and semicrude)	787	748	776	734	908
Imports for consumption (crude and semicrude)	848	878	1,091	1,477	1,420
Aluminum industry shipments[2]	5,644	5,090	[r]5,857	[r]6,509	6,385
Consumption, apparent	4,614	4,370	5,035	5,279	5,174
World: Production	[r]15,079	[r]13,408	13,910	[p]15,664	[e]15,289

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Beginning with 1984, metallic recovery from purchased, tolled, or imported new and old aluminum scrap expanded for full industry coverage. Prior to 1984, aluminum recovered from all types of purchased scrap not expanded for full industry coverage.
[2]To domestic industry.

Legislation and Government Programs.—The Environmental Protection Agency (EPA) and the Aluminum Association tentatively agreed to new guidelines to regulate the effluents from aluminum plants discharged into water. The original regulations promulgated by EPA in March 1984, under the Clean Water Act, placed strict limits on the discharge of effluents from nonferrous metals plants including primary aluminum smelters, secondary aluminum smelters, and aluminum fabricating plants. The revised guidelines would increase the limits for fluoride and other pollutants from primary plants and for metals, including aluminum, chromium, and zinc, from casting, cooling, and demagging operations from secondary plants. The Aluminum Association in a consolidated lawsuit with other metal companies and metal associations had filed petitions to review the original regulations. In agreeing to the new EPA guidelines, the aluminum companies and the Aluminum Association agreed to dismiss their lawsuit. EPA was to issue new regulations, which affected only the aluminum industry.

Under a proposal for the fiscal year 1987 budget, the Office of Management and Budget proposed the sale of the Bonneville Power Administration (BPA) to private interests. The plan was part of a larger scheme that proposed selling several Government assets to private interests.

The General Accounting Office (GAO) study (GAO/RCED-86-23) on the use of recycled U.S. Department of Defense aluminum to meet the National Defense Stockpile (NDS) goal found that with reprocessing and changes in the stockpile procedures, Department of Defense scrap aluminum could make about a 1% increase per year in meeting the aluminum stockpile goal. However, cost of recycling would be about the same as purchasing like amounts of aluminum on the open market.

On July 8, the President approved the National Security Council (NSC) recommendations for modernizng the strategic and critical materials stockpile. Under the NSC proposal, the NDS would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. The status of aluminum was deferred until further detailed studies could be made. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984. The current aluminum metal goal is 700,000 short tons but there is only 2,080 tons in the stockpile.

DOMESTIC PRODUCTION

Primary.—Domestic primary production was about 3.5 million metric tons in 1985. As 1985 began, soft metal ingot prices and high world inventories continued to hurt the domestic industry. U.S. producers that began reducing production in mid-1984 to offset declining prices and high inventories continued to shut down production capacity throughout the year. In late 1985, U.S. annual smelter capacity was reduced to 4.7 million tons because of the permanent closures of Reynolds Metals Co.'s 61,700-ton-per-year smelter at Arkadelphia, AR, the 113,400-ton-per-year smelter at Jones Mills, AR, and the permanent closure of Aluminum Co. of America's (Alcoa) 14,500-ton-per-year experimental chloride plant at Palestine, TX. The Arkadelphia and Jones Mills plants both stopped production of metal in October 1985, and the Palestine plant stopped operation in 1983. By yearend 1985, the operating rate of U.S. primary smelters was about 66.4% with 1.74 million tons of the 4.7 million tons of annual capacity shut down compared with 78.2% of the 4.9 million tons operational at yearend 1984. The status of the primary industry at yearend 1985 was 6 smelters permanently closed, 5 smelters temporarily closed, 18 operating at reduced capacity, and 4 operating at full capacity.

Throughout the year, production capacity was shut down as follows: Alcoa shut down a total of about 431,500 tons of annual capacity at Alcoa, TN, Evansville, IN, Massena, NY, Rockdale, TX, Vancouver, WA, and Wenatchee, WA; Kaiser Aluminum & Chemical Corp. shut down 55,300 tons of capacity at Tacoma, WA, and Ravenswood, WV; Reynolds shut down a total of 245,000 tons at Listerhill, AL, Arkadelphia and Jones Mills, AR, Troutdale, OR, and Longview, WA; Alcan Aluminum Corp. shut down 54,400 tons per year at Sebree, KY; and Alumax Inc. shut down a total of 54,400 tons at Mount Holly, SC, and Frederick, MD. Additional closures during the year were 65,300 tons of annual capacity at Commonwealth Aluminum Corp.'s Goldendale, WA, and 100,200 tons per year of capacity at Noranda Aluminum Inc.'s New Madrid, MO, smelters.

The U.S. aluminum producers made several important adjustments that could change the future domestic aluminum industry. In general, companies moved into new ventures such as fiber optics, ceramics, plastics and vinyls, electronics, and other nonaluminum industries. In addition, the companies were relying less on the production of primary ingot, and instead were concentrating on plans for increasing operations in the fabrication end of the industry. In December, Alcoa announced plans to close down 350,000 tons per year of unspecified primary capacity. Reportedly, future supplies of metal could come from outside sources.

Consolidated Aluminum Corp., St. Louis, MO, a subsidiary of Swiss Aluminium Ltd. (Alusuisse), Zurich, Switzerland, reorganized its U.S. operations into two groups, a basic aluminum business and a value-added diversified organization. The basic group was made responsible for production and sale of ingot and mill products from its two-thirds interest in the Ormet Corp. plants in Hannibal, OH, and its wholly owned plant at New Johnsonville, TN. The diversified group included the Madison, IL, aluminum and magnesium extrusion and rolling mill; a lamination plant at Iuka, MS; a metal filtration-metal treatment plant at Hendersonville, SC; and the Benton, KY, composite plant. The reorganization of Consolidated Aluminum from primary production to value-added fabrication apparently followed the lead of its parent Swiss company, Alusuisse.

In March, BPA provided the Direct Service Industries (DSI), which included the aluminum producers of the Pacific Northwest, a 4-month incentive rate of 19.8 mills per kilowatt hour (mills/kW•h) providing the companies purchased a total of 2,282 megawatts (MW) of power from March 1 to July 1. This rate replaced the incentive rate of 22.7 mills/kW•h that ended February 28. In September, BPA again provided an incentive rate to DSI customers, mainly, to maintain the continued operation of the aluminum smelters, which consumed about 30% of BPA's power output, and to protect BPA revenues. The 10-month incentive rate, effective September 1, reduced the power rate to an average of 18.8 mills/kW•h dependent on a guaranteed usage of 2,050 MW. The incentive rate was to run from September 1, 1985, to June 30, 1986, and reduced the standard rate of 23.5 mills/kW•h, about 6 mills from September through March, 3 mills in April, and 1 mill in May and June.

In a long-range plan to provide stable power to the aluminum and other industries of the Pacific Northwest at competitive costs, BPA conducted a DSI Option Study in early 1985. The final report was released in June 1985, and based on the study, BPA explored three courses of action. BPA considered (1) a variable rate structure for the industry that would respond to the fluctuations in the market price for aluminum, (2) establishment of a joint partnership program for aluminum plant conservation-modernization to finance the modernization of aluminum smelters and stabilize BPA revenues, and (3) the establishment of a functional long-term link between the BPA rate for Industrial Firm (IP) power sold to industries and the weighted average BPA rate charged for Priority Firm (PF) power sold to preference customers, mainly regional utility organizations. One other option considered was no action. Final decisions on these proposals would be made by BPA after public comments and the Environmental Impact Statement have been completed.[3] In December, BPA proposed an initial variable sliding rate scale of 13.8 to 29.1 mills/kW•h tied to the world market price of aluminum.

Reynolds announced that it would terminate its 8-year power contract with the Arkansas Power and Light Co. (AP&L) on January 1, 1987, rather than pay higher electric costs imposed by the utility company following the July 1985 startup of a nuclear powerplant at Grand Gulf, MS. AP&L was required to absorb about 21% of the nuclear plant cost as a participant in a four-utility consortium, and Reynolds reportedly was required to share costs of any new AP&L generating capacity. Estimated costs to Reynolds of the increase in power was about $20 million per year. The increased power costs were a factor in the shutdown of the Arkadelphia and Jones Mills, AR, smelters in October and the permanent closing of the plants in November.

In November, National-Southwire Aluminum Co. announced that it would petition the Kentucky Public Service Commission to reduce the cost from 28 to 22 mills/kW•h for power it purchases from the Big Rivers Electric Corp., Henderson, KY, for the 172,000-ton-per-year Hawesville, KY, smelter. National-Southwire reportedly alleged that Big Rivers is paying too much for coal. National-Southwire also indicated that it could be subsidizing the Alcan 163,000-ton-per-year Sebree, KY, smelter power payments as a result of an Alcan-Big Rivers agreement for linking power costs to the London Metal Exchange (LME) price for metal. Other factors affecting Big Rivers was the notification by the Rural Electrification Administration (REA) that the utility was to pay back $1.1 billion in loans obtained from REA since 1961. Big Rivers was further saddled with a $756 million debt for a coal-fired powerplant it does not need. About 75% of the power sold by Big Rivers was purchased by the National-Southwire Hawesville and Alcan Sebree smelters, and discussions among all parties concerned were expected to be long and detailed. The ultimate operations of the two smelters could rest on the final decisions on power rates.

Alumax, in November, requested a rehearing on the September 1 ruling by the Maryland Public Service Commission that allowed Potomac Edison Co. to increase power costs for the 160,000-ton-per-year Eastalco smelter at Frederick, MD. A rate increase from 24 to 24.8 mills/kW•h was granted Potomac Edison and an additional increase to 26.4 mills/kW•h to cover charges associated with the startup of a new power station was under consideration. In December, Alumax signed an agreement with the State-owned South Carolina Santee Cooper Power Co. electric utility to reduce the power rate for the 181,000-ton-per-year Mount Holly, SC, smelter from 32.9 mills/kW•h to a low of 26 mills/kW•h in the years 1986 to 1991 based on the market price of aluminum ingot. The agreement followed a decision by Santee Cooper that granted Mount Holly a decrease to 30 mills/kW•h for the fiscal year beginning July 1. According to the agreement, Alumax must operate the smelter at 290 MW, to receive a 26-mill/kW•h rate, otherwise the rate would increase proportionally with a decrease in demand to 243 MW. Furthermore, the discount would only apply when the average monthly market price is 62 cents per pound or below. Between 62 cents and 72 cents, there would be no discount, and above 72 cents, Alumax would repay the cost discount. During the period 1991 through 1993, Alumax would be obligated to repay the discounts.

The expansion of the Reynolds' extrusion plant at Torrance, CA, including the installation of a new 3,150-ton extrusion press was completed in October. The expansion and modernization project increased the annual capacity of the plant from 12,000 to 21,500 tons. The new press is computer-controlled and is capable of producing seamless tubing. After a 2-1/2-month strike, production resumed at Reynolds' aluminum extrusion plant in Grand Rapids, MI, following ratification of a new contract by the 350 hourly workers.

National Aluminum Corp., a subsidiary of National Intergroup Inc., announced plans to construct a new extrusion plant in Anniston, AL. The plant would contain several extrusion presses and a paint line and was expected to be operational by fall 1986. National Aluminum has other extrusion plants at Murraysville, PA, and Indianapolis, IN.

Mitsubishi Aluminium Co. of Japan and Thermal Components Inc., Montgomery, AL, announced the formation of an equity joint venture, Thermalex Inc., to construct a new 36,000-ton-per-year aluminum extrusion plant at Thermal Components facility in Montgomery. The plant, including a 1,650-ton press, heating furnace, and related equipment was expected to be transferred from Mitsubishi Corp.'s Fuji, Shizuoka Prefecture, plant for installation at the Montgomery facility. Production was expected by the summer of 1986.

Pechiney Corp., the U.S. subsidiary of Pechiney, France, was to acquire International Container Corp.'s aluminum aerosol can mill at Waterbury, CT. A new company, Pechiney-Cebal Corp., would operate the mill as a subsidiary of Pechiney Corp. The mill had an annual capacity of 30 million aerosol cans but was expected to be expanded to a capacity of 60 million cans.

Alcan Cable, a division of Alcan Aluminum, announced the $600,000 expansion and modernization of its aluminum cable facility at Williamsport, PA. The expansion included a new metal processing furnace and related equipment. Nichols-Homeshield, Aurora, IL, announced the expansion of its aluminum wire operations in Florence, AL, by consolidating production into one large facility. A small wire production line, which operated at a plant in Davenport, IA, was being moved to the Alabama plant.

Norandal USA Inc., a subsidiary of Noranda Aluminum, completed its acquisition of the Revere Copper and Brass Inc.'s aluminum rolling mill at Scottsboro, AL, as part of its program to increase its value-added products involvement. The sale of the mill by Revere required the approval of the bankruptcy court of New York. Revere had been operating the mill under chapter 11 of the Federal Bankruptcy Code, and sale of the mill as part of Revere's reorganization plan required approval of the court overseeing the reorganization. The mill would continue to produce sheet and plate with primary aluminum supplied by Noranda's 204,000-ton-per-year smelter at New Madrid, MO. The Revere Scottsboro primary smelter was not included in the transaction.

Commonwealth Aluminum was incorporated as the U.S. subsidiary of Comalco Pty. Ltd., Australia, which in late 1984 purchased most of the aluminum operations of Martin Marietta Corp. They included a 168,000-ton-per-year Goldendale, WA, primary smelter; a 109,000-ton-per-year rolling mill and 204,000-ton-per-year recycling plant at Lewisport, KY; an alumina unloading port at Portland, OR; and other assets.

Newly formed Northwest Aluminum Co., a group headed by a former executive director of BPA for DSI companies, was granted the exclusive rights to negotiate the purchase of Martin Marietta's 82,000-ton-per-year The Dalles, OR, smelter. The smelter was shut down by Martin Marietta in December 1984 when no buyer for the operation was found.

In September, Atlantic Richfield Co. (ARCO) sold the ARCO Aluminum Co.'s 163,000-ton-per-year Columbia Falls, MT, aluminum smelter to a group of investors headed by a former ARCO executive. The group, Montana Aluminum Investors Corp., began operation of the smelter through the Columbia Falls Aluminum Co. The plant was purchased with financial underwriting from the Montana Board of Investments under a provision that overhead, salaries, hourly labor costs, and BPA energy costs were reduced. The new management announced the smelter would be converted into an international alumina tolling facility following the complete processing of the existing ARCO inventory of alumina in April 1986.

In September, a group of investors headed by Joseph A. Frates, who successfully acquired Kaiser Steel Corp. in 1984, began an attempt to take over Kaiser, Oakland, CA, by filing an intent with the Securities Exchange Commission. The group reportedly announced that it would dispose of all Kaiser assets except the aluminum and industrial chemicals. Kaiser rejected the Frates group's initial offer; however, in December, the group had acquired 14.4% of Kaiser and was offering shareholders $20 per share consisting of $7 cash and $13 in securities. The group also announced that it would consider replacing the company's directors with their own selection. By yearend, it was apparent a major proxy fight was forming between Kaiser and the Frates group.

Alcan and Reynolds announced that Reynolds would purchase Alcan's Metals Goods Div. The division, housed in St. Louis, MO, operated 27 service centers, which distributed aluminum, nickel, stainless steel, and steel. Reynolds indicated the centers would be incorporated into its Reynolds Aluminum Supply Co. Div., which operated distribution service centers in the Southeast, lower Midwest, and West.

In March, Kaiser renegotiated a new 3-year labor contract with the United Steelworkers of America (USWA) for a reduction in wages and benefits. Kaiser's new labor contract replaced the master contract that would have expired on May 31, 1986. The contract called for a total wage and benefit cost reduction of an average of $4.50 per hour, the loss of some paid holidays, and modifications to vacation time and health insurance benefits. In return, the workers would receive a series of preferred stocks that would accumulate in a trust. About 6,500 workers were covered by the contract, which was expected to save the company about $50 million per year.

Table 2.—Primary aluminum production capacity in the United States, by company

Company	Yearend capacity (thousand metric tons) 1975	1985	1985 ownership (percent)
Alcan Aluminum Corp.:			
Sebree, KY[1]	109	163	Alcan Aluminium Ltd., 100%.
Alumax Inc.:			
Ferndale, WA (Intalco)[2]	236	254	AMAX Inc., 50%; Mitsui & Co., 45%; Nippon Steel Corp., 5%.
Frederick, MD (Eastalco)[2]	160	160	Do.
Mount Holly, SC	179	181	Do.
Total	575	595	
Aluminum Co. of America:			
Alcoa, TN	245	200	Aluminum Co. of America, 100%.
Badin, NC	109	115	Do.
Evansville, IN (Warrick)	254	270	Do.
Massena, NY	122	205	Do.
Palestine, TX[3]	--	--	Do.
Point Comfort, TX	163	--	Do.
Rockdale, TX	258	310	Do.
Vancouver, WA	104	110	Do.
Wenatchee, WA	163	205	Do.
Total	1,418	1,415	
Columbia Falls Aluminum Co.:			
Columbia Falls, MT[4]	163	163	Montana Aluminum Investors Corp., 100%.
Commonwealth Aluminum Corp.:			
Goldendale, WA[5]	109	168	Comalco Pty. Ltd., 100%.
Consolidated Aluminum Corp.:			
Lake Charles, LA[6]	33	--	Swiss Aluminium Ltd., 100%.
New Johnsonville, TN	128	131	Do.
Total	161	131	
Kaiser Aluminum & Chemical Corp.:			
Chalmett, LA	236	236	Kaiser Aluminum & Chemical Corp., 100%.
Mead, WA (Spokane)	200	200	Do.
Ravenswood, WV	148	148	Do.
Tacoma, WA	73	73	Do.
Total	657	657	
Martin Marietta Aluminum Inc.:			
The Dalles, OR	82	82	Martin Marietta Corp., 87.2%; private interests, 12.8%.
National-Southwire Aluminum Co.:			
Hawesville, KY	163	172	National Steel Corp., 50%; Southwire Co., 50%.
Noranda Aluminum Inc.:			
New Madrid, MO	64	204	Noranda Mines Ltd., 100%.
Ormet Corp.:			
Hannibal, OH	236	245	Consolidated Aluminum Corp., 66%; Revere Copper and Brass Inc., 34%.
Revere Copper and Brass Inc.:			
Scottsboro, AL	103	105	Revere Copper and Brass Inc., 100%.
Reynolds Metals Co.:			
Arkadelphia, AR	62	--	Reynolds Metals Co., 100%.
Corpus Christi, TX	103	--	Do.
Jones Mills, AR	113	--	Do.
Listerhill, AL	183	183	Do.
Longview, WA	190	191	Do.
Massena, NY	114	114	Do.
Troutdale, OR	118	118	Do.
Total	883	606	
Grand total	4,723	4,706	

[1]Purchased from ARCO Metals Co. in 1985, which purchased from Anaconda Aluminum Co. in 1982.
[2]Alumax Inc. purchased equity share from Howmet Inc. in 1983.
[3]Experimental 16,000-ton-per-year chloride reduction plant opened in 1976, closed Dec. 1985.
[4]Purchased from ARCO Metals in 1985, which purchased from Anaconda Aluminum in 1982.
[5]Purchased from Martin Marietta Aluminum Inc. in 1985.
[6]Sold to Reynolds Metals Co. in 1983.

Secondary.—Consumption of purchased new and old aluminum scrap was about 1.9 million tons, the same as that of 1984. Recycled used beverage cans (UBC) continued to be a major source of old scrap. According to the Aluminum Association, 33.1 billion aluminum cans were recycled in 1985 representing about 51% of aluminum cans shipped.[4] The recycling effort of UBC represented an estimated energy savings of about 9.5 billion kilowatts of electricity.

In September, Alcoa opened a new aluminum UBC plant in Edison, NJ, which processed cans from 11 Eastern States. The plant was expected to sort and bale about 36 million cans per year. The recycled cans were sent to Alcoa's Tennessee facilities for remelting and fabrication into can sheet stock.

Allied Metals Co., Chicago, IL, delivered its first 37,000-pound shipment of molten metal from its Division Street plant to a diecasting facility in August. The plant, acquired from Harco Aluminum Co. during a bankruptcy sale in 1984, was modernized for molten metal operation with a new 190,000-pound-capacity reverberatory furnace, and three 18,000-pound-capacity holding vessels to accommodate the molten metal, and a 60-short-ton-capacity crane to load the vessels on custom-made trailers. The new equipment reportedly reduced the cost of heating gas per pound of metal produced.

Alumax, San Mateo, CA, closed its Rockwell, TX, secondary smelter at yearend 1984 for an indefinite period of time reportedly because of an oversupply of primary aluminum ingot in the company's system. The Rockwell smelter, acquired as part of Howmet Aluminum Corp., a subsidiary of Pechiney, in 1983, was producing about 75 million pounds of rolling ingot and billet annually for Alumax's Lancaster, PA, rolling mill and Magnolia, AR, extrusion plants, respectively.

Charles Batchelder Co. Inc., a Connecticut secondary aluminum smelter, asked creditors to delay their request for payments in order to avoid filing a chapter 11 petition for bankruptcy protection. The company's financial problems were the result of an explosion in April 1984 that caused a loss of production for a long period and a low volume of sales after production resumed. The company was seeking a loan of about $3 million to help reestablish its financial condition.

Huron Valley Steel Corp., Beltsville, MI, ceased production of secondary aluminum ingot at its Trenton, MI, facility. The plant produced about 36 million pounds of secondary aluminum from scrap. The company was expected to remain in the secondary aluminum business by providing aluminum scrap to the U.S. Reduction Co. for processing at the Toledo, OH, facility.

A new secondary aluminum smelter was scheduled to open in Hammond, IN, by Standard Alloys Corp. The corporation, headed by a former officer of Wabash Alloys Inc., expected secondary aluminum sales to exceed $35 million per year.

CONSUMPTION

Apparent consumption of aluminum metal decreased by less than 2% in 1985 compared with that of 1984. Although the largest consumer of aluminum in 1985 was the containers and packaging industry, accounting for 27% of the total shipments, the increase in consumption of metal by this sector was less than 2%. The low growth rate was, in part, the result of improved technology to produce a thinner walled and lighter weight beverage can.

Table 3.—U.S. consumption of and recovery from purchased new and old aluminum scrap,[1] by class

(Metric tons)

Class	Consumption	Calculated recovery	
		Aluminum	Metallic
1984			
Secondary smelters	792,907	633,287	684,500
Primary producers	782,105	654,642	701,926
Fabricators	192,288	164,342	175,949
Foundries	94,141	78,482	84,417
Chemical producers	37,217	16,707	17,277
Total	1,898,658	1,547,460	1,664,069
Estimated full industry coverage	2,010,000	1,637,000	1,760,000
1985			
Secondary smelters	853,722	702,136	757,674
Primary producers	725,890	611,371	655,250
Fabricators	178,494	154,310	165,074
Foundries	93,680	78,209	84,163
Chemical producers	26,758	12,246	13,113
Total	1,878,544	1,558,272	1,675,274
Estimated full industry coverage	1,978,000	1,638,000	1,762,000

[1]Excludes recovery from other than aluminum-base scrap.

Table 4.—U.S. stocks, receipts, and consumption of purchased new and old aluminum scrap[1] and sweated pig in 1985

(Metric tons)

Class of consumer and type of scrap	Stocks, Jan. 1	Net receipts[2]	Consumption	Stocks, Dec. 31
Secondary smelters:				
New scrap:				
Solids	r11,979	213,196	208,819	16,356
Borings and turnings	r7,211	124,742	125,130	6,823
Dross and skimmings	r7,741	60,119	63,537	4,323
Other[3]	r2,909	32,695	34,682	922
Total	r29,840	430,752	432,168	28,424
Old scrap:				
Castings, sheet, clippings	r7,193	148,400	148,593	7,000
Aluminum-copper radiators	r1,265	15,381	15,429	1,217
Aluminum cans	r6,816	[4]173,495	[4]178,083	2,228
Other[5]	r37	2,231	2,234	34
Total	r15,311	339,507	344,339	10,479
Sweated pig	r9,324	75,249	77,215	7,358
Total secondary smelters	r54,475	845,508	853,722	46,261
Primary producers, foundries, fabricators, chemical plants:				
New scrap:				
Solids	r17,373	443,826	438,738	22,461
Borings and turnings	192	24,473	24,559	106
Dross and skimmings	r690	22,462	22,766	386
Other[3]	r7,209	46,751	48,487	5,473
Total	r25,464	537,512	534,550	28,426
Old scrap:				
Castings, sheet, clippings	r959	52,117	52,162	914
Aluminum-copper radiators	11	1,532	1,515	28
Aluminum cans	25,956	377,232	392,407	10,781
Other[5]	2,742	19,467	20,467	1,742
Total	r29,668	450,348	466,551	13,465
Sweated pig	r654	23,363	23,721	296
Total primary producers, etc	r55,786	1,011,223	1,024,822	42,187

See footnotes at end of table.

Table 4.—U.S. stocks, receipts, and consumption of purchased new and old aluminum scrap[1] and sweated pig in 1985 —Continued

(Metric tons)

Class of consumer and type of scrap	Stocks, Jan. 1	Net receipts[2]	Consumption	Stocks, Dec. 31
All scrap consumed:				
New scrap:				
Solids	r29,352	657,022	647,557	38,817
Borings and turnings	r7,403	149,215	149,689	6,929
Dross and skimmings	r8,431	82,581	86,303	4,709
Other	r10,118	79,446	83,169	6,395
Total new scrap	r55,304	968,264	966,718	56,850
Old scrap:				
Castings, sheet, clippings	r8,152	200,517	200,755	7,914
Aluminum-copper radiators	r1,276	16,913	16,944	1,245
Aluminum cans	r32,772	550,727	570,490	13,009
Other	2,779	21,698	22,701	1,776
Total old scrap	r44,979	789,855	810,890	23,944
Sweated pig	r9,978	98,612	100,936	7,654
Total of all scrap consumed	r110,261	1,856,731	1,878,544	88,448

rRevised.
[1]Includes imported scrap. According to reporting companies, 6.63% of total receipts of aluminum-base scrap, or 123,060 metric tons, was received on toll arrangements.
[2]Includes inventory adjustment.
[3]Includes data on foil, can stock clippings, and other miscellaneous.
[4]Used beverage cans toll treated for primary producers are included in secondary smelter tabulation.
[5]Includes municipal wastes (includes litter) and fragmentized scrap (auto shredder).

Table 5.—Production and shipments of secondary aluminum alloys by independent smelters in the United States

(Metric tons)

	1984		1985	
	Production	Net shipments[1]	Production	Net shipments[1]
Die-cast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	110,904	111,549	111,361	111,042
380 and variations	286,458	285,374	279,892	278,868
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	30,188	30,487	26,475	27,474
No. 12 and variations	W	W	W	W
No. 319 and variations	53,647	53,184	43,940	44,720
F-132 alloy and variations	13,535	13,296	12,116	12,419
Al-Mg alloys	548	632	292	410
Al-Zn alloys	4,095	4,309	5,154	4,955
Al-Si alloys (0.6% to 2.0% Cu)	4,293	4,337	5,593	5,490
Al-Cu alloys (1.5% Si, maximum)	2,573	2,512	1,807	2,113
Al-Si-Cu-Ni alloys	2,406	2,250	1,012	1,012
Other	481	495	664	653
Wrought alloys: Extrusion billets	107,292	105,684	97,168	96,929
Miscellaneous:				
Steel deoxidation	23,778	23,084	27,735	28,010
Pure (97.0% Al)	168	169	168	168
Aluminum-base hardeners	1,557	1,566	1,236	1,275
Other[2]	6,799	6,788	14,504	14,305
Total	648,722	645,716	629,117	629,843
Less consumption of materials other than scrap:				
Primary aluminum	41,443	--	45,034	--
Primary silicon	35,093	--	25,028	--
Other	2,316	--	2,227	--
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot[3]	569,870	XX	556,828	XX

W Withheld to avoid disclosing company proprietary data; included with "Sand and permanent mold: Other."
XX Not applicable.
[1]Includes inventory adjustment.
[2]Includes other die-cast alloys and other miscellaneous.
[3]No allowance made for melt-loss of primary aluminum and alloying ingredients.

Table 6.—U.S. apparent aluminum supply and consumption

(Thousand metric tons)

	1981	1982	1983	1984	1985
Primary production	4,489	3,274	3,353	4,099	3,500
Change in stocks:[1] Aluminum industry	-694	+184	+547	-388	+312
Imports	848	878	1,091	1,477	1,420
Secondary recovery:[2]					
New scrap	1,031	884	953	935	912
Old scrap	758	782	820	825	850
Total supply	6,432	6,002	6,764	6,948	6,994
Less total exports	787	748	776	734	908
Apparent aluminum supply available for domestic manufacturing	5,645	5,254	5,988	6,214	6,086
Apparent consumption[3]	4,614	4,370	5,035	5,279	5,174

[1]Positive figure indicates a decrease in stocks; negative figure indicates an increase in stocks.
[2]Metallic recovery from purchased, tolled, or imported new and old aluminum scrap expanded for full industry coverage.
[3]Apparent aluminum supply available for domestic manufacturing less recovery from purchased new scrap (a measure of consumption in manufactured end products).

Table 7.—Distribution of end-use shipments of aluminum products in the United States, by industry

Industry	1983		1984		1985[p]	
	Quantity (thousand metric tons)	Percent of grand total	Quantity (thousand metric tons)	Percent of grand total	Quantity (thousand metric tons)	Percent of grand total
Containers and packaging	1,777	[r]27.7	1,829	26.1	1,863	26.9
Building and construction	1,302	20.3	1,295	18.5	1,381	19.9
Transportation	[r]1,062	[r]16.5	1,370	19.5	1,364	19.7
Electrical	589	9.2	677	9.7	642	9.3
Consumer durables	478	[r]7.4	502	7.2	477	6.9
Machinery and equipment	353	5.5	375	5.4	377	5.4
Other markets	[r]261	[r]4.1	274	3.9	265	3.8
Statistical adjustment	[r]+35	[r].5	+187	2.7	+16	.2
Total to domestic users	[r]5,857	91.2	6,509	93.0	6,385	92.1
Exports	563	8.8	488	7.0	546	7.9
Grand total	[r]6,420	100.0	6,997	100.0	6,931	100.0

[p]Preliminary. [r]Revised.

Source: The Aluminum Association Inc.

Table 8.—U.S. net shipments[1] of aluminum wrought and cast products, by producers

(Metric tons)

	1983	1984	1985[p]
Wrought products:			
Sheet, plate, foil	[r]3,248,948	3,259,163	3,288,544
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing	[r]1,037,526	1,182,458	1,240,482
Rolled and continuous-cast rod and bar; wire	[r]423,024	451,493	378,700
Forgings (including impacts)	52,711	65,398	67,180
Powder, flake, paste	[r]35,675	44,758	48,670
Total	[r]4,797,884	5,003,270	5,023,576
Castings:			
Sand	[r]75,503	89,651	120,736
Permanent mold	[r]137,122	160,566	151,745
Die	[r]592,475	679,159	565,017
Other	[r]55,881	61,092	36,850
Total	[r]860,981	990,468	874,348
Grand total	[r]5,658,865	5,993,738	5,897,924

[p]Preliminary. [r]Revised.
[1]Net shipments derived by subtracting the sum of producers' domestic receipts of each mill shape from the domestic industry's gross shipments of that shape.

Source: U.S. Department of Commerce.

Table 9.—Distribution of wrought products in the United States

(Percent)

	1983	1984	1985[p]
Sheet, plate, foil:			
Nonheat-treatable	[r]56.9	53.8	55.4
Heat-treatable	3.1	3.6	2.7
Foil	7.8	7.8	7.3
Rolled and continuous-cast rod and bar; wire:			
Rod, bar, wire	2.3	2.3	1.5
Cable and insulated wire	6.5	6.7	6.1
Extruded products:			
Rod and bar	[r]1.1	1.1	1.3
Pipe and tubing	1.3	1.6	2.3
Shapes	[r]18.1	19.9	21.1
Tubing:			
Drawn	.6	.5	NA
Welded	.5	.5	NA
Powder, flake, paste	.7	.9	1.0
Forgings (including impacts)	1.1	1.3	1.3
Total	100.0	100.0	100.0

[p]Preliminary. [r]Revised. NA Not available.

Source: U.S. Department of Commerce.

STOCKS

Inventories of aluminum ingot, mill products, and scrap at reduction and other processing plants as reported by the Bureau of Industrial Economics, U.S. Department of Commerce, decreased from about 2.65 million tons at yearend 1984 to about 2.35 million tons at yearend 1985.

PRICES

The producer list price for 99.5%-pure aluminum ingots remained at 81 cents per pound throughout 1985. Several domestic producers continued to maintain the transaction price, a price more comparable with the market or spot price. At yearend 1984, the average weekly market price for aluminum ingot, usually 99.7% pure, as published by Metals Week (McGraw-Hill), was 50.2 cents per pound. By yearend January 1985, the price had risen to about 52 cents. The price remained relatively stable until April when it began to soften, reaching about 46.5 cents by July 1. It remained weak during the summer and early autumn before declining to a 1985 low of 45 cents in mid-November. During the last half of November and during December, the market price increased rapidly, closing out the year at a weekly average of about 53 cents per pound. Both the LME and New York Commodity Exchange (COMEX) prices for aluminum futures followed the same general trend as the market prices. However, the LME cash price, as published by Metals Week, was usually about 2 to 3 cents lower than the U.S. market price until November, when the difference in prices was about 4 cents per pound. COMEX prices, when compared with market prices, were usually 2 to 4 cents lower per pound for metal with short delivery dates and about 1 to 2 cents higher per pound with longer delivery dates. Producer U.S. transaction prices, as published by Metals Week, were usually plus or minus 0.5 cent per pound of the market price. The following table summarizes aluminum prices at selected dates during the year, in cents per pound:

	COMEX 1[1]	COMEX 2[1]	COMEX 3[1]	LME (cash)	U.S. market	U.S. transaction
1984: December 31	47.21	47.92	51.82	47.64	49.75-50.75	49.72
1985:						
January 28	49.48	49.99	53.62	49.63	50.75-52.00	51.33
February 25	49.25	49.84	53.54	49.74	51.25-52.25	51.54
March 25	49.15	49.69	53.89	49.83	51.25-52.50	51.82
April 29	48.65	49.18	52.76	50.72	52.25-53.00	52.71
May 27	48.11	48.58	52.07	50.11	51.75-52.50	51.93
June 24	44.83	45.27	48.30	46.67	47.75-48.75	48.27
July 29	44.52	44.97	48.29	45.77	47.00-48.00	47.04
August 26	44.97	45.46	48.67	46.26	47.75-48.35	46.78
September 30	43.09	43.72	47.20	44.60	46.25-46.75	45.69
October 28	42.96	43.47	46.67	43.55	45.50-46.00	45.44
November 25	43.63	44.17	47.18	43.39	45.25-46.00	45.66
December 30	51.03	51.49	54.64	48.76	52.00-53.50	52.21

[1]COMEX delivery positions: 1—within 1 month; 2—within 3 months; and 3—within 12 months.

Source: Metals Week.

Secondary aluminum prices, as quoted in the American Metal Market, followed a price trend similar to that of primary aluminum. Secondary aluminum alloy 360 and 413 began the year at about 68 to 70 cents per pound. In July, alloy 360 had declined to 57 to 58 cents and alloy 413 was 58 to 59 cents. Prices of these alloys began to increase about September, and by yearend, alloy 413 was 62 to 63 cents and alloy 360 was 61 to 62 cents per pound. Alloy 380 was about 3 to 4 cents per pound lower than alloys 413 and 360. Buying prices of old sheet and cast aluminum scrap ranged from a high of about 35 cents per pound in February to a low of 28 cents in July and August. UBC scrap, processed and delivered to producers, was bought throughout the year at a range of from 29 to 39 cents per pound.

FOREIGN TRADE

Exports of all forms of aluminum from the United States increased substantially from the 1984 level. Canada, Japan, and Mexico accounted for most of the increase, reflecting increased shipments of crude metal and scrap to Japan and of crude metal to Canada and Mexico. Exports of plates, sheets, bars, etc., decreased from 1984, reflecting a decrease of shipments to the United Kingdom. Imports of aluminum in all forms decreased slightly from those of 1984, but total imports remained substantially greater than the quantity of aluminum exported. In descending order, the major aluminum shipping countries to the United States were Canada, Japan, Venezuela, Brazil, Belgium-Luxembourg, the United Arab Emirates, and Argentina. Canada provided most of the ingot and scrap metal while Japan, Venezuela, and Belgium-Luxembourg supplied most of the semicrude forms. Bahrain, a large supplier of ingots in 1984, reduced its supply to the United States by about 60%.

U.S. tariff rates in effect during 1985 for aluminum products from countries with most-favored-nation status were as follows:

Item	TSUS No.	Import duty
Unwrought metal (in coils)	618.01	2.8% ad valorem.
Unwrought (other than Si-Al alloys)	618.02	0.2 cent per pound.
Wrought (bars, plates, sheets, strip)	618.25	3% ad valorem.
Waste and scrap	618.10	2% ad valorem.

Table 10.—U.S. exports of aluminum, by class

Class	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	259,598	$396,798	347,292	$441,598
Scrap	258,404	275,686	374,646	350,669
Plates, sheets, bars, etc.	198,399	496,841	167,874	411,337
Castings and forgings	11,590	69,845	12,408	74,498
Semifabricated forms, n.e.c	5,822	34,259	5,656	32,984
Total	733,813	1,273,429	907,876	1,311,086
Manufactures:				
Foil and leaf	21,369	33,320	19,497	28,800
Powders and flakes	3,219	11,951	2,492	9,838
Wire and cable	4,824	14,535	5,619	15,358
Total	29,412	59,806	27,608	53,996
Grand total	763,225	1,333,235	935,484	1,365,082

Source: Bureau of the Census.

Table 11.—U.S. exports of aluminum, by country

Country	Metals and alloys, crude: Quantity (metric tons)	Metals and alloys, crude: Value (thousands)	Plates, sheets, bars, etc.[1]: Quantity (metric tons)	Plates, sheets, bars, etc.[1]: Value (thousands)	Scrap: Quantity (metric tons)	Scrap: Value (thousands)	Total: Quantity (metric tons)	Total: Value (thousands)
1984:								
Argentina	44	$197	119	$717	18	$17	181	$931
Australia	1,517	2,494	1,537	6,642	339	445	3,393	9,581
Belgium-Luxembourg	10	25	495	2,441	1,632	1,610	2,137	4,076
Brazil	278	1,404	1,090	5,589	270	549	1,638	7,542
Canada	17,356	34,324	130,978	335,468	21,630	23,794	169,964	393,586
Chile	165	260	88	436	139	218	392	914
Colombia	134	544	173	1,537	6	20	313	2,101
Germany, Federal Republic of	99	760	1,894	10,296	5,881	5,894	7,874	16,950
Hong Kong	3,370	4,703	375	1,932	231	322	3,976	6,957
Israel	115	492	2,553	13,135	28	73	2,696	13,700
Italy	40	272	4,967	17,703	2,823	2,820	7,830	20,795
Japan	139,717	209,866	3,517	14,561	170,596	184,264	313,830	408,691
Korea, Republic of	21,166	28,784	976	4,369	1,168	1,400	23,310	34,553
Mexico	15,845	25,222	21,865	50,487	32,056	35,638	69,766	111,347
Netherlands	7,851	10,033	1,705	7,893	3,780	3,512	13,336	21,438
Taiwan	14,519	19,367	975	8,980	16,193	13,287	31,687	41,634
United Kingdom	113	702	21,774	49,296	208	274	22,095	50,272
Venezuela	66	274	8,782	22,771	2	3	8,850	23,048
Other	r37,193	r57,075	r11,948	r46,692	r1,404	r1,546	50,545	105,313
Total	259,598	396,798	215,811	600,945	258,404	275,686	733,813	1,273,429
1985:								
Argentina	38	150	132	828	57	41	227	1,019
Australia	227	600	1,110	5,605	24	37	1,361	6,242
Belgium-Luxembourg	55	39	513	2,956	2,934	2,555	3,502	5,550
Brazil	234	1,066	1,006	5,334	941	886	2,181	7,286
Canada	36,200	50,867	127,064	303,756	15,840	15,599	179,104	370,222
Chile	111	147	15	113	53	76	179	336
Colombia	33	113	1,598	3,766	21	333	1,652	4,212
Germany, Federal Republic of	288	856	1,556	9,833	4,844	4,342	6,688	15,031
Hong Kong	4,167	4,789	862	2,908	130	164	5,159	7,861
Israel	172	828	4,082	15,911	29	49	4,283	16,788
Italy	21	169	2,300	12,215	5,029	4,393	7,350	16,777
Japan	198,341	239,255	3,753	17,121	263,620	243,664	465,714	500,040
Korea, Republic of	21,065	24,729	1,485	4,420	783	770	23,333	29,919
Mexico	20,011	27,786	22,958	57,115	49,772	53,891	92,741	138,792
Netherlands	27,346	29,762	1,189	7,104	5,271	4,538	33,806	41,404
Taiwan	15,007	17,660	1,316	5,800	21,601	16,221	37,924	39,681
United Kingdom	1,414	2,170	2,923	17,046	1,581	1,556	5,918	20,772
Venezuela	50	285	5,091	13,807	2	5	5,143	14,097
Other	22,512	40,327	6,985	33,181	2,114	1,549	31,611	75,057
Total	347,292	441,598	185,938	518,819	374,646	350,669	907,876	1,311,086

rRevised.
[1]Includes castings, forgings, and unclassified semifabricated forms.

Source: Bureau of the Census.

Table 12.—U.S. imports for consumption of aluminum, by class

Class	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	881,956	$1,292,724	868,674	$1,017,453
Circles and disks	13,219	31,672	11,764	25,130
Plates, sheets, etc., n.e.c	393,738	893,013	344,943	721,308
Rods and bars	46,531	90,337	63,714	86,162
Pipes, tubes, etc	4,074	12,609	3,348	14,876
Scrap	137,675	145,748	127,501	108,625
Total	1,477,193	2,466,103	1,419,944	1,973,554
Manufactures:				
Foil	24,496	90,629	25,934	82,879
Leaf	(1)	108	(1)	108
Flakes and powders	4,673	8,601	4,480	7,593
Wire	3,017	6,633	4,238	8,123
Total	32,186	105,971	34,652	98,703
Grand total	1,509,379	2,572,074	1,454,596	2,072,257

[1]1984—aluminum leaf not over 30.25 square inches in area, 1,375,995 leaves, and aluminum leaf over 30.25 square inches in area, 85,741,332 square inches; and 1985—aluminum leaf not over 30.25 square inches in area, 1,505,626 leaves, and aluminum leaf over 30.25 square inches in area, 68,118,504 square inches.

Source: Bureau of the Census.

Table 13.—U.S. imports for consumption of aluminum, by country

Country	Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1984:								
Argentina	8,859	$13,226	4,936	$10,357	--	--	13,795	$23,583
Australia	2,329	3,749	25,921	59,152	--	--	28,250	62,901
Bahrain	39,141	30,587	288	461	--	--	39,429	31,048
Belgium-Luxembourg	948	1,389	29,781	56,210	1,731	$2,058	32,460	59,657
Brazil	44,523	68,973	15,379	28,166	--	--	59,902	97,139
Canada	603,069	906,200	68,454	156,787	91,947	99,809	763,470	1,162,796
Costa Rica	19	42	1,115	2,176	56	82	1,190	2,300
Germany, Federal Republic of	12,335	25,277	15,841	43,054	398	406	28,574	68,737
Israel	1,280	1,762	1,503	6,424	165	240	2,948	8,426
Italy	1,715	2,184	11,519	25,358	895	1,247	14,129	28,789
Japan	356	1,368	134,385	315,666	66	81	134,807	317,115
Mexico	814	589	2,623	3,895	4,367	4,742	7,804	9,226
Netherlands	1,564	2,109	6,124	22,200	1,612	2,256	9,300	26,565
South Africa, Republic of	19,662	30,056	767	1,376	35	43	20,464	31,475
Spain	18,933	27,317	4,073	8,640	--	--	23,006	35,957
United Arab Emirates	34,160	51,807	--	--	5,033	367	39,193	52,174
United Kingdom	13,132	20,530	5,765	16,982	12,444	16,470	31,341	53,982
Venezuela	37,540	46,468	36,049	57,817	11,615	10,585	85,204	114,870
Other	r41,577	r59,091	r93,039	r212,910	r7,311	r7,362	141,927	279,363
Total	881,956	1,292,724	457,562	1,027,631	137,675	145,748	1,477,193	2,466,103

See footnotes at end of table.

Table 13.—U.S. imports for consumption of aluminum, by country —Continued

Country	Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1985:								
Argentina	25,307	$29,471	4,515	$7,308	--	--	29,822	$36,779
Australia	1,346	1,752	15,401	32,792	26	$70	16,773	34,614
Bahrain	12,403	15,520	1,081	1,099	--	--	13,484	16,619
Belgium-Luxembourg	935	1,433	33,006	48,769	509	469	34,450	50,671
Brazil	41,737	46,083	6,144	10,350	--	--	47,881	56,433
Canada	675,705	773,060	48,162	97,007	101,736	86,593	825,603	956,660
Costa Rica	18	31	159	262	71	41	248	334
Germany, Federal Republic of	3,219	11,302	17,783	43,589	646	598	21,648	55,489
Israel	1,494	1,672	2,442	9,916	326	295	4,262	11,883
Italy	42	43	10,385	18,738	252	214	10,679	18,995
Japan	1,660	2,817	143,815	329,232	4	7	145,479	332,056
Mexico	90	69	1,613	2,311	5,342	4,426	7,045	6,806
Netherlands	1,498	2,616	7,256	21,659	183	182	8,937	24,457
South Africa, Republic of	15,111	18,396	790	1,291	34	36	15,935	19,723
Spain	21,265	24,886	3,119	6,013	6	4	24,390	30,903
United Arab Emirates	29,304	36,037	621	753	--	--	29,925	36,790
United Kingdom	3,078	4,415	8,838	24,647	2,673	2,376	14,589	31,438
Venezuela	7,517	7,924	54,294	63,331	6,723	5,718	68,534	76,973
Other	26,945	39,926	64,345	128,409	8,970	7,596	100,260	175,931
Total	868,674	1,017,453	423,769	847,476	127,501	108,625	1,419,944	1,973,554

[r]Revised.
[1]Includes circles, disks, rods, pipes, tubes, etc.

Source: Bureau of the Census.

WORLD REVIEW

World primary aluminum production capacity decreased slightly in 1985. Although there were significant reductions of annual capacity in Japan and the United States, they were offset by capacity expansions in Australia, Brazil, and Canada. Several other countries announced plans to increase annual primary smelter capacity within the next several years.

World production of primary aluminum fell slightly to 15.3 million tons in response to high metal inventories and lower prices. The United States led the world in reducing metal production. Several of the West European countries and Japan also lowered production, but their lower production was offset by increased production in Australia, Brazil, and Canada as new production capacity potlines were brought on-stream.

Primary aluminum inventories held by members of the International Primary Aluminum Institute (IPAI), which represent the bulk of the stocks held outside the centrally planned economy countries, decreased from 2.59 million tons at yearend 1984 to 2.18 million tons at yearend 1985. IPAI reported that total metal inventories, including secondary aluminum, was 3.96 million tons at yearend.

During 1985, two separate international conferences by independent aluminum producers met to discuss cooperation among countries in matters of common interest. Nine independent producers from Argentina, Bahrain, Brazil, Dubai, Egypt, Indonesia, Norway, Switzerland, and Venezuela met in Buenos Aires to discuss aluminum supply, demand, and pricing. The results of the meeting appeared to be some cooperation in regard to pricing of aluminum and the formation of a study group. In Cairo, the Second Arab Aluminum Conference (ARABAL 85) was attended by 12 Arab countries, India, and 11 European countries to discuss ways of maintaining or improving the Arab aluminum industry's competitiveness in world markets.

Argentina.—In July, Aluminios Argentinos S.A.I.C. (ALUAR) cut its production rate by 10,000 tons per year but increased its annual capacity by 6,000 tons to 146,000 tons in June and planned to increase annual capacity to 150,000 tons by February 1986.

Australia.—Alcan Australia Ltd. brought the third potline into commission at its Kurri Kurri smelter. The new 50,000-ton-per-year potline, which increased annual capacity to 140,000 tons, was completed in October 1984, but commissioning the potline was delayed owing to poor aluminum prices. However, about mid-1985, Alcan stated that the current value of the Australian dollar made production at the Kurri Kurri smelter competitive with world prices.

Partnership of the Portland, Victoria, aluminum smelter continued to change during the year. Alcoa of Australia Ltd. and the Victorian State government, the major partners, increased their shares of the smelter to 60% and 40% from their original 45% and 25%, respectively, when the Australian Commonwealth Superannuation Fund Investment Trust and Hyundai Corp., the Republic of Korea, decided against proposed stakes in the partnership. In September, First National Ltd., a banking arm of the National Australia Bank, agreed to take a 10% share in the smelter reducing both Alcoa's and the State government's shares by 5%. In October, the China International Trust and Investment Corp. agreed to take an additional 10% interest in the smelter. At yearend 1985, the proposed ownership of the 300,000-ton-per-year smelter project was Alcoa of Australia, 50%; Victoria State government, 30%; First National, 10%; and China International Trust, 10%. The first 150,000-ton-per-year potline was about 55% complete and was expected to come on-stream about November 1986. The second 150,000-ton-per-year potline was scheduled for startup in 1988.

The proposed 220,000-ton-per-year smelter project for Western Australia, sponsored by Reynolds, Griffin Coal Mining Co. Ltd., and the Western Australian government, was suspended indefinitely in 1985. The withdrawal of the fourth partner, Kukje Corp.-ICC Group of the Republic of Korea, left the group without a 50%-equity participant.

Bahrain.—Gulf Aluminum Rolling Mill Co. constructed a 40,000-ton-per-year computer-controlled aluminum foil rolling mill in Bahrain. The mill was sponsored by Bahrain, Iraq, Kuwait, Oman, Qatar, and Saudi Arabia, and major equipment will consist of a four-high reversing hot mill and a four-high nonreversing cold mill. Width of the mill was 1,751 millimeters.

Belgium-Luxembourg.—National Luxembourg Aluminium Co. (NLAC) increased its foil and casting capacity at its Dundelange plant by the installation of a continuous casting plant. It also increased its molten metal processing capacity in its casthouse by 20%. NLAC, which came on-stream early in 1985, is a subsidiary of the U.S.-based National Intergroup.

Brazil.—Cia. Brasileira de Alumínio (CBA) announced that it would increase the annual capacity of its Sorocaba, Sáo Paulo, smelter to 340,000 tons by the end of the century. CBA increased annual capacity from 125,000 to 155,000 tons in 1985 and planned to increase capacity to 170,000 tons in 1986 and to 240,000 tons by 1990. CBA, a subsidiary of S.A. Indústria Votorantim is the only wholly Brazilian-owned producer of aluminum.

Consorcio de Alumínio Albras e Alunorte S.A. inaugurated its first 80,000-ton-per-year potline at the proposed 320,000-ton-per-year smelter in November 1985. The smelter is about 50 miles upstream of the mouth of the Amazon River (Belem). The project is 51% owned by the Brazilian Government, Cia. Vale do Rio Doce (CVRD), and 49% by a consortium of 33 Japanese companies, Nippon Amazon Aluminium Co. Differences between the two partners over pricing for aluminum remained unresolved at yearend, and there was some doubt whether the second stage of the project should proceed under current market conditions.

Vale do Sul Alumínio S.A.—jointly owned by CVRD (52%), Shell do Brasil S.A. (44%) (a subsidiary of Billiton Metais S.A.), and Reynolds (4%)—reportedly planned to expand its 86,000-ton-per-year Santa Cruz smelter another 90,000 to 110,000 tons per year. The plant came on-line in 1982, and provisions were made for adding two 90,000-ton-per-year-capacity sections in the original project.

In December, the Brazilian Government created a study task force to report on the possibility of ending the electric power discount to aluminum producers. Should the task force recommend ending the discount, future increases in Brazil's smelting capacity could be affected.

Reynolds reportedly was negotiating to construct a $50 million can production plant in Brazil. The plant was expected to have an annual capacity of about 800 million cans.

Canada.—Canadian Reynolds Metals Co. Ltd., a subsidiary of Reynolds, Richmond, VA, expanded the annual capacity of its Baie Comeau, Quebec, smelter from 159,000 to 272,000 tons in September at a cost of about $400 million. The North Plant expansion contained a potline of 240 cells in two parallel buildings and used the Pechiney 180,000-ampere-cell design with current fed to the cells at 1,000 volts. The cells were considered to be the most energy efficient and environmentally acceptable in the world. The 536 pots in the older South Plant were removed, rebuilt, and modernized with improved technology at a cost of $110 million. The original plant was built in 1957 and expanded in 1968. An agreement between the government of Quebec and Reynolds provided a reduction in power rates during the plant's first 5 years of operation.

Alcan Aluminium Ltd. and the Canadian Association of Smelter and Allied Workers at Alcan's Kitimet, British Columbia, 268,000-ton-per-year smelter signed a new labor agreement effective July 24, 1985. The 3-year contract called for some wage increases and some job security benefits.

Aluminiere de Bécancour Inc., jointly owned by Pechiney (50%), Alumax (25%), and Société Générale de Financement du Quebec (25%), announced that construction of the Bécancour smelter in Quebec was several months ahead of schedule and about $45 million below cost. The first potline of the 230,000-ton-per-year smelter was scheduled to begin operation about mid-1986, with the second 115,000-ton-per-year potline scheduled to begin operations in 1987.

Alcan announced the indefinite postponement of the greenfield Laterriere smelter at Chicoutimi, Quebec, owing to low metal prices and high metal inventories. The original project, announced in 1984, called for construction of a 250,000-ton-per-year smelter costing about $750 million.

Canadian Reynolds and American Can Canada Inc., a subsidiary of American Can Co., Greenwich, CT, formed a new company, Bevco, to market aluminum and steel beverage cans produced at American Can's existing Canadian can plants and Reynolds' U.S. can facilities. The Bevco partnership covers only beverage cans and will market 8-, 16-, and 32-ounce aluminum cans produced by Reynolds. In 1984, Reynolds announced that it may construct three canmaking plants in Quebec to utilize the metal from the Baie Comeau smelter expansion.

The government of Ontario, which had restricted beverage container materials to steel or glass, drafted new regulations that allowed other types of nonrefillable containers for beverages but only in tandem with a materials recovery program. The regulation also provided that refillable glass containers would be guaranteed a protected share of the market. Aluminum beverage can use in the Province was expected to utilize about 29,000 tons per year of aluminum.

China.—Construction began on a 200,000-ton-per-year aluminum smelter in Datong, Quinhai. The plant to be built in two phases that reportedly would coincide with construction of an alumina plant in Shanxi Province and a hydropowerplant on the Yellow River at Quinhai. The first 100,000 tons of annual capacity with a foundry and environmental control facilities was scheduled to come on-stream by yearend 1987.

The Japanese companies Nissho-Iwai Corp. and Nippon Light Metal Co. Ltd. reportedly have agreed to assist China in building an integrated aluminum smelting operation at Pingguo in the Guangxi region. The first phase of the project would be a 100,000-ton-per-year smelter with possible completion by 1987.

China was considering the purchase of Japan's idled 100,000-ton-per-year Toyo smelter from Sumitomo Aluminium Smelting Co. Ltd. as the first step in construction of a 200,000-ton-per-year smelter near Xian in Shaanxi Province. Another possible Japanese plant for the Xian project was part of the Ryoka Light Metal's 76,000-ton-per-year Sakaide smelter.

Davy McKee Corp., a United Kingdom engineering company, contracted to build a 6,000-ton-per-year aluminum foil rolling mill for China's Shanghai aluminum mill plant. It was expected to be completed by mid-1988.

Colombia.—Industrias Metalurgicas Unidas S.A. purchased Alcan Aluminium's 50% equity interest in Aluminio Alcan de Colombia S.A., a sheet rolling and extrusion facility. Industrias Metalurgicas already owned one-half of the fabrication facility.

France.—Pechiney delayed startup of its 89,000-ton-per-year St. Jean-de-Maurienne, Savoie, aluminum potline owing to poor market conditions. The potline, originally scheduled to begin in the fourth quarter of 1984, increased annual capacity of the smelter to 130,000 tons. In addition, Pechiney shut down 17,000 tons of old capacity at St. Jean and 20,000 tons at its l'Argentiere, Hautes-Alpes, smelter.

Pechiney will build a 3,500-ton-per-year aluminum-lithium (Al-Li) alloy foundry at its Issoire facility in central France. It will produce 1.5-ton Al-Li ingots for the aerospace industries. The plant was expected to come on-stream in late 1987 and may eventually be expanded to 12,000 tons of annual capacity.

Alusuisse and Pechiney signed an agreement to form a joint subsidiary to operate a facility to manufacture aluminum slugs for aerosol cans and soft tubes. Pechiney Cebal, a subsidiary of Pechiney, would have a 51% share in the company and Alusuisse, a 49% share of the plant at Alusuisse's Beaurepaise slug plant in Isère, France. The agreement also called for doubling the plant's annual capacity to 15,000 tons.

Alcoa sold its French soft alloy extrusion and anodizing mill at Châteauroux to Norsk Hydro A/S of Norway. Norsk Hydro reportedly would invest between $1.1 and $2.16 million to modernize the mill. The mill produced extrusions mainly for the construction industry and had an annual capacity of about 8,000 tons.

Électricité de France, a state-owned utility company, and Pechiney concluded an agreement to obtain a special fixed low price for 3 billion kilowatts of power annually for 10 years. Pechiney agreed to present Électricité with 2 billion francs worth of nonvoting securities, which pay dividends on Pechiney's corporate profit.

Germany, Federal Republic of.—Vereinigte Aluminium Werke AG (VAW) began construction of a foil rolling plant at Grevenbroich. The plant will consist of four fully automated computer-controlled foil mills with rolling speeds of 2,000 meters per minute and a foil width of 2,000 millimeters. The improved technology for the foil mills reportedly would increase productivity about 50% in comparison with world foil mill standards.

Ghana.—Volta Aluminium Co. (VALCO) restarted two of its five 40,000-ton-per-year potlines at the Tema smelter. The smelter, 90% owned by Kaiser and 10% by Reynolds, was shut down in 1983 owing to low water at the Akosombo Dam, which led to a curtailment of hydroelectric power. In 1985, VALCO and the Government of Ghana signed an agreement, after 2 years of negotiation, that increased the price VALCO would pay for power and restricted the amount of firm power provided annually to the smelter. Under abnormal conditions, power may be further curtailed in favor of Ghanian essential domestic requirements.

Iceland.—Icelandic Aluminium Co. Ltd. (ISAL), a subsidiary of Alusuisse, Switzerland, was considering plans to increase capacity at its 86,000-ton-per-year Straumsvik smelter to 130,000 tons. The China

National Nonferrous Industries Corp. discussed a 10% participation in the expansion with Alusuisse and the Icelandic Government.

India.—The new aluminum complex owned by National Aluminium Co. Ltd. (NALCO), a Government-owned company in Tolcher, Orissa, was expected to be commissioned in September 1986 with the startup of one of two 109,000-ton-per-year potlines. Reportedly, Hindustan Aluminium Co. Ltd., jointly owned by Kaiser and private interests, implemented a program to increase the annual capacity of the Renukoot, Uttar Pradesh, smelter from 120,000 to 150,000 tons per year.

Italy.—The Italian state-owned Ente Participazione Finanziamento Industria Manifattura (EFIM) postponed the closing of the 35,000-ton-per-year Bolzano smelter. New plans announced the closing of the 30,000-ton-per-year Porto Marghera smelter between 1987 and 1989.

Japan.—The Ministry of International Trade and Industry (MITI) agreed to reduce tariffs on aluminum plate, sheet, and strip from 11.5% ad valorem to 9.2% early in 1986, and further reduce the 9.3% tariff on these mill products to 3% and the 9% tariff on aluminum ingot to 1% effective January 1, 1988, with intermediate reductions April 1, 1987.

Showa Light Metal Co. Ltd., jointly owned by Showa Denko K.K. (50%) and Comalco of Australia (50%), announced the closing of its 59,000-ton-per-year Chiba smelter effective in May 1986.

Furukawa Electric Co. Ltd. purchased Alcoa's 13% share of the Furukawa Aluminium Co. Ltd., and aluminum semimanufacturing company. The purchase terminated Alcoa's minority joint interest in the manufacturing company from Alcoa's 33% interest 5 years ago, and increased Furukawa Electric's interest to 94%. The remaining shares of the Japan-based company are owned by the trading house C. Itoh & Co. Ltd.

Korea, North.—Reportedly, North Korea will operate an aluminum smelter at Pyong Kouk. Construction apparently started in 1984 with economic and technological assistance obtained from the U.S.S.R. A completion date was not available.

Korea, Republic of.—Pechiney, France, reportedly discussed sale of its 50% equity in Aluminium of Korea Ltd. (Koralu) to its partner Hyundai Industries, which would give Hyundai complete ownership. Koralu operates a 20,000-ton-per-year smelter at Ulson.

Mando Machinery Corp., Anyong, the Republic of Korea, and Ford Motor Co., Detroit, MI, reached an agreement to form a joint venture company to produce about 450,000 metal aluminum radiators for South Korean automakers. Mando was the leading manufacturer of automotive parts in the Republic of Korea.

Mexico.—Alcan Aluminium sold its 49% interest in Alcan Mexicana S.A. de C.V. to Aluminio S.A. de C.V., in which Alcoa holds a 44% interest. Alcan Mexicana was a holding company with three operating subsidiaries involved in aluminum semifabrication, building products and truck bodies, and marketing and fabrication.

Netherlands.—Hunter Douglas Ltd. Europe began installing an integrated cold mill strip annealing facility for heat-treated aluminum alloys in its Rotterdam plant. The new installation was not expected to increase the annual capacity but should modernize the plant and increase efficiency. The plant modernization would be completed by mid-1986.

New Zealand.—Comalco and the New Zealand Government reached an agreement for a new electric-power-pricing formula, based on the Pechiney Independent Price, to calculate power charges at the 244,000-ton-per-year Tiwai Point aluminum smelter. The new formula replaced Comalco's use of the Alcan World Price, which was discontinued in 1984. The future of the Tiwai Point smelter was in doubt after the Government increased electricity prices to the smelter by 25% on April 1. The smelter is jointly owned by Comalco (60%), Sumitomo Aluminium (20%), and Showa Light Metal (20%). Late in the year, the smelter was operating at about 12,000 tons below annual capacity owing to a pot attrition policy.

Norway.—Ardal og Sunndal Verk A/S (ASV Group), owned by the Government of Norway, planned to increase annual capacity at the Ardal plant from 187,000 to about 230,000 tons through modernization programs. Modernization of an old 22,000-ton-per-year potline, shut down in May, should increase the line to 44,000 tons per year. Improvements in the remaining sections of the plant were expected to raise the annual capacity to 220,000 tons. Using the company's own technology, modernization began on five pots with completion expected by late 1985.

Annual capacity of the Sör-Norge Aluminium A/S (Soral) 66,000-ton Huenes smelter was to be increased to 100,000 tons. The Huenes plant is owned by Alusuisse (75%) and Norsk Hydro (25%); however, following the expansion, Alusuisse's share would be reduced to 50%. The project should be completed about 2 years after necessary approvals are received.

Norsk Hydro's Karmöy Fobriskker announced plans to expand the Karmöy Island smelter from 160,000 to 210,000 tons per year by 1987. Technology developed by Pechiney would be used, and work was scheduled to begin in mid-1985. The smelter is owned by Norsk Hydro (49%) and the Government of Norway (51%).

Discussions between ASV Group and Norsk Hydro on a merger of the two organizations were continued throughout the year. By yearend, no agreement was reached owing to major differences on the type of joint venture organization. Merger of these two organizations could give the new company a total annual capacity of over 600,000 tons after expansions.

Table 14.—Aluminum, primary: World production,[1] by country

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina	134	138	133	134	136
Australia	379	381	478	758	[2]851
Austria	[r]94	94	94	95	[2]94
Bahrain	[r]130	171	172	177	177
Brazil	256	299	401	455	540
Cameroon	[r]65	[r]79	77	73	75
Canada	1,116	1,065	1,091	1,227	[2]1,282
China[e]	[r]350	380	[r]400	[r]400	410
Czechoslovakia	33	34	36	32	32
Egypt	134	141	140	166	175
France	436	390	361	342	[2]293
German Democratic Republic[e]	60	58	57	58	58
Germany, Federal Republic of	729	723	743	777	745
Ghana	190	174	42	--	48
Greece[3]	[r][e]146	[r][e]135	136	136	[2]123
Hungary	74	74	74	74	[2]74
Iceland	[r]74	[r]75	76	80	74
India[3]	213	217	204	269	268
Indonesia[3]	--	[r]33	115	199	213
Iran	[r]13	45	39	42	42
Italy	274	233	196	230	[2]245
Japan[4]	771	351	256	287	227
Korea, North[e]	10	10	10	10	10
Korea, Republic of[3]	18	15	13	18	18
Mexico[3]	43	41	40	44	43
Netherlands	262	251	235	249	253
New Zealand	154	[r]163	219	243	240
Norway[5]	634	[r]638	715	761	[2]724
Poland[6]	66	43	44	46	[2]47
Romania[5]	[r]242	208	223	215	220
South Africa, Republic of	[r]84	[r]106	161	167	168
Spain	397	367	358	381	[2]370
Suriname[7]	41	[r]43	34	[r][e]23	23
Sweden[5]	83	79	82	83	[2]84
Switzerland	82	75	76	79	[2]73
Taiwan[3]	31	10	--	--	--
Turkey	40	[r]36	30	38	38
U.S.S.R.[e]	1,800	1,875	2,000	2,100	2,200
United Arab Emirates: Dubai	106	149	151	155	155
United Kingdom	339	241	252	288	[2]275
United States	4,489	3,274	3,353	4,099	[2]3,500
Venezuela	314	274	335	386	396
Yugoslavia[3]	173	[r]220	258	268	270
Total	[r]15,079	[r]13,408	13,910	15,664	15,289

[e]Estimated. [p]Preliminary. [r]Revised.

[1]The Bureau of Mines defines primary aluminum as "The weight of liquid aluminum as tapped from pots, excluding the weight of any alloying materials as well as that of any metal produced from either returned scrap or remelted materials." International reporting practices vary from country to country, some nations conforming to the foregoing definition and others using different definitions. For those countries for which a different definition is given specifically in the source publication, that definition is provided in this table by footnote. Table includes data available through June 3, 1986.

[2]Reported figure.

[3]Primary ingot.

[4]Excludes high-purity aluminum containing 99.995% or more as follows, in metric tons: 1981—6,222; 1982—4,345; 1983—2,679; 1984—4,358; and 1985—4,783.

[5]Primary unalloyed metal plus primary alloyed metal, thus including weight of alloying material.

[6]Primary unalloyed ingot plus secondary unalloyed ingot.

[7]Data represent exports of ingot aluminum, presumably all primary.

Spain.—Empresa Nacional del Alúminio S.A. (ENDASA) and Alúminio de Galicia S.A. (ALUGASA) were merged into one new company known as ENDASA. The new company will be owned by the Spanish state holding company Instituto Nacional de Industria (INI) (72%), Alcan (23%), and Spanish banks (5%). Pechiney sold its 37% interest in ALUGASA to INI in April, and Alcan had a 36% interest in ENDASA prior to the merger. Following the merger, the shutdown of the 25,000-ton-per-year Valladolid smelter was begun, and one-half of the 20,000-ton-per-year "Series I" installation at the 100,000-ton-per-year Avilés smelter was closed, with the remaining one-half scheduled for closure in 1985. The closure would leave the new Spanish company with about 338,000 tons of annual aluminum capacity.

Sweden.—Gränges Aluminium AB began operation of a new 20,000-ton-per-year UBC scrap remelting and rolling plant at Finspang to produce can body stock. The plant had an annual capacity to produce up to 15,000 tons of can stock and was built to achieve Sweden's goal of a 75% aluminum can recycling rate. Material from the plant would be mainly for Sweden's domestic consumption.

Table 15.—Aluminum: World capacity, by continent and country[1]

(Thousand metric tons)

Continent and country	1983	1984	1985
North America:			
Canada	1,234	1,234	1,347
Mexico	45	45	45
United States	4,996	r4,896	4,706
South America:			
Argentina	140	140	146
Brazil	419	519	629
Suriname	60	60	60
Venezuela	400	400	400
Europe:			
Austria	92	92	92
Czechoslovakia	60	60	60
France	378	333	333
German Democratic Republic	85	85	85
Germany, Federal Republic of	772	777	777
Greece	145	145	145
Hungary	76	76	76
Iceland	86	86	86
Italy	276	276	276
Netherlands	266	266	266
Norway	r770	r770	770
Poland	55	110	110
Romania	250	250	250
Spain	389	389	379
Sweden	82	82	82
Switzerland	86	86	86
U.S.S.R	2,320	2,490	2,550
United Kingdom	287	287	287
Yugoslavia	357	357	357
Africa:			
Cameroon	80	80	80
Egypt	166	166	170
Ghana	200	200	200
South Africa, Republic of	172	172	172
Asia:			
Bahrain	170	170	170
China	r413	r413	413
India	363	363	363
Indonesia	150	225	225
Iran	50	50	50
Japan	712	712	425
Korea, North	20	20	20
Korea, Republic of	18	18	18
Taiwan	50	50	50
Turkey	60	60	60
United Arab Emirates: Dubai	149	149	149
Oceania:			
Australia	594	812	862
New Zealand	244	244	244
Total	r17,737	r18,215	18,071

rRevised.

[1]Detailed information on the individual aluminum reduction plants is available in a 2-part report that can be purchased from Chief, Division of Finance, Bureau of Mines, Bldg. 20, Federal Center, Denver, CO 80225. Part 1 of "Primary Aluminum Plants, Worldwide" details location, ownership, and production capacity for 1983-90 and sources of energy and aluminum raw materials for foreign and domestic primary aluminum plants, including those in centrally planned economy countries. Part 2 summarizes production capacities for 1983-90 by smelter and country.

Switzerland.—Allegedly, an environmentalist group took responsibility for a bomb attack on the Usine d'Aluminium Martigny S.A. 10,000-ton-per-year smelter at Martigny. The plant was expected to be idled up to 6 months after the March attack. The attack was aimed at a power facility to be constructed on the Rhône River.

United Kingdom.—To increase casting capacity, British Alcan Aluminium Ltd. announced plans to build new casting facilities with associated furnaces at its 125,000-ton-per-year Lynemouth primary smelter. The company also started a program to convert Lynemouth's smelting pots to automatic feeding of raw materials. The conversion was expected to take about 5 years.

Alcan Enfield Alloys was expected to close one of its two United Kingdom-based secondary aluminum plants. The plant, the London Colney works, had an annual capacity of 20,000 tons. Operations at the plant would be transferred to the secondary smelter at Bradford.

Venezuela.—Construction began at the Industria Venezolana de Aluminio C.A. (VENALUM), San Felix, Guayana, smelter to increase annual capacity by 30,000 tons to 310,000 tons. The smelter, owned 80% by the Government and 20% by six Japanese companies, would be modernized by improving the efficiency of the existing potlines rather than by the addition of pots.

Yugoslavia.—The Government company, Boris Kidric Tvornica Glirice Aluminja, announced plans to modernize and expand the 50,000-ton-per-year smelter at Kedricevo, Slovenio. The expansion to 70,000 tons per year was expected to be completed by 1990.

Zaire.—A consortium, led by Alusuisse, decided to postpone the Aluzaire aluminum project at Banana, Cabinda. Lack of progress by the Zairian Government to establish infrastructure support for the 210,000-ton-per-year smelter was the major factor in the decision to abandon the project.

TECHNOLOGY

Development of Al-Li alloys continued during the year.[5] Both domestic and foreign aluminum producers began production of Al-Li alloys, and several of the producers announced plans to construct commercial production facilities. Evaluation of the alloys in the form of extrusions, forgings, and sheets were being conducted by the major aerospace companies. The use of these alloys could reduce the weight of a large commercial aircraft by as much as 15%, thus, increasing the payload and decreasing fuel consumption.

Metal matrix composites (MMC), using aluminum combined with fibers, whiskers, or particles of oxides, carbides, and nitrides, impart strengths up to 10 times the strength of aluminum and stiffness up to twice that of steel. Densities of most aerospace MMC were about one-third that of steel. MMC materials can be used in aerospace applications because of their large weight reductions of up to 50%. Fabrication of MMC to near final shapes reduces machine wastes. The advantages and disadvantages of MMC were discussed.[6]

The effects of surface oxides on the mechanical properties and microstructure of high-strength corrosion-resistant and high-temperature aluminum powder metallurgy (PM) alloys were investigated.[7] Oxide surface layers, when incompletely broken up or nonuniformly distributed during consolidation of the particles, detrimentally affect the mechanical properties of the metal. Breakup of the surface oxides depends on the dehydration and constitual changes that occur during degassing of the powder.

An investigation on the effect of different fluoride additions on the vaporization of cryolite indicated that there is a relationship between the cationic radius of the fluoride added and the vapor pressure of the liquid cryolite.[8] Other parameters that influence the total vapor pressure above the melts are the bath temperature, the acidity of the bath owing to aluminum fluoride (AlF_3) additions, and the amount of lithium fluoride (LiF) and aluminum oxide (Al_2O_3). The catalytic effect of fluorides on the Al_2O_3 phase transformation, and the formation of the crust in aluminum cells was studied.[9] Commercial alumina was heat treated with additions of 2 weight percent of different fluorides and ranked according to the effect of the fluorides on the transformation temperature of the Al_2O_3 phase. The coherence of the alumina-network crusts was explained.

Several investigations were conducted on the electrolysis of aluminum chloride ($AlCl_3$) electrolyte for production of aluminum. Using bench scale cells, the effects of $AlCl_3$ concentration, convection, electrode spacing, and current density on the cell voltage, current efficiencies, and power efficiencies of the cell was investigated during the electrolysis of $AlCl_3$ in lithium chloride-sodium chloride (LiCl-NaCl) fused salt electrolytes at 700° C employing graphite electrodes.[10] Energy consumption was about 4.03 kW•h per pound of metal compared with an average of 7.5 kW•h per pound in the Hall-Heroult cell. The kinetics of aluminum deposition from NaCl-$AlCl_3$ melts in alumina crucibles was investigated at 820° C by linear sweep voltometry and potential step amperometry.[11] At a low $AlCl_3$ mole concentration (0.4 mole percent), the reduction of $AlCl_3$ on liquid aluminum was found to be diffusion controlled. At higher concentrations, passivation, apparently caused by precipitation of alumina from the supersaturated melt in the diffusion layer of the aluminum cathode, was observed during the deposition reaction.

Titanium diboride (TiB_2) material for use as electrodes in aluminum smelting cells continued to be investigated. Carbon pipes with a chemically vapor-deposited TiB_2 coating 700 micrometers thick were tested for corrosion and/or erosion resistance in a laboratory aluminum smelting cell for 100 hours.[12] Projected lifetime of the coating was only 30 days because of grain boundary attack with subsequent crystal pullout. As part of an inert electrode material study, the electrical resistivity of monocrystalline and polycrystalline TiB_2 was measured under an inert atmosphere by a four-point alternating current impedance technique over the range from 298° K to 1,373° K.[13] Values for 69%-dense and 99%-dense polycrystalline and for monocrystalline TiB_2 were determined.

Over a dozen papers on the processing, recovery, and recycling of scrap aluminum were published.[14] Several papers addressed the melting of low-density scrap, such as foil and beverage cans and can sheet scrap. Other papers addressed the recycling of UBC scrap and the design of recycling facilities. A plenary lecture presented an overview of the Bureau of Mines research on the recycling of minerals and metals.[15]

Studies by the Bureau of Mines on the development of new methods of purifying metal by fractionating multicomponent molten metal scrap by filtration were described.[16] One method was the separation of liquid and crystalline phases formed by addition of a component to produce a solid phase. Data for the purification of aluminum by the addition of titanium and boron to form TiB_2 were given. The chemistry and properties of salts used as fluxes for recycling aluminum were investigated.[17] Most of the salts fall within the six component system, sodium chloride-potassium chloride-aluminum chloride-sodium fluoride-potassium fluoride-aluminum fluoride (NaCl-KCl-$AlCl_3$-NaF-KF-AlF_3) with NaCl-KCl, KCl-AlF_3, and NaCl-AlF_3 as the stable binary systems. Twelve subsolidus compatability tetrahedra were determined by X-ray analysis. The technique for separating cast aluminum alloys from wrought alloys exploiting the difference in mechanical properties of the two types of alloys at elevated temperature was described.[18] Between 520° C and 580° C, casting alloys become brittle and can be fragmentized and separated from wrought alloys. Above 600° C, the wrought alloys also become brittle and efficiency of separation decreases. Separation is almost 100% when in the solidus temperature range of the casting alloys.

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[1]All quantities in this chapter are given in metric tons unless otherwise indicated.

[2]Physical scientist, Division of Nonferrous Metals.

[3]U.S. Department of Energy, Bonneville Power Administration. Direct Service Industry Options Final Environmental Impact Statement (EIS). DOE/EIS-0123F, Apr. 1986, 241 pp.

[4]American Metal Market. 33.1B Units Recycled in '85: Aluminum Assoc. V. 94, No. 78, Apr. 22, 1986, p. 9.

[5]Aviation Week & Space Technology. Companies Detail Applications for Aluminum-Lithium Alloys. V. 123, No. 8, Aug. 26, 1985, pp. 67-70.

[6]Schoutens, J. E. Metal Matrix Composite Materials Today. J. Met., v. 37, No. 6, June 1985, p. 43.

[7]Kim, Y. W., W. M. Griffith, and F. H. Froes. Surface Oxides in P/M Aluminum Alloys. J. Met., v. 37, No. 8, Aug. 1985, pp. 27-33.

[8]Jaimes, J. G. Vaporization of Molten Fluorides. Inst. of Inorg. Chem., Norwegian Inst. Tech., Univ. Trondheim, Trondheim, Norway, Feb. 1986, 174 pp.

[9]Oedegard, R., S. Roenning, S. Rolseth, and J. Thonstad. Crust Formation in Aluminum Cells. J. Met., v. 37, No. 11, Nov. 1985, pp. 25-28.

[10]Hauksson, T., and F. R. Foulkes. A Study of the Voltage and Current Efficiencies of Fused Salt $AlCl_3$ Electrolysis Using Bench Scale Cells. Can. J. Chem. Eng., v. 63, No. 2, Apr. 1985, pp. 237-243.

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[14]Taylor, P. R., H. Y. Sohn, and N. Jarrett (ed.). Recycle and Secondary Recovery of Metals (Proc. Int. Symp. on Recycle and Secondary Recovery of Metals and the Fall Extract and Proc. Met. Meeting, AIME, Ft. Lauderdale, FL, Dec. 1-4, 1985). Metall. Soc. AIME, Warrendale, PA, 1985, 862 pp.

[15]Kaplan, R.S. An Overview of the Bureau of Mines Recycling Research. Paper in Recycle and Secondary Recovery of Metals, ed. by P. R. Taylor, H. Y. Sohn, and N. Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 3-11.

[16]Sorrell, C. A., H. E. Hilliard, and D. J. Schrodt. Purification of Metals by Molten Metal Filtration. Paper in Recycle and Secondary Recovery of Metals, ed. by P. R. Taylor, H. Y. Sohn, and N. Jarrett. Metall. Soc. AIME, Warrendale, PA, 1985, pp. 503-517.

[17]Sorrell, C. A., and J. G. Groetsch, Jr. Subsolidus Compatibility in the System NaCl-KCl-$AlCl_3$-NaF-KF-AlF_3. J. Am. Ceram. Soc., v. 69, No. 4, Apr. 1986, pp. 333-338.

[18]Brown, R. D., Jr., F. Ambrose, and D. Montagna. Separation of Cast and Wrought Aluminum Alloys by Thermomechanical Processing. BuMines RI 8960, 1985, 12 pp.

Antimony

By Patricia A. Plunkert[1]

The production of primary antimony products decreased slightly compared with that of 1984 as a result of a general softening of demand in the antimony market. Imports for consumption were also down from those of 1984. In September, the General Services Administration (GSA) completed the sale of excess antimony metal from the National Defense Stockpile (NDS).

Domestic Data Coverage.—Domestic production data for antimony are developed by the Bureau of Mines from two voluntary surveys of U.S. operations. Typical of these surveys is the "Primary Antimony" survey. Of the 10 operations to which a survey request was sent, all responded, representing 100% of the primary smelter production shown in table 1 and 100% of the total antimony content of primary antimony production by class shown in table 3.

Table 1.—Salient antimony statistics

(Short tons of antimony content unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production:					
Primary:					
Mine (recoverable antimony)	646	503	838	557	W
Smelter[1]	17,844	12,282	14,557	r17,639	16,449
Secondary	19,856	16,596	14,204	r14,823	13,572
Exports of metal, alloys, waste and scrap	324	830	304	511	362
Exports of antimony oxide	375	277	365	480	885
Imports for consumption	17,970	13,387	12,885	23,089	20,694
Reported industrial consumption, primary antimony[1]	11,592	9,414	10,418	r12,465	11,701
Stocks: Primary antimony, all classes, Dec. 31	9,158	5,973	3,935	r6,895	6,033
Price: Average, cents per pound[2]	135.5	107.2	91.3	151.2	131.1
World: Mine production	r63,510	r61,131	55,880	p60,396	e60,621

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Includes primary antimony content of antimonial lead produced at primary lead refineries.
[2]New York dealer price for 99.5% to 99.6% metal, c.i.f. U.S. ports.

Legislation and Government Programs.—On September 20, the Environmental Protection Agency issued final regulations under the Clean Water Act for nonferrous metals manufacturing operations that limit the discharge of pollutants into navigable waters and into publicly owned treatment works. The primary antimony subcategory, 1 of 25 subcategories covered by this regulation, set limits on effluent discharges from both new and existing primary antimony plants that generate process wastewaters. Daily and monthly average maximums on the antimony, arsenic, and mercury content of effluents emanating from these plants were specified. The compliance date for existing plants was September 20, 1988.[2]

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Public Law 96-510), commonly known as the Superfund, expired on September 30, 1985. At yearend, various reauthorization bills, such as S-51 passed by the Senate on September 26 and HR-2817 passed by the House of Representatives on December 10, were under consideration by the Congress.

On September 18, GSA completed its latest sale of excess antimony metal from the NDS. Of the 1,000 short tons of metal authorized for disposal by Public Law 98-525 during fiscal year 1985, a total of 997 tons was sold. The total sale of excess antimony metal during calendar year 1985 was 928 tons. Any future sales of antimony from the stockpile will require additional legislative authority. GSA reported that yearend Government stocks of antimony metal in the NDS totaled 37,843 tons of stockpile-grade material. The stockpile goal remained at 36,000 tons.

On July 8, the White House announced that the President had approved the National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the NDS would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of materials already possessed by the Government. Antimony was included in tier I of this proposal with a goal of 4,585 tons. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, stated that no action may be taken before October 1, 1986, to implement or administer any change in a stockpile goal in effect on October 1, 1984, that results in a reduction in the quality or quantity of any strategic and critical material to be acquired for the NDS.

DOMESTIC PRODUCTION

MINE PRODUCTION

Sunshine Mining Co. produced antimony as a byproduct of the treatment of tetrahedrite, a complex silver-copper-antimony sulfide, one of the principal ore minerals in the Kellogg, ID, area. United States Antimony Corp.'s (USAC) antimony mining operation at Thompson Falls, MT, was closed during 1985.

Antimony was also produced by ASARCO Incorporated as a byproduct of the smelting of some domestic lead ores.

Table 2.—Antimony mine production and shipments in the United States

(Short tons of recoverable antimony)

Year	Produced	Shipped
1981	646	590
1982	503	365
1983	838	878
1984	557	711
1985	W	W

W Withheld to avoid disclosing company proprietary data.

SMELTER PRODUCTION

Primary.—Production of primary antimony products decreased compared with that of 1984 owing to a decrease in demand.

Amspec Chemical Corp. announced that it planned to add a second antimony furnace to its plant in Gloucester City, NJ. The new furnace reportedly would enable the company to produce antimony trioxide from a greater variety of raw materials including ores, crude oxide, and metal. Installation was scheduled to be completed by May 1986.

Anzon America Inc. announced that it was upgrading its antimony facilities in Laredo, TX, in order to make the plant more flexible. The planned addition of a new blast furnace reportedly would increase plant capacity and enable the company to use a wider range of feed materials. In addition to improving its production facilities, the company also announced that it was moving downstream into consumption with the acquisition of a New Jersey plastics firm, Monmouth Plastics Inc., which produced flame retardant materials, the major use for antimony trioxide.

The other producers of primary antimony products were: Asarco, Omaha, NE, and El Paso, TX; Chemet Co., Moscow, TN; Laurel Industries Inc., La Porte, TX; McGean Chemical Co. Inc., Cleveland, OH; M & T Chemicals Inc., Baltimore, MD; Sunshine Mining, Kellogg, ID; and USAC, Thompson Falls, MT.

Table 3.—Primary antimony produced in the United States

(Short tons of antimony content)

Year	Class of material produced				Total
	Metal	Oxide	Residues	Byproduct antimonial lead	
1981	790	16,425	83	546	17,844
1982	539	11,564	179	W	12,282
1983	1,121	13,153	283	W	14,557
1984	1,113	r16,379	147	W	r17,639
1985	943	15,398	108	W	16,449

rRevised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

Secondary.—Old scrap, predominantly lead battery plates, was the source of most of the secondary output. New scrap, mostly in the form of drosses and residues from various sources, supplied the remainder. The antimony content of scrap was usually recovered and consumed as antimonial lead.

Table 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons of antimony content unless otherwise specified)

	1984r	1985
KIND OF SCRAP		
New scrap: Lead- and tin-base	1,326	1,184
Old scrap: Lead- and tin-base	13,497	12,388
Total	14,823	13,572
FORM OF RECOVERY		
In antimonial lead	13,862	12,456
In other lead- and tin-base alloys	961	1,116
Total	14,823	13,572
Value (millions)	$44.8	$35.6

rRevised.

CONSUMPTION AND USES

Reported domestic consumption of primary antimony decreased compared with that of 1984 but remained slightly above the average 11,000 tons per year of material consumed during the previous 5-year period. Antimony compounds were used in plastics both as stabilizers and as flame retardants. Antimony stabilizers were used to retard heat and light degradation in plastics such as polyvinyl chloride. Antimony trioxide in an organic solvent was used to make fabrics, plastics, and other combustibles flame retardant. Antimony was also used as a decolorizing and refining agent in some types of glass such as special optical glass.

Antimony metal alloyed with lead was used in lead-acid storage batteries, industrial chemical pumps and pipes, tank linings, roofing sheets, and cable sheaths. In these alloys, antimony increases strength and inhibits chemical corrosion. In 1985, the Battery Council International reported that the total domestic shipments of replacement and original equipment automotive batteries in the United States were about the same as those of 1984. However, there were about 360,000 less units exported in 1985.

Table 5.—Reported industrial consumption of primary antimony in the United States

(Short tons of antimony content)

Year	Class of material consumed					Total
	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1981	1,546	9,385	32	83	546	11,592
1982	1,282	7,924	29	179	W	9,414
1983	1,245	8,867	23	283	W	10,418
1984	r1,543	10,747	28	147	W	r12,465
1985	1,507	10,053	33	108	W	11,701

rRevised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

Table 6.—Reported industrial consumption of primary antimony in the United States, by product

(Short tons of antimony content)

Product	1981	1982	1983	1984	1985
Metal products:					
Ammunition	409	294	175	W	410
Antimonial lead	1,257	793	926	845	568
Bearing metal and bearings	206	143	143	r182	179
Cable covering	24	25	31	W	W
Castings	11	9	9	11	11
Collapsible tubes and foil	9	1	W	W	W
Sheet and pipe	36	26	43	80	W
Solder	105	124	154	r232	338
Type metal	19	11	10	31	31
Other	69	67	71	337	105
Total	2,145	1,493	1,562	r1,718	1,642
Nonmetal products:					
Ammunition primers	25	20	16	21	27
Ceramics and glass	782	1,358	1,252	1,292	1,187
Fireworks	4	6	4	7	4
Pigments	341	330	198	178	147
Plastics	1,551	1,050	993	1,108	998
Rubber products	232	221	70	21	25
Other	111	103	119	r161	141
Total	3,046	3,088	2,652	r2,788	2,529
Flame-retardant:					
Adhesives	585	179	184	343	310
Paper	131	103	133	159	111
Pigments	40	25	14	8	8
Plastics	4,509	3,312	4,441	5,858	5,529
Rubber	174	104	220	342	315
Textiles	962	1,110	1,212	1,249	1,257
Total	6,401	4,833	6,204	7,959	7,530
Grand total	11,592	9,414	10,418	r12,465	11,701

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."

Table 7.—Industry stocks of primary antimony in the United States, December 31

(Short tons of antimony content)

Stocks	1981	1982	1983	1984	1985
Antimonial lead[1]	117	W	W	W	W
Metal	916	556	805	r582	800
Ore and concentrate	2,529	532	446	1,304	1,164
Oxide	4,707	4,711	2,614	4,926	3,954
Residues and slags	864	150	51	69	99
Sulfide	25	24	19	14	16
Total	9,158	5,973	3,935	r6,895	6,033

rRevised. W Withheld to avoid disclosing company proprietary data; not included in "Total."
[1]Inventories from primary sources at primary lead refineries only.

PRICES

The New York dealer price for imported antimony metal was $1.35 to $1.40 per pound at the beginning of the year. The price fluctuated throughout the year and reached a high of $1.42 to $1.47 per pound at the end of March. At yearend, the dealer price was listed at $1.28 to $1.32 per pound.

Asarco's published price for high-tint antimony trioxide in lots of 40,000 pounds was $1.65 per pound at the beginning of the year. The price was reduced several times during the year and reached a low of $1.45 per pound in September. Asarco's published price remained at this level through yearend. Other domestic producers also adjusted their prices during the year to remain competitive with generally lower priced imported material.

Metal Bulletin (London) published European price quotations for antimony ore and concentrates. Both prices decreased steadily throughout the year. At yearend, the quotations were as follows: clean sulfide concentrates, 60% antimony content, $20.50 to $24.00 per metric ton unit (equivalent to $18.60 to $21.75 per short ton unit), and lump sulfide ore, 60% antimony content, $23.00 to $26.00 per metric ton unit (equivalent to $20.85 to $23.60 per short ton unit).

Table 8.—Antimony price ranges in 1985, by type

Type	Price per pound
Domestic metal[1]	$2.00
Foreign metal[2]	$1.20- 1.47
Antimony trioxide[3]	1.45- 1.65

[1]Based on antimony in alloy.
[2]Duty-paid delivery, New York.
[3]Producer price, published by ASARCO Incorporated, for high-tint antimony trioxide.

FOREIGN TRADE

Exports of antimony oxide increased significantly and reached their highest level since 1967, the year the Bureau of Mines began reporting this data. In addition to exports of antimony oxide, the United States also exported 1,582 tons (gross weight) of other antimony compounds with a value of $4.7 million. Approximately 45% of these compounds was shipped to the Federal Republic of Germany, and the balance was divided among 26 other countries.

Total imports of antimony materials decreased compared with those of 1984, led by a 40% decrease in imports of antimony oxide. China remained the principal source of imported material and increased its share of total U.S. antimony imports from 34% in 1984 to approximately 40% in 1985.

In 1985, a few source countries for antimony metal and oxide were eligible for special duty-free status under the Generalized System of Preferences, namely, Bolivia, Brazil, Hong Kong, Mexico, and Peru.[3]

Table 9.—U.S. exports of antimony metal, alloys, waste and scrap, by country

Country	1984		1985	
	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)
Australia	41	$129	--	--
Belgium	--	--	99	$242
Canada	20	33	2	10
Dominican Republic	9	14	4	15
Germany, Federal Republic of	2	3	2	3
India	--	--	59	223
Italy	19	25	--	--
Japan	21	45	48	34
Korea, Republic of	19	15	--	--
Mexico	24	67	41	103
Netherlands	60	168	11	30
Spain	--	--	28	41
Taiwan	223	127	--	--
Trinidad	5	11	--	--
United Kingdom	5	19	21	76
Venezuela	28	150	1	2
Other	36	111	46	97
Total[1]	511	915	362	876

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 10.—U.S. exports of antimony oxide, by country

Country	1984 Gross weight (short tons)	1984 Antimony content[1] (short tons)	1984 Value (thousands)	1985 Gross weight (short tons)	1985 Antimony content[1] (short tons)	1985 Value (thousands)
Australia	80	66	$348	4	3	$15
Canada	98	81	248	368	305	1,051
Germany, Federal Republic of	57	47	123	123	102	260
Israel	18	15	16	2	2	4
Italy	83	69	316	139	115	538
Japan	69	57	157	25	21	78
Korea, Republic of	3	2	12	7	6	57
Mexico	28	23	92	59	49	87
Netherlands	21	17	62	3	2	6
Singapore	36	30	112	4	3	12
United Kingdom	53	44	113	308	256	677
Venezuela	16	13	55	6	5	24
Other	14	12	40	19	16	67
Total[2]	578	480	1,693	1,067	885	2,876

[1]Estimated by the Bureau of Mines.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 11.—U.S. import duties for antimony

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Ore	601.03	Free	Free	Free.
Needle or liquated	603.10	0.1 cent per pound	0.1 cent per pound	0.25 cent per pound.
Metal, unwrought	632.02	.3 cent per pound	Free	2 cents per pound.
Antimony oxide	417.50	.1 cent per pound	do	Do.

Table 12.—U.S. imports for consumption of antimony, by class and country

Country	1984 Gross weight (short tons)	1984 Antimony content[1] (short tons)	1984 Value (thousands)	1985 Gross weight (short tons)	1985 Antimony content[1] (short tons)	1985 Value (thousands)
Antimony ore and concentrate:						
Bolivia	1,923	1,253	$2,016	973	642	$1,349
Canada	18	9	11	756	421	406
Chile	319	188	279	429	276	486
China	270	158	249	4,555	1,798	5,144
Guatemala	--	--	--	655	320	391
Honduras	192	96	119	273	150	223
Hong Kong	61	25	56	22	14	25
Malaysia	--	--	--	55	17	25
Mexico	3,976	970	1,288	4,000	2,055	1,948
Peru	139	84	160	--	--	--
Singapore	--	--	--	1,727	661	1,754
South Africa, Republic of	1,075	596	1,079	--	--	--
Taiwan	--	--	--	450	90	94
Thailand	1,918	920	1,541	443	181	406
United Kingdom	--	--	--	43	13	130
Total	9,891	4,299	6,798	14,381	6,638	12,381
Antimony oxide:						
Belgium-Luxembourg	591	491	1,513	607	504	1,549
Bolivia	1,206	1,001	1,981	685	569	1,325
Brazil	--	--	--	92	76	194
Canada	101	84	10	19	16	65
Chile	61	51	76	--	--	--
China	5,983	4,966	13,612	3,404	2,825	8,789
France	1,721	1,428	4,615	1,436	1,191	5,134
Germany, Federal Republic of	123	102	609	97	80	653

See footnotes at end of table.

Table 12.—U.S. imports for consumption of antimony, by class and country —Continued

Country	1984 Gross weight (short tons)	1984 Antimony content[1] (short tons)	1984 Value (thousands)	1985 Gross weight (short tons)	1985 Antimony content[1] (short tons)	1985 Value (thousands)
Antimony oxide —Continued						
Hong Kong	174	144	$384	482	401	$1,281
Italy	59	49	117	--	--	--
Japan	3	2	60	7	6	35
Korea, Republic of	--	--	--	20	17	68
Netherlands	20	17	42	--	--	--
South Africa, Republic of	7,463	6,194	2,207	3,534	2,933	785
Switzerland	--	--	--	31	26	126
Taiwan	20	17	36	--	--	--
U.S.S.R	44	37	66	--	--	--
United Kingdom	315	261	1,020	206	171	761
Total	17,884	14,844	26,348	10,620	8,815	20,765
Antimony sulfide:[2]						
Austria	2	1	15	--	--	--
Belgium-Luxembourg	11	7	30	6	4	15
Canada	--	--	--	10	7	17
China	37	26	47	126	84	187
Germany, Federal Republic of	2	1	20	1	1	10
Ivory Coast	--	--	--	24	16	26
Japan	--	--	--	([3])	([3])	1
South Africa, Republic of	20	13	45	--	--	--
Total	72	48	157	167	112	256

[1]Antimony ore and concentrate content reported by Bureau of the Census. Antimony oxide and antimony sulfide content estimated by the Bureau of Mines.
[2]Includes needle or liquated.
[3]Less than 1/2 unit.

Source: Bureau of the Census.

Table 13.—U.S. imports for consumption of antimony metal, by country

Country	1984 Gross weight (short tons)	1984 Value (thousands)	1985 Gross weight (short tons)	1985 Value (thousands)
Belgium-Luxembourg	257	$282	1	$4
Bolivia	357	552	--	--
Canada	5	235	1	175
Chile	79	198	--	--
China	2,641	6,208	3,398	8,617
France	--	--	([1])	4
Germany, Federal Republic of	1	64	([1])	30
Hong Kong	--	--	228	601
Japan	([1])	12	([1])	6
Mexico	467	365	1,247	1,006
Peru	33	42	101	205
Spain	17	28	58	150
Taiwan	--	--	95	185
U.S.S.R	19	34	--	--
United Kingdom	22	17	--	--
Total	3,898	8,037	5,129	10,983

[1]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—In June, Durham Resources Inc. reported that production of antimony concentrates had resumed at its Lake George Mine in New Brunswick. At full capacity, the mill reportedly could process 100,000 tons per year of ore averaging 4.15% antimony. Shaft extension to the new ore zone at the mine was completed and development work on the ore body continued. The new ore zone, underlying the original ore body that reportedly was depleted in 1981, was estimated to contain about 850,000 tons of ore.

China.—Amspec announced that it had signed a letter of intent with numerous Chinese Government agencies to construct an antimony plant similar to Amspec's facility in Gloucester City, NJ. Reportedly, the plant would be situated in Yiyan, Hunan, and have an annual capacity of 3,000 to 5,000 tons of antimony oxide. Construction was expected to start within a couple of years.[4]

Guatemala.—Minas de Guatemala S.A. announced the reopening of its Annabella and Los Lirios antimony-tungsten mines after a 4-year shutdown. Production levels of 33 tons per day of antimony ore, grading 3.5% antimony, were reported. The company expected production levels to increase to 83 tons per day by yearend 1985.

Japan.—Antimony trioxide production, mainly from imported material, was 9,087 tons, a decrease of 15% compared with 1984 production levels. Antimony metal production increased from 279 tons in 1984 to 326 tons in 1985.[5]

In October, Dowa Mining Co. Ltd. announced the start of antimony trioxide production at its Kosaka smelter. The company reportedly planned to increase its production levels from the initial 22 tons of antimony trioxide per month to 44 tons per month in January 1986. The company also announced plans to begin production of sodium antimonate from imported raw material in the near future.[6]

Table 14.—Antimony: World mine production (content of ore unless otherwise specified), by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Australia[2]	1,241	1,263	592	1,014	1,100
Austria	665	735	726	687	660
Bolivia	16,866	15,408	10,969	10,231	9,500
Brazil	[r]68	--	--	--	--
Burma	[e]110	--	--	--	--
Canada[3]	1,840	--	--	610	1,205
China[e]	11,000	13,200	16,500	16,500	16,500
Czechoslovakia	805	770	990	1,100	1,100
France	344	340	122	--	--
Guatemala[e]	[4]563	550	--	100	220
Honduras[e]	22	--	--	350	440
Italy	767	374	--	269	[4]546
Malaysia (Sarawak)	211	153	148	19	20
Mexico[5]	1,984	1,725	2,777	3,377	3,300
Morocco	[r]565	998	500	1,071	1,100
Pakistan	22	([6])	([6])	1	--
Peru (recoverable)	755	814	786	741	720
South Africa, Republic of (content of concentrates)	10,814	[7]10,070	[7]6,947	8,201	8,150
Spain	712	506	539	643	635
Thailand	1,322	734	1,315	2,172	2,250
Turkey	924	1,189	926	1,121	1,100
U.S.S.R.[e]	9,500	9,900	10,000	10,300	10,400
United States[8]	646	503	838	557	W
Yugoslavia	1,604	1,672	1,047	[r] [e]1,050	1,400
Zimbabwe	160	227	158	282	275
Total	[r]63,510	[r]61,131	55,880	60,396	60,621

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 27, 1986.
[2]Antimony content of antimony ore and concentrates, lead concentrates, and lead-zinc concentrates.
[3]Partly estimated on the basis of reported value of total production.
[4]Reported figure.
[5]Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced.
[6]Revised to zero.
[7]Reported figure from Consolidated Murchison Ltd. 1983 Annual Report.
[8]Production from antimony mines; excludes amount produced as a byproduct of domestic lead ores.

Mexico.—Anzon America Inc. and Cía. Minera y Refinadora Mexicana S.A. announced plans to install a new concentrator for low-grade ore at their mine in Wadley, Mexico. Upon completion, production capacity was expected to be increased by 1,100 tons of concentrate per year.

Thailand.—BP Minerals International Ltd., Siam Cement Co., and the Government of Thailand announced the formation of a joint venture company, Associated Minerals Co. Ltd., to explore and eventually mine antimony deposits in the Bor Thong District of Chonburi Province. Exploration was expected to commence by yearend.[7]

TECHNOLOGY

General Electric Co. announced the fabrication of indium-antimonide infrared sensor arrays, using an epitaxial process, that exhibited significantly improved sensitivity. The new type of sensors, which can be operated at reportedly higher temperatures than bulk-type indium-antimonide sensors, permit the use of passive cooling techniques in space applications. The sensors were fabricated at the company's Electronics Laboratory in Syracuse, NY.[8]

Fujitsu Ltd. of Japan announced the recent development of a new material for erasable optical disks. The material, which was coated with a thin film of selenium-indium-antimony alloy, was reportedly stable in both the recording and erasing modes. A 20-centimeter diameter disk made of this material had a reported memory capacity of one gigabyte, about 600 times that of an 8-inch floppy disk. Fujitsu announced that it planned to commercialize the disk, together with a disk drive unit, within 2 to 3 years.[9]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Federal Register. U.S. Environmental Protection Agency. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 50, No. 183, Sept. 20, 1985, pp. 38276-38402.

[3]U.S. International Trade Commission. Tariff Schedules of the United States Annotated 1985, 3rd Supplement. USITC Publ. 1610, Sept. 1, 1985, varying pagination.

[4]Metal Bulletin (London). Chinese Sign Antimony Plant Contract. No. 6979, Apr. 19, 1985, p. 15.

[5]Japan Metal Journal. V. 16, No. 10, Mar. 24, 1986, p. 6.

[6]———. V. 15, No. 60, Dec. 16, 1985, p. 10.

[7]Industrial Minerals (London). Antimony Joint-Venture Signed. No. 214, July 1985, pp. 13, 15.

[8]Aviation Week and Space Technology. V. 123, No. 9, Sept. 2, 1985, p. 91.

[9]Japan Chemical Week. Fujitsu Develops New Material for Erasable Optical Disc. V. 26, No. 1298, Feb. 14, 1985, p. 9.

Asbestos

By Robert L. Virta[1]

U.S. apparent consumption of asbestos declined in 1985. Shipments from domestic mines remained unchanged while imports for consumption decreased 32% from those of 1984. Adverse publicity on asbestos-related health risks and a proposed Environmental Protection Agency (EPA) ban of certain asbestos products contributed to the poor market conditions in the United States.

Domestic Data Coverage.—Domestic production data for asbestos are developed by the Bureau of Mines by means of a voluntary industry survey. Of the three canvassed operations to which a survey request was made, all responded, representing 100% of the total production data shown in table 1.

Table 1.—Salient asbestos statistics

	1981	1982	1983	1984	1985
United States:					
Production (sales):					
Quantity ---------- metric tons	75,618	63,515	69,906	57,422	57,457
Value[1] ---------- thousands	$30,685	$24,917	$27,866	$24,238	$20,485
Exports and reexports (unmanufactured):					
Quantity ---------- metric tons	64,419	58,771	54,634	39,919	45,656
Value ---------- thousands	$21,508	$19,713	$19,683	$18,346	$16,489
Exports and reexports of asbestos products:					
Value ---------- do	$145,130	$127,867	$129,582	$163,347	$193,765
Imports for consumption (unmanufactured):					
Quantity ---------- metric tons	337,618	241,737	196,387	209,963	142,431
Value ---------- thousands	$103,893	$64,925	$57,956	$64,749	$44,093
Consumption[2] ---------- metric tons	348,800	246,500	217,000	226,000	162,000
World: Production ---------- do	[r]4,349,466	[r]4,036,213	4,178,660	[p]4,105,884	[e]4,111,298

[e]Estimated. [p]Preliminary. [r]Revised.
[1]F.o.b. mine.
[2]Calculated as the total of U.S. beginning stocks plus production plus imports minus ending stocks and exports.

Legislation and Government Programs.—On February 1, 1985, the EPA announced that occupational safety and consumer risks associated with asbestos would be referred to the Occupational Safety and Health Administration (OSHA) and the Consumer Product Safety Commission under section 9 of the Toxic Substances Control Act (TSCA).[2] This action was reviewed by the House Energy and Commerce Subcommittee on Oversight and Investigations. As a result of the investigation, EPA halted the referral plan on March 8, 1985.

The EPA proposed a temporary rule to limit asbestos exposures for State and local government employees who were not covered by OSHA regulations or by State plans adopted under the Occupational Safety and Health Act.[3] The ruling specifies that the average asbestos exposure for workers engaged in the removal, enclosure, or encapsulation of any material containing more than 1% asbestos by weight cannot exceed 2 fibers per cubic centimeter per 8-hour work period.

The EPA proposed a rule to establish Recommended Maximum Contaminant Levels (RMCL) for synthetic organic chemicals, inorganic chemicals, and microbiological parameters in drinking water.[4] Asbestos was included under the inorganic chemicals category. The proposal recommends establishing a RMCL for asbestos fibers exceeding 10 micrometers in length.

On December 13, the EPA submitted to the Office of Management and Budget a proposal to immediately ban the manufacture, importation, and processing of certain asbestos construction materials (asbestos cement pipe and fittings, roofing felts, flooring felts, felt back sheet floorings, vinyl asbestos floor tile, and asbestos clothing) under section 6 of the 1976 TSCA.[5] In addition, the mining and importation of asbestos and importation of asbestos products not directly banned would be placed under a permit system. The permit system would limit the mining and importation of asbestos to 30% of the 1981, 1982, and 1983 average values and would phase out asbestos use within 10 years.

OSHA continued to review a proposed standard for occupational exposure to asbestos.[6] The two permissible exposure limits to airborne asbestos being considered, 0.2 fiber per cubic centimeter or 0.5 fiber per cubic centimeter, would be a reduction from the existing asbestos exposure standard of 2 fibers per cubic centimeter per 8-hour work period.

Stockpile goals for asbestos were unchanged from those of 1984.

Table 2.—Stockpile goals and Government inventories for asbestos as of December 31

(Metric tons)

	Stockpile goals	Total inventories 1983	1984	1985
Amosite	15,422	38,591	30,855	30,855
Chrysotile	2,722	9,753	9,754	9,772
Crocidolite	--	754	33	33
Total	18,144	49,098	40,642	40,660

Source: General Services Administration, Federal Property Service.

Environmental Impact.—Fifty asbestos producers and insurance companies agreed to establish an asbestos claims facility in the United States.[7] The facility will settle asbestos liability claims with the objective of avoiding long and costly litigations. Only about one-third of the $1 billion spent on asbestos compensation cases in the past 10 years has been paid to the claimants.

In 1985, the EPA awarded $45 million in grants and loans for controlling asbestos hazards in schools. Funds were authorized by the Asbestos School Hazard Abatement Act of 1984. Approximately $600 million is to be distributed to local jurisdictions for asbestos abatement over a 7-year period.

The State of New Jersey enacted legislation limiting asbestos exposure during the removal of asbestos from buildings to 330 nanograms per cubic centimeter (approximately 0.01 fiber per cubic centimeter).[8] The purpose of the regulation was to prevent improper or unnecessary removal of asbestos materials from buildings.

DOMESTIC PRODUCTION

Mine shipments were unchanged in quantity but decreased 15% in value from those of 1984. The decrease in value was due primarily to a depressed market and high producer inventories.

Asbestos was produced in three mines in California and Vermont. Calaveras Asbestos Ltd. in California was the leading U.S. producer of asbestos, followed by Calidria Corp. and Vermont Asbestos Group Inc. Calidria, a subsidiary of Union Carbide Corp., was sold to a private investor group and renamed KCAC Inc.[9]

Table 3.—Asbestos producers in the United States in 1985

State and company	County	Mine	Type of asbestos
California:			
Calaveras Asbestos Ltd	Calaveras	Copperopolis	Chrysotile.
Calidria Corp	San Benito	Santa Rita	Do.
Vermont: Vermont Asbestos Group Inc	Orleans	Lowell	Do.

CONSUMPTION AND USES

Total U.S. asbestos consumption decreased 28%. Approximately 92% of the asbestos consumed was chrysotile and 3% was crocidolite. Small amounts of amosite were reported used. Chrysotile grade 7 was most commonly used, followed by grades 4, 6, and 5. Spinning grades 1, 2, and 3 represented approximately 1% of the total consumption.

The end-use pattern for chrysotile presented in table 4 has been estimated from data supplied by U.S. producers and the Asbestos Institute in Québec in cooperation with the Government of Canada. The data account for 92% of the asbestos consumed.

Table 4.—U.S. asbestos consumption by end use, grade, and type

(Thousand metric tons)

End use	Chrysotile[1]							Amosite	Crocidolite	Other[2]	Total asbestos
	Grades 1 and 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total				
1984 total	0.1	2.0	25.1	21.7	17.4	153.6	219.9	0.4	5.7	--	226.0
1985:											
Asbestos-cement pipe	--	--	16.8	1.9	4.5	--	23.2	--	4.8	--	28.0
Asbestos-cement sheet	--	--	--	(3)	3.9	2.7	6.6	--	--	--	6.6
Coatings and compounds	--	--	--	--	--	23.1	23.1	--	--	--	23.1
Flooring products	--	--	--	--	--	7.0	7.0	--	--	--	7.0
Friction products	--	.2	.5	6.5	4.0	22.7	33.9	--	--	--	33.9
Insulation:											
Electrical	--	--	.1	--	--	.3	.4	.1	--	--	.5
Thermal	--	--	(3)	(3)	--	--	.1	--	--	--	.1
Packing and gaskets	--	.2	.6	3.3	.3	2.0	6.4	--	--	--	6.4
Paper	--	--	--	--	.5	16.3	16.8	--	--	--	16.8
Plastics	--	--	--	.1	--	.6	.7	--	--	--	.7
Roofing products	--	--	--	(3)	.5	25.7	26.2	--	--	--	26.2
Textiles	--	1.2	(3)	--	--	--	1.2	--	--	--	1.2
Other	.1	.1	.8	.2	(3)	3.6	4.8	.2	--	--	5.0
Total	.1	1.7	18.8	[4]12.1	13.7	104.0	150.4	.3	4.8	7.3	[5]155.5

[1]Estimated distribution based upon data provided by the Asbestos Institute, Montreal, Canada, and the Bureau of Mines, asbestos producer survey.
[2]Bureau of the Census.
[3]Less than 1/10 unit.
[4]Data do not add to total shown because of independent rounding.
[5]Does not include "Other" category in total. "Other" contains unspecified fiber type and end use.

PRICES

Depressed markets and high producer inventories of the last few years have caused negotiated asbestos prices to be lower than listed prices. The average unit value of domestically produced asbestos in 1985 was $357 per metric ton. The average unit value of exported asbestos was $361 per ton.

Table 5.—Customs unit values of imported asbestos

(Dollars per metric ton)

	1981	1982	1983	1984	1985
Canada:					
Chrysotile:					
Cement	272	234	257	284	--
Crude	--	380	199	1,084	576
Spinning	927	917	932	699	731
Other	373	334	384	431	283
South Africa, Republic of:					
Amosite	728	771	840	869	830
Crocidolite	676	646	629	705	569

Source: Bureau of the Census.

FOREIGN TRADE

There was a 16% increase in the total value of asbestos fibers and asbestos products exported from the United States. The asbestos fiber portion was 8% of total value. Exports of brake linings and disk pads accounted for 75% of the value of all asbestos products exported. It is the only export category that increased in value from that of 1984. Canada remained the largest importer of U.S. asbestos fibers and products, followed by Japan, Mexico, Brazil, and Venezuela.

Canada provided 92% of the asbestos imported into the United States, and the Republic of South Africa provided 8%. Several other countries provided minor amounts. Approximately 91% of asbestos fiber imports were chrysotile. The value of imported asbestos fiber decreased 32%.

Table 6.—Countries importing U.S. asbestos fibers and products

(Thousand dollars)

Country	1984			1985		
	Unmanufactured fibers	Manufactured products	Total	Unmanufactured fibers	Manufactured products	Total
Australia	55	2,457	2,512	1	1,379	1,380
Brazil	215	3,683	3,898	251	3,592	3,843
Canada	r888	112,012	r112,900	714	148,663	149,377
Germany, Federal Republic of	1,023	2,540	3,563	75	1,948	2,023
Japan	3,279	9,062	12,341	3,294	10,140	13,434
Korea, Republic of	479	1,259	1,738	190	1,814	2,004
Kuwait	31	857	888	31	437	468
Mexico	6,997	4,649	11,646	6,261	6,483	12,744
Saudi Arabia	4	4,904	4,908	2	1,409	1,411
Thailand	1,916	179	2,095	2,330	332	2,662
Turkey	13	350	363	--	544	544
United Kingdom	192	619	811	50	926	976
Venezuela	571	3,975	4,546	267	3,487	3,754
Other	2,557	16,144	18,701	2,900	12,325	15,225
Total[1]	18,221	162,690	180,911	16,366	193,479	209,845

rRevised.
[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 7.—U.S. exports and reexports of asbestos and asbestos products

Products	1983		1984		1985	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
EXPORTS						
Unmanufactured:						
Crudes, fibers, stucco ---- metric tons	40,476	$14,879	26,381	$14,106	29,382	$12,705
Sand and refuse ---- do	13,760	4,519	13,398	4,115	15,693	3,661
Total ---- do	54,236	19,398	39,779	18,221	45,075	16,366
Manufactured:						
Asbestos fibers ---- do	1,537	5,198	958	5,067	607	3,793
Brake linings and disk brake pads ---- do	NA	70,456	NA	103,303	NA	144,262
Clutch facings and linings ---- number	NA	20,285	NA	23,206	NA	20,718
Gaskets ---- metric tons	337	2,196	275	1,815	78	900
Insulation ---- do	NA	3,270	NA	5,720	NA	4,566
Packing and seals ---- do	1,015	10,174	1,150	9,063	1,192	6,716
Shingles and clapboard ---- do	3,082	1,935	2,098	1,615	984	893
Other articles of asbestos ---- do	4,953	5,593	1,759	2,595	1,521	2,437
Other articles, n.s.p.f ---- do	NA	9,477	NA	10,306	NA	9,191
Total	XX	128,584	XX	162,690	XX	193,476

See footnotes at end of table.

Table 7.—U.S. exports and reexports of asbestos and asbestos products —Continued

Products	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
REEXPORTS						
Unmanufactured:						
Crudes and fibers metric tons	333	$271	140	$125	369	$71
Sand and refuse do	65	14	--	--	212	52
Total do	398	285	140	125	581	123
Manufactured:						
Asbestos fibers do	3	7	1	5	(1)	3
Brake linings and disk brake pads do	NA	318	NA	47	NA	103
Clutch facings and linings number	NA	167	NA	194	NA	73
Gaskets metric tons	(1)	117	46	136	1	18
Insulation do	NA	10	(1)	10	NA	8
Packing and seals do	1	10	(1)	1	4	63
Other articles of asbestos do	59	203	NA	264	NA	20
Other articles, n.s.p.f do	NA	166	--	--	NA	1
Total	XX	998	XX	657	XX	289

NA Not available. XX Not applicable.
[1]Less than 1/2 unit.

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption of asbestos fibers, by type, origin, and value

Type	Canada Quantity (metric tons)	Canada Value (thousands)	South Africa, Republic of Quantity (metric tons)	South Africa, Republic of Value (thousands)	Other Quantity (metric tons)	Other Value (thousands)	Total Quantity (metric tons)	Total Value (thousands)
1983	184,303	$49,733	11,754	$7,740	330	$483	196,387	$57,956
1984:								
Amosite	--	--	715	621	--	--	715	621
Chrysotile:								
Crude	85	92	--	--	--	--	85	92
Spinning fibers	2,041	1,369	--	--	93	123	2,134	1,492
All other	193,525	54,806	7,541	3,423	307	326	201,373	58,555
Crocidolite (blue)	--	--	5,656	3,989	--	--	5,656	3,989
Total	195,651	56,267	13,912	8,033	400	449	209,963	64,749
1985:								
Amosite	--	--	121	100	--	--	121	100
Chrysotile:								
Crude	94	86	174	100	--	--	268	187
Spinning fibers	1,990	1,454	--	--	90	110	2,080	1,564
All other	127,307	36,045	522	301	37	16	127,866	36,362
Crocidolite (blue)	--	--	4,794	2,726	--	--	4,794	2,726
Other (unspecified asbestos type)	1,728	962	5,374	1,997	200	196	7,302	3,155
Total	131,119	38,547	10,985	5,224	327	322	142,431	[1]44,093

[1]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World production of asbestos increased slightly from that of 1984. The major production changes occurred in Canada, where shipments were down 95,000 tons, and in the U.S.S.R., where production was estimated to be 100,000 tons greater than that of 1984. The U.S.S.R. remained the largest producer of asbestos, followed by Canada, the Republic of South Africa, Zimbabwe, Italy, China, and Brazil.

Depressed economic conditions and adverse publicity on asbestos-related health risks have contributed to poor market conditions, limited growth in asbestos production, and resulted in a decrease in exploration and development.

There were temporary shutdowns in several mining operations in Canada. In addition, four mining companies are forming a partnership to improve their position in the market. Many companies were delaying expansion of their operations until the effects of the proposed EPA asbestos ban on future markets are known. Expanding markets for asbestos were in the Far East and in developing countries.

Australia.—The New South Wales (NSW) State government rejected the Woodsreef Mines Ltd. application to extract 25 million tons of asbestos from mine tailings at its plant near Barraba.[10] Woodsreef Mines had received approval from the Australian Government to extract asbestos from mine tailings using a wet process. The NSW Minerals Resources Department was not satisfied with the safety provisions of the mining project.

Canada.—Four Canadian asbestos producers, Asbestos Corp. Ltd., Bell Asbestos Mines Ltd., Campbell Resources Inc., and Lac d'Amiante du Quebec, signed a memorandum of intent to form a partnership that would strengthen their resources and improve their position in domestic and export markets.[11] All four companies operated mines in the Thetford area of Quebec. The partnership would control over 50% of the asbestos output in Quebec. Earlier in 1985, Asbestos Corp. had devalued the book value of its Asbestos Hill Mine in northern Quebec and suspended operations indefinitely at the Thetford Mines' Quebec plant. Under the partnership, three mines and two of five processing mills owned by the four companies will be closed. Approximately 725 of the 2,225 employees will be dismissed, and production will be limited to 300,000 tons of chrysotile per year.

China.—A new asbestos dressing plant for concentrating ore began operation at Mangnai in Qinghai Province.[12] This plant has a production capacity of 12,000 tons per year. The construction of a second plant was being considered for the Province, where reserves are estimated at 20 million tons.

Cyprus.—Asbestos was produced from one mine in the Troodos Massif. The mine is operated by Cyprus Asbestos Mines Ltd. Prior to 1985, Cyprus Asbestos produced mainly chrysotile grades 3S and HSH. The company began developing new grades of chrysotile when sales of grades 3S and HSH declined. In 1985, full-scale production of chrysotile grades 4 through 7 was begun.[13] Approximately 40% of production is grade 4T, and 30% is grade 5R and 6D. Most of the asbestos produced is exported to Europe, the Middle East, the Far East, and India for asbestos cement products.

U.S.S.R.—Chrysotile asbestos production was estimated to be slightly greater than that of 1984.[14] Reconstruction and modernization of equipment at the Uralasbest complex was reported to have increased mine efficiency. In addition, the Baikal-Amor Mainline Railway was being developed to improve access to the Kiyembay complex in Siberia's South Muya mountain range.

Approximately 45% of the production was exported, mainly to centrally planned economy countries. In recent years, surplus fiber also has been marketed in market economy countries.

United Kingdom.—The Health and Safety Commission introduced new proposals to improve control of asbestos in the workplace.[15] These proposals were in response to a European Economic Community directive on worker protection and asbestos usage. The key provisions included assessment of the nature and degree of exposure and preventive measures to minimize exposure. Emphasis was placed on air monitoring, medical surveillance, and provisions for washing, changing, eating, and drinking.

Table 9.—Asbestos: World production, by country[1]

(Metric tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina	1,280	1,218	1,240	[e]1,250	1,200
Australia	45,494	18,587	3,723	(3)	--
Brazil (fiber)	[r]138,417	145,998	158,885	131,000	135,000
Bulgaria	400	600	700	500	600
Canada (shipments)	1,122,000	834,000	858,000	837,000	742,000
China[e]	106,000	110,000	160,000	[r]135,000	140,000
Colombia[e]	5,400	5,400	5,400	[4]9,982	10,000
Cyprus	24,440	18,952	17,288	7,429	6,000
Egypt	325	424	245	[e]325	325
Greece	457	17,016	31,811	45,376	48,000
India	24,515	26,761	24,873	25,450	25,000
Indonesia[e]	5,000	25,000	25,000	25,000	25,000

See footnotes at end of table.

Table 9.—Asbestos: World production, by country[1] —Continued

(Metric tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Italy	137,086	116,410	139,054	147,272	140,000
Japan	3,950	4,135	[e]4,000	[e]4,000	4,000
Korea, Republic of	14,084	15,933	12,506	8,062	10,000
Mozambique	[r]1,425	[r]852	[e]800	[e]800	800
South Africa, Republic of	235,943	211,860	221,111	167,389	165,000
Swaziland	35,264	[r]30,145	26,287	25,832	26,000
Taiwan	2,317	2,392	2,819	1,355	1,500
Turkey	3,860	958	1,510	1,499	1,500
U.S.S.R.[e]	2,105,000	2,180,000	2,250,000	2,300,000	2,400,000
United States (sold or used by producers)	75,618	63,515	69,906	57,422	[4]57,457
Yugoslavia	13,591	11,657	10,502	8,556	[4]6,916
Zimbabwe	247,600	194,400	153,000	165,385	165,000
Total	[r]4,349,466	[r]4,036,213	4,178,660	4,105,884	4,111,298

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through Apr. 29, 1986.

[2]In addition to the countries listed, Afghanistan, Czechoslovakia, North Korea, and Romania also produce asbestos, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.

[3]Revised to zero.

[4]Reported figure.

TECHNOLOGY

Preliminary laboratory testing for the mutagenicity of surface-treated chrysotile indicated that it was less biologically reactive than untreated chrysotile.[16] The treated chrysotile, which is being developed by Société Nationale de l'Amiante of Quebec, was produced by exposing chrysotile to phosphorus oxychloride and phosphorus pentachloride vapors. Phosphorus compounds were chemically bonded to the chrysotile fiber surface when the gas reacted with the chrysotile. The lower mutagenicity was attributed to the phosphorus compound coating. If a safe form of modified chrysotile is developed, chrysotile could continue to be used commercially. Use of chrysotile rather than asbestos substitutes would be advantageous to industry because the engineering and physical properties of chrysotile are well known and existing technology could continue to be used. The use of substitute materials would require some modification to current industrial production processes and possibly require the development of new products. The long-term quality of products using substitute materials has not been documented, and long-term health effects also are unknown.

The concentrations of airborne asbestos in ambient environments were determined using transmission electron microscopy.[17] However, ambient asbestos levels determined by this technique varied by several orders of magnitude owing to the lack of standard reference materials (SRM). The National Bureau of Standards (NBS) in cooperation with EPA developed reference materials (RM) and SRM for use in testing, refining, and calibrating sample preparation and analysis procedures. These standards were prepared on polycarbonate filters and consist of chrysotile asbestos fibers mixed with NBS SRM 1648, an urban-air particulate matrix. The RM was typical of a general urban environment with low concentrations of ambient chrysotile. The SRM was representative of an ambient air sample collected near an asbestos source.

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[1]Physical scientist, Division of Industrial Minerals.

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[14]Work cited in footnote 13.

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Barite

By Sarkis G. Ampian[1]

Domestic production of barite, after increasing in 1984, resumed the downward trend started in 1982 by decreasing 5% to 739,000 short tons valued at $21 million. Production from Nevada, the leading producer, decreased 4% to 590,000 tons. Production from Georgia and Missouri, the second and third leading States, respectively, decreased. Imports for consumption of crude barite rose 19% to 2.1 million tons, and ground barite imports increased nearly 60% from 45,024 tons to 71,024 tons valued at $4.7 million. Imports of barite for the fourth straight year led domestic production, and the 2.1-million-ton import figure for 1985 was only 200,000 tons below the record high imported during 1982. Ground barite imports, except for the drilling boom years of the late 1970's and early 1980's, were negligible. The principal use for barite, as a weighting agent in oil- and gas-well-drilling fluids (muds), accounted for 93% of U.S. consumption. Chemicals, glass, and filler and/or extender uses accounted for the remaining 7%.

Demand for barite, after increasing in 1984, returned to the downward slide that began in 1982 owing to a decrease in drilling activity, prompted by oil oversupplies. However, this decrease was accompanied by the return to drilling deeper wells that consume more barite. U.S. mine production continued, although still depressed, spurred on by regional sales and lower rail rates, which increased the competitiveness of domestic ores in the gulf coast and midcontinent areas. Barite grinding capacity, despite numerous closures, mergers, and acquisitions, continued in a position to meet present and future requirements.

Domestic Data Coverage.—Domestic production data for barite are developed by the Bureau of Mines from one voluntary survey of U.S. operations. Of the 108 operations to which a survey request was sent, all responded, representing 100% of the total crushed and ground production sold or used shown in table 1.

Table 1.—Salient barite and barium chemical statistics

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Barite, primary:					
Sold or used by producers	2,849	1,845	754	775	739
Value	$102,439	$69,522	$29,203	$25,445	$21,501
Exports	62	49	23	1	6
Value	$9,947	$6,510	$3,514	$574	$692
Imports for consumption (crude)	1,932	2,320	1,396	1,731	2,056
Consumption (apparent)[1]	4,719	4,116	2,127	2,505	2,789
Crushed and ground (sold or used by processors)[2]	4,716	4,088	2,745	2,883	2,184
Value	$406,255	$322,700	$194,380	$220,806	$154,463
Barium chemicals (sold or used by processors)	34	25	22	26	24
Value	$20,670	$18,720	$16,860	$17,105	$16,036
World: Production	[r]9,057	[r]8,002	5,982	[p]6,352	[e]6,671

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Sold or used plus imports minus exports.
[2]Includes imports.

DOMESTIC PRODUCTION

The term "primary barite" denotes the first marketable product and includes crude run-of-mine barite, flotation concentrates, and material concentrated by other beneficiated processes such as washing, jigging, or magnetic separation. Run-of-mine barite, the lowest cost primary barite, sold or used by producers represented 59% of total production compared with 64% in 1984; flotation concentrates was 8% of total 1985 production; and the balance was other beneficiated material.

Reported primary production decreased 5%. Nevada and Georgia remained the two leading barite producing States. Other producing States, in descending order, were Missouri, Montana, Tennessee, Washington, and Illinois. Barite was produced as a coproduct of fluorspar mining and milling in Illinois, and in Washington, production was limited to stockpile shipments; in all other States, barite is the primary product.

The leading domestic barite producers were Dresser Minerals Div., Dresser Industries Inc.; IMCO Services Div., Halliburton Co.; and NL BAROID/NL Industries Inc., all with mines in Missouri and Nevada; and Milchem Inc., with mines in Nevada. Another producer in Nevada was FMC Corp., and in Missouri, DeSoto Mining Co. and General Barite Co.

The domestic barite industry experienced a downturn during the year primarily owing to a decrease in drilling activity. This downturn, except for a slight upturn in 1984, returns to the trend of declining barite production rates that have been prevalent since 1981, the record-high production year (2.8 million tons). Production data also revealed that, despite a downturn in drilling activity, lower rail rates to the gulf coast and midcontinent areas based on unit trains and guaranteed tonnage contracts enabled modest domestic mining campaigns. Nevertheless, the persistent oil glut and lower energy consumption rates exacerbated at yearend by Mideast overproduction continued to thwart an upturn in oil- and gas-well-drilling activity. Other factors depressing the domestic marketplace were the continued low oil prices that discouraged exploration drilling activity and the world barite oversupply and lower ocean freight rates, in part owing to lower bunker fuel costs and excess bottoms. These factors combined to make foreign ores more attractively priced than domestic barite. In addition, the shrinking domestic market, the world's largest, has turned a soft market situation into a buyer's market. The competitiveness of the domestic industry, both for producers and grinders alike, continued to be threatened by imports of ground barite into an already depressed marketplace, which could further soften foreign barite prices.

A majority of the mining and grinding facilities still operational continued to be either suspended or on minimal production schedules. Most changes to mining, milling, and/or grinding capacity were largely modernizations and flowsheet changes to reduce production costs to remain competitive in the current soft market situation. Many capital-intensive projects, both ongoing and planned, have been deferred indefinitely. In some circumstances, companies closed their grinding plants and were obtaining specification-grade drilling mud barite from custom grinders.

In mergers, acquisitions, and closures, Milchem, a subsidiary of Baker International Corp., and Eisenman Chemical Co., a subsidiary of Newpark Resources Inc., formed a partnership, Milpark, to run their merged mining and grinding facilities. Eisenman's Corpus Christi, TX, mill and Milchem's Argenta Mine, and plants in New Orleans, LA, Galveston, TX, and Oklahoma, were operational.

The Environmental Protection Agency issued a final general National Pollutant Discharge Elimination System permit for oil and gas stratigraphic and exploration tests in the Outer Continental Shelf of Alaska, excluding development or production operations, in Federal water.[2] A similar draft permit factsheet was issued for oil and gas operations in portions of the Gulf of Mexico.[3]

Table 2.—U.S. primary barite sold or used by producers, by State

State	Number of operations	Run of mine		Flotation concentrates		Beneficiated material[1]		Total	
		Quantity (thousand short tons)	Value (thousands)	Quantity (thousand short tons)	Value (thousands)	Quantity (thousand short tons)	Value (thousands)	Quantity (thousand short tons)	Value (thousands)
1984:									
Georgia	2	--	--	W	W	W	W	W	W
Illinois	1	--	--	W	W	--	--	W	W
Missouri	3	W	W	--	--	W	W	W	W
Montana	1	W	W	--	--	W	W	W	W
Nevada	10	449	$10,527	--	--	166	$4,397	615	$14,924
Tennessee	1	W	W	--	--	--	--	W	W
Washington	1	--	--	W	W	--	--	W	W
Total	19	499	12,298	60	$4,146	216	9,000	775	[2]25,445
1985:									
Georgia	2	--	--	W	W	W	W	W	W
Illinois	1	--	--	W	W	--	--	W	W
Missouri	3	26	896	--	--	21	1,895	47	2,791
Montana	1	W	W	--	--	--	--	W	W
Nevada	9	389	7,485	--	--	201	3,419	590	10,904
Tennessee	1	W	W	--	--	--	--	W	W
Washington	1	--	--	W	W	--	--	W	W
Total	18	436	9,441	58	4,099	246	7,961	[2]739	21,501

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes some flotation concentrates.
[2]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Consumption of crushed and ground barite decreased about 24% from 2.9 million tons in 1984 to 2.2 million tons in 1985. This downturn, after an increase in 1984, reinstates the downtrend in barite consumption that has occurred since 1981, when the record high of 4.7 million tons of crushed and ground barite was established. This decrease indicated a downturn in barite required for oil-well drilling, which accounted for 93% of total sales. The oil- and gas-well-drilling industry completed over 52,000 wells and drilled over 243 million feet of hole.[4] The figures indicated a decrease from that of 1984 in the number of wells and feet drilled of 36% and 30%, respectively.

Total well footage drilled exceeded 10 million feet in five States: Texas, 95.0 million feet; Oklahoma, 29.8 million feet; Louisiana, 26.6 million feet; Kansas, 15.3 million feet; and Ohio, 10.5 million feet. Generally, the deeper a hole is drilled, the more barite is used per foot of drilling. Among the five leading States, Louisiana had the highest well depth, over 5,500 feet, and Kansas, the lowest, had an average depth of about 3,800 feet. Wyoming, absent from the top States this year in well footage drilled, again had the highest average well depth, nearly 7,500 feet. The U.S. average increased nearly 500 feet to 4,700 feet. The main reason that barite consumption decreased was because of the 64% reduction in the number of wells drilled. This decrease, however, was offset by an increase of barite per foot of drilling, which rose to 16.8 pounds per foot of drilling compared with 15.5 pounds per foot in 1984.

The increase was due to deeper drilling rigs that require more barite. Another benchmark of drilling activity, the Hughes Tool Co. rig count, showed the average number of operating domestic rigs decreased by over 18% to 1,980 rigs.[5] The decrease in rigs reestablished a downward trend that, except for 1984, saw the number of rigs fall from the 1981 record high of 3,969 rigs to 2,232 rigs in 1983. The 1986 average rig count of 1,980 is the first time since 1976 (1,658 rigs) that the count was below 2,000. The estimated rig count during the year ranged from a low of 1,858 to a high of 2,452.

Table 3.—Crushed and ground barite[1] sold or used by processors in the United States, by State

State	1984 Number of plants	1984 Quantity (thousand short tons)	1984 Value (thousands)	1985 Number of plants	1985 Quantity (thousand short tons)	1985 Value (thousands)
Louisiana	13	1,315	$109,413	10	937	$60,702
Missouri	2	W	W	3	15	1,529
Nevada	9	478	15,691	4	274	13,426
Oklahoma	5	91	6,737	4	79	6,206
Texas	14	783	63,186	13	700	49,163
Utah	4	55	3,976	4	35	2,493
Other[2]	11	161	21,803	9	144	20,944
Total	58	2,883	220,806	47	2,184	154,463

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes imports.
[2]Includes Arkansas, California, Georgia, Illinois, Montana, New York, and Washington (1984).

Table 4.—Crushed and ground barite[1] sold or used by processors in the United States, by use

(Thousand short tons and thousand dollars)

Use	1984 Quantity	1984 Value	1985 Quantity	1985 Value
Barium chemicals, filler and/or extender, glass	188	23,783	142	21,504
Well drilling	2,695	197,023	2,042	132,959
Total	2,883	220,806	2,184	154,463

[1]Includes imports.

Table 5.—U.S. barium chemicals[1] produced and sold or used by processors

Barium chemical	1984 Plants[2]	1984 Production (short tons)	1984 Sold or used by processors: Quantity (short tons)	1984 Sold or used by processors: Value (thousands)	1985 Plants[2]	1985 Production (short tons)	1985 Sold or used by processors: Quantity (short tons)	1985 Sold or used by processors: Value (thousands)
Barium carbonate	2	W	W	W	2	W	W	W
Barium chloride	2	W	W	W	2	W	W	W
Black ash	1	W	W	W	1	W	W	W
Blanc fixe	1	W	W	W	1	W	W	W
Other	2	27,364	26,249	$17,105	2	24,057	23,811	$16,036
Total	3	27,364	26,249	17,105	3	24,057	23,811	16,036

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Only data reported by barium chemical plants that consume barite are included. Partially estimated.
[2]A plant producing more than one product is counted only once.

Table 6.—U.S. hydrocarbon well drilling and barite consumption

Year	Barite used for well drilling (thousand short tons)	Wells drilled (thousands)[1]				Successful wells (percent)	Average depth per well (feet)	Average barite per well (short tons)
		Oil	Gas	Dry holes	Total			
1965	987	18.07	4.48	16.23	38.78	58.1	4,510	25.45
1966	1,022	16.78	4.38	15.23	36.39	58.1	4,478	28.08
1967	965	15.33	3.66	13.23	32.22	58.9	4,385	29.95
1968	1,006	14.33	3.46	12.81	30.60	58.1	4,738	32.88
1969	1,235	14.37	4.08	13.74	32.19	57.3	4,881	38.37
1970	1,119	13.02	3.84	11.26	28.12	60.0	4,952	39.79
1971	1,044	11.86	3.83	10.16	25.85	60.7	4,806	40.39
1972	1,183	11.31	4.93	11.06	27.30	59.5	4,932	43.33
1973	1,326	9.90	6.39	10.31	26.60	61.2	5,129	49.85
1974	1,440	12.78	7.24	11.67	31.69	63.2	4,750	45.44
1975	1,638	16.41	7.58	13.25	37.24	64.4	4,685	43.98
1976	1,986	17.06	9.09	13.62	39.77	65.7	4,571	49.94
1977	2,372	18.91	11.38	14.69	44.98	67.3	4,687	52.73
1978	2,632	17.76	12.93	16.25	46.94	65.4	4,829	56.07
1979	2,967	19.38	14.68	15.75	49.81	68.4	4,791	59.57
1980	3,385	26.99	15.74	18.09	60.82	70.3	4,675	55.66
1981	4,526	37.67	17.89	22.97	78.53	70.8	4,602	57.63
1982	4,048	40.30	18.95	26.55	85.80	69.1	4,616	47.18
1983	2,648	37.21	15.63	23.49	76.33	69.2	4,268	34.69
1984	2,695	41.10	15.71	25.23	82.04	69.5	4,246	32.85
1985	2,042	26.24	10.15	15.97	52.36	69.5	4,658	39.00

[1]Includes exploratory and development wells; excludes service wells, stratigraphic tests, and core tests.

Source: American Petroleum Institute.

PRICES

Price quotations in trade publications for barite remained unchanged. These prices may serve as a general guide but do not reflect actual transactions.

The reported average value per ton of domestic barite, based on actual sales, decreased nearly 13% f.o.b. plant. The average reported value per ton of ground drilling-mud-grade barite from Louisiana and Texas was $67.28; the average value of that from California, Nevada, and Utah was $62.50 per ton. The value of the Louisiana and Texas ground material, in direct response to both foreign competition and soft market conditions, declined 18%. Material from the other major grinding States remained relatively unchanged. The average customs value of barite exported to Canada was about $275 per ton; the customs value of material exported to Mexico and Latin America was about $110 per ton.

Table 7.—Barite price quotations

Item	Price per short ton[1]	
	1984	1985
Barite:[2]		
Chemical, filler, glass grades, f.o.b. shipping point, carlots:		
Handpicked, 95% $BaSO_4$, not over 1% Fe	$90.00	$90.00
Magnetic or flotation, 96% to 98% $BaSO_4$, not over 0.5% Fe	106.00	106.00
Water-ground, 95% $BaSO_4$, 325 mesh, 50-pound bags	$80.00-165.00	$80.00-165.00
Drilling-mud-grade:		
Dry-ground, 83% to 93% $BaSO_4$, 3% to 12% Fe, specific gravity 4.20 to 4.30, f.o.b. shipping point, carlots	80.00-115.00	80.00-115.00
Crude, imported, specific gravity 4.20 to 4.30, f.o.b. shipping point	55.00- 75.00	55.00- 75.00
Barium chemicals:[3]		
Barium carbonate:		
Precipitated, bulk, carlots, freight equalized (per pound)	.24	.25
Electronics-grade, bags	510.00	510.00
Barium chloride:		
Technical crystals, bags, carlots, works	450.00	450.00
Anhydrous, bags, carlots, same basis	565.00	565.00
Barium hydrate: Mono, 55-pound bags, carlots, delivered (100 pounds)	46.00	46.00

See footnotes at end of table.

Table 7.—Barite price quotations —Continued

Item	Price per short ton[1]	
	1984	1985
Barium chemicals[3] —Continued		
Barium sulfate:		
Blanc fixe, technical-grade, bags, carlots	400.00	400.00
U.S.P., X-ray diagnosis-grade, powder, 25-kilogram bags, 10,000-kilogram lots (per pound)	.59	.59
Barium sulfide (black ash), drums, carlots, works	460.00	460.00

[1]Unless otherwise specified.
[2]Engineering and Mining Journal. V. 185, No. 12, Dec. 1984, p. 27; and v. 186, No. 12, Dec. 1985, p. 11.
[3]Chemical Marketing Reporter. V. 226, No. 27, Dec. 31, 1984, p. 21; and v. 228, No. 25, Dec. 16, 1985, p. 41.

FOREIGN TRADE

Exports of natural barium sulfate or barite increased fourfold from about 1,500 tons to nearly 6,000 tons. This represented an increase in exports after 5 consecutive years of decline from the record high of 1979 when 109,000 tons was exported. The 1984 and 1985 ground barite exports are the smallest since 1969, when barite export statistics were first listed in the "Minerals Yearbook." Export and import data provided by the Bureau of the Census do not indicate the grades of barite traded; however, based on the value of individual shipments, an estimated 80% was ground drilling-mud grade, and an estimated 20% was chemical, filler, or glass grade. Crude barite was not exported in 1985. Canada and Mexico, traditionally either first or second among export recipients, were replaced by Liberia, the Barbados, and Mozambique, in decreasing order, as the leading buyers of U.S. ground barite and accounted for 64% of the total exports. Canada and Mexico received about 15% of the total. Exports to Mexico, a major oil producing country, declined to only 5 tons from a high of 18,000 tons in 1983. Both Canada and Mexico continued to rely more on domestic production. The strong U.S. dollar, which weakened at yearend, along with low exploration levels continued to have an adverse effect on barite exports.

Imports of crude barite increased 19% from 1.73 million tons to 2.06 million tons. The 1985 barite import figure was still 11% below the record high of 2.32 million tons set in 1982. The average unit c.i.f.[6] value of this material dropped 8% to $38.04 per ton, indicating that prices of foreign ores continued to decline in response to oversupply and lower ocean shipping rates. Domestic producers and consumers, faced with high rail rates from domestic drilling-quality barite mines in Nevada to gulf coast area grinding plants, continued to take advantage of the lower priced foreign ores to meet their demands in this highly competitive gulf coast area. Average value per ton of material shipped from the principal source countries was Mexico, $42.84; India, $38.66; China, $38,47; Thailand, $37.93; Morocco, $37.27; Indonesia, $36.86; Peru, $36.50; Chile, $27.81; and Ireland, $26.60. The costlier, high-quality barite, generally material with a specific gravity greater than 4.2, is usually blended with lower grade ore, foreign or domestic, during grinding to meet American Petroleum Institute specifications for 4.2 drilling-mud-grade barite. Imports of ground barite increased nearly 58% to over 71,000 tons from about 45,000 tons in 1984; of this, China and Morocco supplied 67% and 24%, respectively. Ground barite imports up to those of 1983 had been limited to premium-quality pharmaceutical grade from Belgium-Luxembourg, Canada, France, the Federal Republic of Germany, and the Netherlands, unavailable domestically and averaging $300 to $600 per ton. The average c.i.f. value of the Chinese and Moroccan imports, $53.22 and $73.30, respectively, suggests that this barite is probably drilling-grade material. The last significant imports of mud-grade barite, excluding that of 1984, occurred during the drilling boom years of the late 1970's and early 1980's when imports, mainly from Morocco, Mexico, Singapore, and China, in decreasing order, averaged under 10,000 tons per year. Continued imports of ground drilling-grade barite, in an already soft market situation, will probably result in the closure of some grinding plants and adversely affect the few domestic mines that still supply ore for blending. The value of imports from Thailand, about $115 per ton, indicates that this ground material was probably destined for domestic filler and/or extender markets that are usually supplied by U.S. producers. Crude barite, for the most part, entered through customs districts near most drilling-mud markets along the gulf coast for delivery to grinding plants in the area. The import distribution by customs districts in 1985 (1984) was New Orleans, LA, 58% (53%); Houston, TX, 38% (31%); Laredo, TX (Port of Brownsville, TX), 4% (8%); and Port Arthur, TX (includes Port of Lake Charles, LA), 0% (8%).

Imports of barium chemicals decreased 7% to about 33,000 tons valued at over $20 million. Barium carbonate, the predominant chemical imported, declined nearly 14% to nearly 12,500 tons. The Federal Republic of Germany, China, Italy, Brazil, Canada, and Japan, in descending order, were the major suppliers.

Table 8.—U.S. exports of natural barium sulfate, by country

Country	1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	25	$9	59	$43
Barbados	259	30	1,266	149
Canada	707	254	897	244
Japan	62	20	21	8
Liberia	--	--	1,485	16
Mexico	87	193	5	1
Mozambique	--	--	1,018	82
Paraguay	--	--	762	81
Philippines	36	13	14	3
Venezuela	39	21	50	24
Other	235	34	301	42
Total[1]	1,449	574	5,876	692

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of barite, by country

Country	1984		1985	
	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)
Crude barite:				
Chile	87,202	$3,136	72,219	$2,008
China	905,158	40,038	890,659	34,265
India	133,785	4,997	443,406	17,142
Indonesia	--	--	33,013	1,217
Ireland	39,683	1,509	19,499	519
Mexico	59,446	1,275	35,533	1,522
Morocco	335,375	13,582	319,207	11,897
Peru	64,006	2,618	28,991	1,058
Switzerland	--	--	80,919	3,410
Thailand	64,753	2,618	115,316	4,374
Other	41,552	1,937	17,162	803
Total[2]	1,730,960	71,708	2,055,924	78,216
Ground barite:				
Belgium-Luxembourg	103	41	20	6
Canada	1,565	374	3,539	499
China	31,382	1,691	47,779	2,543
France	80	24	20	5
Germany, Federal Republic of	324	92	353	106
Mexico	1	(3)	--	--
Morocco	11,112	887	17,107	1,254
Netherlands	368	115	146	46
Thailand	67	10	2,050	234
Turkey	22	3	--	--
Other	--	--	10	4
Total	45,024	3,237	71,024	4,697

[1]C.i.f. value.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

Source: Bureau of the Census.

Table 10.—U.S. imports for consumption of barium chemicals

Year	Lithopone		Blanc fixe (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1981	NA	NA	8,402	$5,369	3,601	$1,170	3,663	$2,451
1982	NA	NA	8,135	5,580	2,930	878	3,570	2,758
1983	NA	NA	9,087	5,911	3,402	1,016	4,799	3,751
1984	NA	NA	9,302	6,381	3,680	1,576	5,452	3,973
1985	NA	NA	8,971	6,295	2,839	1,125	5,708	3,959

Year	Barium nitrate		Barium carbonate, precipitated		Other barium compounds	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1981	270	$87	5,709	$2,323	664	$538
1982	682	263	7,787	3,055	753	629
1983	777	275	8,821	3,884	946	1,256
1984	1,278	478	14,476	7,269	1,020	847
1985	1,339	643	12,457	5,400	1,593	2,556

NA Not available.

Source: Bureau of the Census.

Table 11.—U.S. imports for consumption of crude, unground, and crushed or ground witherite[1]

Year	Crude, unground		Crushed or ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1981	7	$2	92	$85
1982	292	82	41	44
1983	1	4	49	12
1984	41	24	185	129
1985	1	6	141	68

[1]Barium carbonate.

Source: Bureau of the Census.

WORLD REVIEW

Estimated world production of barite increased slightly to 6.7 million tons. The United States produced 11% of the world total and imported 31% of the world output.

Canada.—The Newfoundland and Labrador Department of Mines was involved in a number of industrial minerals projects including a major study of their barite resources.[7] The projects were designed chiefly to exploit the areas' mineral deposits.

China.—The Ministry of Geology and Mineral Resources reported the discovery of a barite deposit containing about 400 million tons of recoverable ore.[8] The ore body between the Hunan, Guizhou, and Guangxi Provinces is close to the surface and easily minable. The Government was pressing to develop new barite mines to ensure its market shares in the drilling-mud, chemical, and filler-extender industries.[9]

Gabon.—The Government was seeking assistance in exploiting its Bourekiki barite deposit, which has stated ore reserves in excess of 1 million tons.[10] Initial plans called for a $15 million mining operation, with the barite being marketed mostly in the neighboring countries of Angola and the Congo.

Greece.—The downturn in worldwide oil and gas drilling activities forced Silver and Barytes Ores Mining Co. to operate its Kavos and Pikridou Mines on the Island of Milos on an intermittent basis.[11] The facility, capable of producing 6,000 tons of 3.9 specific gravity filler-grade material, completed installation of a 12,000-ton-per-year flotation plant to upgrade the ore to meet drilling-mud specifications.

India.—Mineral and Metal Trading Corp. started on its long-range plans of diversifying and expanding along the lines of some of the large Japanese trading companies.[12] Future activities were to include mining, mine financing, trading, and distribution aimed at increasing its turnover by 1990. One announced mining plan was a joint venture with Andhra Pradesh Mineral and Development Corp. (APMDC) to develop a barite operation in southern India.

APMDC, with nearly 80 million tons of barite reserves (one-third of the country's total), reportedly contributed over 98% of India's total barite production.[13] In addition to Andhra Pradesh, the other producing States, in descending order, are Rajasthan, Madhya Pradesh, Maharashtra, and Bihar.

Indonesia.—Large deposits of high-quality barite were discovered on Lembata Island in East Nusa Tenggara.[14] The find was made by P.T. Bariod Indonesia, a joint venture between NL BAROID/NL Industries and P.T. Indokar. Indonesia planned to discontinue barite imports from Thailand when the new mines and mill complex come on-stream.

Malaysia.—The Government's Malaysia Mining Corp. announced a feasibility study for its newly outlined barite deposit, containing upwards of 500,000 tons of reserves, at Sungei Pedah.

Mexico.—Church and Dwight Co. Inc., Piscataway, NJ, purchased 49% interest in Sales y Óxides, a Monterrey-based producer of barium and strontium carbonates.[15] Production capacity increases were planned for the strontium chemical stream.

Oman.—IMCO Services, a division of Halliburton, placed its grinding plant on-stream early in the year.[16]

Pakistan.—The Geological Survey's extensive exploratory and evaluation work over the last 4 years located several viable industrial mineral deposits.[17] One area of note is the barite associated with lead-zinc mineralization in the Khuzdar District.

Tunisia.—Expansion plans at the Zriba fluorspar operations, scheduled for completion in 1986, called for increasing byproduct barite production to about 40,000 tons per year.

Turkey.—Barit Maden Turk AS, a major barite producer and grinder, trebled its grinding capacity by acquiring Matosan Ltd.'s facilities.[18] Barit's grinding capacity will be increased to nearly 300,000 tons per year after new equipment is installed at its Bahce, Adana plant, about 50 miles from the Port of Iskenderun on the Mediterranean coast. Barit produces drilling-mud-grade barite from its mines in Marash, Adana, Sivas, and Kayseri Districts.

The State mining company, Etibank, was looking for foreign partners to upgrade its 100,000-ton-per-year open pit mine at Beysehir and the associated grinding and bagging facilities at Antalya.[19] The foreign partner was also expected to help in establishing new overseas markets.

United Kingdom.—Minworth Metals Ltd. began exploratory work and opencast mining operations for exploiting the larger and thicker barite veins found at Cumberhead in the Clydesdale District of southern Scotland.[20] The entire complex is planned to cover approximately 3 hectares of ground divided between three separate mines within 1 mile of each other. Minworth was also planning to build a 35,000-ton-per-year washing and heavy-media separation plant at Carluke, about 20 miles to the east of Cumberland, for the production of oil well drilling-grade material.

Venezuela.—The Ministry of Energy and Mines' preliminary findings from a number of mineral-related projects conducted during the year revealed a large deposit of drilling-mud-quality barite in the Northwestern Region.[21] Venezuela, a large oil producing country, currently imports about 100,000 tons of barite annually for its oil and gas exploration activities.

Yugoslavia.—New deposits of barite, with reserves estimated at 2 million tons, were found on Mount Bobija near Ljubovija in Serbia.[22] Although the Government already produces about 350,000 tons per year of barite, mostly for export, plans were under way to increase the concentrator's capacity an additional 35,000 tons annually.

Table 12.—Barite: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Afghanistan[3]	1	2	[e]2	[r] [e]2	2
Algeria	98	112	[e]120	97	100
Argentina	54	40	67	49	55
Australia	45	31	13	22	22
Belgium[e]	44	44	44	[r]43	44
Bolivia	2	1	1	1	2
Brazil	128	[r]155	140	158	160
Burma[4]	8	18	11	[e]12	12
Canada	95	31	50	52	50
Chile	286	322	126	24	24
China[e]	880	990	1,100	1,100	1,100
Colombia	[r]3	4	4	4	4
Czechoslovakia[e]	67	67	67	[r]66	66
Egypt	2	3	4	[e]4	4
Finland	--	--	4	10	10
France	210	[r]158	168	163	165
German Democratic Republic[e]	39	39	39	[r]39	37
Germany, Federal Republic of	182	183	181	184	187
Greece[5]	52	[r]43	33	3	19
Guatemala	6	2	[e]([6])	([6])	([6])
India	390	359	356	463	670
Iran[e]	83	88	94	100	100
Ireland	302	[r]293	220	243	243
Italy	195	198	153	118	110
Japan	62	66	77	73	[7]85
Kenya	[e]7	--	([6])	([6])	([6])
Korea, North[e]	110	--	--	--	--
Korea, Republic of	--	--	1	3	2
Malaysia	21	28	24	26	45
Mexico	350	401	394	470	540
Morocco	513	[r]565	318	469	468
Pakistan	[r]30	[r]24	29	35	40
Peru	451	413	[e]180	[e]180	180
Philippines	2	10	1	([8])	--
Poland	94	100	89	89	88
Portugal	1	1	1	[e]([6])	([6])
Romania[e]	87	86	86	80	80
South Africa, Republic of	[r]2	4	7	5	[7]3
Spain	58	55	58	76	70
Thailand	338	365	207	193	190
Tunisia	27	34	22	13	22
Turkey	205	[r]127	87	218	220
U.S.S.R.[e]	560	570	570	[r]580	595
United Kingdom	69	89	40	69	77
United States[9]	2,849	1,845	754	775	[7]739
Yugoslavia	49	35	39	[e]40	40
Zimbabwe	--	1	1	1	1
Total	[r]9,057	[r]8,002	5,982	6,352	6,671

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 17, 1986.
[2]In addition to the countries listed, Bulgaria also produces barite, but available information was inadequate to make reliable estimates of output levels.
[3]Year beginning Mar. 21 of that stated.
[4]Data are for fiscal years beginning Apr. 1 of that stated.
[5]Barite concentrates.
[6]Less than 1/2 unit.
[7]Reported figure.
[8]Revised to zero.
[9]Sold or used by producers.

TECHNOLOGY

A short survey highlighting the qualities of Turkish barite deposits, including data on reserves, resources geology, mining and production methods, and recent production statistics, was published.[23] The paper features nonograms and graphs showing the relationship between barium sulfate ($BaSO_4$) content and density and its subsequent applicability in glass and chemicals manufacturing and its use in drilling muds. A comprehensive paper featuring barite was published in a treatise on the industrial minerals of the Federal Republic of Germany.[24] The article examines barite geology, mining and production methods, reserve estimates, and the individual companies involved in the nondrilling mud markets. High-quality West German barites have been traditionally used in barium chemicals, lithopone, and to a lesser degree in the filler and extender areas of paint, rubber, and plastics. Similar, but less vigorous studies, were released on the mineral industries of Greece,[25] Spain,[26] and California.[27] The Greek article stressed barite mining and processing flowsheets, while the Spanish work, in addition, detailed the geology of its deposits. The California study detailed its run-of-mine production of high-grade 4.4 specific gravity barite and blending schemes, using selected low-grade Nevada ore, to meet drilling mud specifications for the demanding onshore and offshore California markets.

A technically oriented article was published on the mineral requirements of the paint manufacturers in the United States, Western Europe, and Japan, for increasing specialized grades of materials.[28] The article also discussed the chemical and physical properties of the three main paint components: pigment, medium (binder or vehicle), and solvent (thinner). A special pigment section listed specifications for barite, blanc fixe, and lithopone, and also included detailed flowsheets used in their production. An interesting feature of the article was its description of the wide range of substitutability possible in pigment material to reduce raw material cost, yet still remain capable of producing high-quality competitive paint.

The technical rationale for the past, present, and future industrial minerals usage by the U.S. drilling industry[29] and North Sea Oilfields was published.[30] The U.S. drilling industry paper stressed the indispensibility of barite weighting agents and new material usages, such as organoclays and mineral-wool fibers. The North Sea paper attempted to forecast the future mineral requirements of the areas based on the technology of developing 80 new fields and 100 production platforms, and drilling up to 1,500 appraisal and development wells.

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Bauxite and Alumina

By Luke H. Baumgardner[1] and Ruth A. Hough[2]

For the major U.S. aluminum companies, 1985 was a year of restructuring and expansion into peripheral fields. There was increased interest in specialty aluminas for abrasives, ceramics, electronics, and refractories. Domestic and world production of bauxite and alumina declined from 1984 output levels, and world alumina capacity decreased by 7% with the closing of five plants in Japan and the United States. The permanent closure of three refineries reduced domestic annual alumina capacity by 30%, further increasing U.S. reliance on foreign sources of supply.

Domestic Data Coverage.—Domestic production data for bauxite and alumina are developed by the Bureau of Mines from three separate voluntary surveys of U.S. operations. Typical of these surveys are the quarterly and annual "Production of Bauxite" surveys. Of the six operations to which a survey form was sent, all responded, representing 100% of the 1985 U.S. bauxite production shown in tables 1, 2, and 18.

Table 1.—Salient bauxite statistics

(Thousand metric tons and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Production: Crude ore (dry equivalent)	1,510	732	679	856	674
Value	$26,489	$12,334	$11,309	$15,643	$12,855
Exports (as shipped)	20	49	74	82	56
Imports for consumption[1]	12,802	10,122	7,601	r10,228	7,944
Consumption (dry equivalent)	13,525	9,217	9,100	10,519	8,206
World: Production	r85,347	r79,318	78,644	p88,173	e85,133

eEstimated. pPreliminary. rRevised.

[1]Excludes calcined bauxite. Includes bauxite imported to the U.S. Virgin Islands.

Legislation and Government Programs.—There were no changes in the National Defense Stockpile (NDS) goals for bauxite during the year. The goal for metal grade bauxite, Jamaica-type, was 21.3 million tons,[3] and for Suriname-type, 6.2 million tons. The goals for calcined abrasive grade and refractory grade were 1 million and 1.4 million tons, respectively. The General Services Administration (GSA) reported inventories at yearend of 12.7 million tons of Jamaica-type and 5.4 million tons of Suriname-type, metal grade bauxite. The final deliveries of metal grade, Jamaica-type bauxite were accepted for the stockpile by GSA, increasing the inventory in 1985 by 1.02 million tons. Deliveries of 76,000 tons of calcined refractory grade bauxite from China, purchased under two 1984 GSA contracts, began during the year but had neither been completed nor added to the inventory by yearend.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, two forms of bauxite would be listed in tier II.

The goal for metal grade bauxite would be 3.88 million tons of aluminum metal equivalent (identical to the 1985 yearend metal grade bauxite inventory), and the goal for calcined refractory grade bauxite would be 279,339 tons.

The Occupational Safety and Health Administration hazard communication standard went into effect on November 25. Domestic companies, including the bauxite and alumina industries, were to determine whether any of their products contained substances hazardous to their employees or customers, and if so, how they were to be labeled.

DOMESTIC PRODUCTION

Production of bauxite in the United States was 674,000 tons, or about 21% lower than the 856,000 tons produced in 1984. Near Bauxite, AR, the Aluminum Co. of America (Alcoa) mined bauxite to supply its local alumina plant and to calcine for use in proppants and abrasives. Nearby at Bryant, AR, American Cyanamid Co. mined and calcined bauxite for shipment to the company's plants in Michigan and Illinois for the production of aluminum sulfate. The Porocel Corp. at Berger, AR, calcined bauxite purchased from a local supplier to produce activated bauxite used principally by the petroleum industry. In the southeastern bauxite mining district, Harbison-Walker Refractories Co., a division of Dresser Industries Inc., mined bauxite west of Eufaula, AL, for calcining to refractory material and as raw material feed for the production of proppants at another division of Dresser Industries, the plant in Eufaula. Mullite Co. of America mined bauxite in Henry County, AL, and in Sumter County, GA, for calcining to refractory grade bauxite at the company's plant near Andersonville, GA.

Domestic alumina production capacity was reduced by 1.935 million tons per year with the permanent closure of refineries by Martin Marietta Aluminum Inc. at St. Croix, VI, in May; by Ormet Corp. at Burnside, LA; and by Kaiser Aluminum & Chemical Corp. at Baton Rouge, LA, at yearend 1985. Of the nine domestic alumina plants that were in operation in 1982, only four were still operating at yearend 1985.

Total production of alumina (calcined equivalent) during the year declined to about 3.4 million tons, the lowest level since 1960. Based on an average annual capacity figure of 5.4 million tons, apparent capacity utilization in 1985 was about 64%.

Table 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States

(Thousand metric tons and thousand dollars)

Year	Mine production			Shipments from mines and processing plants to consumers[1]		
	Crude	Dry equivalent	Value[2]	As shipped	Dry equivalent	Value[2]
1983	826	679	11,309	977	913	26,370
1984	1,054	856	15,643	1,332	1,227	35,719
1985	787	674	12,855	993	989	34,506

[1]May exclude some bauxite mixed in clay products.
[2]Computed from values assigned by producers and from estimates of the Bureau of Mines.

Table 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Thousand metric tons)

Year	Crude ore treated	Total processed bauxite recovered[1]	
		As recovered	Dry equivalent
1984	361	168	294
1985	329	166	284

[1]Dried, calcined, and activated bauxite. May exclude some bauxite mixed in clay products.

Table 4.—Percent of domestic bauxite shipments, by silica content

SiO_2 (percent)	1981	1982	1983	1984	1985
From 8 to 15	65	63	W	W	W
More than 15	35	37	W	W	W

W Withheld to avoid disclosing company proprietary data.

Table 5.—Production and shipments of alumina in the United States

(Thousand metric tons)

Year	Calcined alumina	Other alumina[2]	Total[1]	
			As produced or shipped[3]	Calcined equivalent
Production:[e]				
1981	5,490	700	6,190	5,960
1982	3,810	465	4,280	4,130
1983	3,540	680	4,220	4,000
1984[r]	4,160	560	4,720	4,545
1985	2,860	860	3,725	3,465
Shipments:[e]				
1981	5,610	715	6,320	6,085
1982	3,730	420	4,150	4,020
1983	3,480	670	4,150	3,945
1984[r]	4,230	570	4,800	4,620
1985	2,890	760	3,650	3,425

[e]Estimated. [r]Revised.
[1]Data may not add to totals shown because of independent rounding.
[2]Trihydrate, activated, tabular, and other aluminas. Excludes calcium and sodium aluminates.
[3]Includes only the end product if one type of alumina was produced and used to make another type of alumina.

Table 6.—Capacities of domestic alumina plants,[1] December 31

(Thousand metric tons per year)

Company and plant	1984	1985
Aluminum Co. of America:		
Bauxite, AR	340	340
Point Comfort, TX	1,400	1,600
Total	1,740	1,940
Martin Marietta Aluminum Inc.: St. Croix, VI	635	--
Kaiser Aluminum & Chemical Corp.:		
Baton Rouge, LA	955	--
Gramercy, LA	770	770
Total	1,725	770
Ormet Corp.: Burnside, LA	545	--
Reynolds Metals Co.: Corpus Christi, TX	1,700	1,700
Grand total	6,345	4,410

[1]Capacity may vary depending upon the bauxite used.

CONSUMPTION AND USES

Consumption of crude and dried bauxite declined substantially from 1984 levels as a direct result of reduced alumina demand and alumina plant closures. Calcined and activated bauxite consumption was about the same as that of 1984. Of the total bauxite consumed during the year, 987,000 tons, or 12%, went to refractories, abrasives, chemicals, proppants, and other nonalumina uses. The 27 U.S. primary aluminum smelters that operated during all or part of the year consumed about 82% of the total domestic alumina produced, while the remaining 634,000 tons (calcined equivalent) served as feedstocks to the abrasives, ceramics, chemicals, and refractories industries. As in 1984, the only domestic bauxite refined to alumina was mined and processed in Arkansas, and virtually all of the alumina produced was consumed in nonmetal uses.

The market for proppant sales to the U.S. petroleum industry, which looked promising in 1984, was beginning to weaken by yearend 1985 as domestic drilling slowed in response to lowered world oil prices. Demand for bauxite-based refractories by the steel industry, the principal user, exhibited no improvement during the 12-month period and characterized the flat or downward trend in consumption of all specialty bauxites.

Table 7.—U.S. consumption of bauxite, by industry

(Thousand metric tons, dry equivalent)

Industry	Domestic	Foreign	Total[1]
1984:			
Alumina	724	8,741	9,465
Abrasive[2]	W	W	328
Chemical	[3]39	[3]268	251
Refractory	119	301	420
Other	W	W	56
Total[1] [2]	977	9,542	10,519
1985:			
Alumina	664	6,555	7,219
Abrasive[2]	W	W	305
Chemical	[3]30	[3]244	219
Refractory	111	297	408
Other	W	W	55
Total[1] [2]	868	7,338	8,206

W Withheld to avoid disclosing company proprietary data; included with "Chemical" or "Total."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes consumption by Canadian abrasive industry.
[3]Includes "Other."

Table 8.—U.S. consumption of crude and processed bauxite

(Thousand metric tons, dry equivalent)

Type	Domestic origin	Foreign origin	Total[1]
1984:			
Crude and dried	826	9,007	9,833
Calcined and activated	151	535	686
Total	977	9,542	10,519
1985:			
Crude and dried	729	6,797	7,526
Calcined and activated	140	541	680
Total[1]	868	7,338	8,206

[1]Data may not add to totals shown because of independent rounding.

Table 9.—Production and shipments of selected aluminum salts in the United States, in 1984

Item	Number of producing plants	Production (thousand metric tons)	Total shipments including interplant transfers	
			Quantity (thousand metric tons)	Value (thousands)
Aluminum sulfate:				
Commercial and municipal (17% Al_2O_3)	62	1,025	946	$120,371
Iron-free (17% Al_2O_3)	19	103	85	10,711
Aluminum chloride:				
Liquid and crystal (32° Be)	3	6	W	W
Anhydrous (100% $AlCl_3$)	4	19	W	W
Aluminum fluoride, technical	4	W	W	W
Aluminum hydroxide, trihydrate (100% $Al_2O_3 \cdot 3H_2O$)	7	609	612	161,573
Other inorganic aluminum compounds[1]	XX	XX	XX	59,553

W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Includes sodium aluminate, light aluminum hydroxide, cryolite, and alums.

Source: Data are based upon Bureau of the Census report Form MA-28A, "Annual Report on Shipments and Production of Inorganic Chemicals."

Table 10.—Stocks of bauxite in the United States,[1] December 31

(Thousand metric tons, dry equivalent)

Sector	1984	1985
Producers and processors	r499	413
Consumers	r4,382	3,431
Government	17,338	18,357
Total	r22,219	22,201

rRevised.
[1]Domestic and foreign bauxite; crude, dried, calcined, activated; all grades.

Table 11.—Stocks of alumina in the United States,[1] December 31

(Thousand metric tons, calcined equivalent)

Sector	1984	1985
Producers[e]	229	194
Primary aluminum plants	1,485	1,438
Total[e]	1,714	1,632

[e]Estimated.
[1]Excludes consumers' stocks other than those at primary aluminum plants.

PRICES

Metal grade bauxite is rarely traded on world commodity markets, and sales of metal grade calcined alumina are equally limited. Neither the inter- and intracompany long-term sales contracts nor the government-to-company contracts normally are made public. A few trade journals quote spot sales and prices of specialty forms of bauxite and alumina.

The average value in 1985 of domestic crude bauxite shipments, f.o.b. mine or plant, was estimated by the Bureau of Mines to be $16.53 per ton. The average value of calcined domestic bauxite was estimated to be $113 per ton. Base prices quoted by principal sales agents for imported calcined refractory grade bauxite ranged from $117 to $145 per ton, f.o.b. barge, Louisiana, for Chinese material, 85% Al_2O_3 typical. Guyana refractory bauxite, minimum 86% Al_2O_3, ranged in price from $154 per ton in January to $168 in December, f.o.b. car, Baltimore, MD, or f.o.b. barge, Burnside, LA. In each case, adjustments were applied to the base price for various grain-size specifications, size of order, and fuel cost factors.

The estimated average value of shipments of domestic calcined alumina was $179 per ton. Trade data of the Bureau of Census indicated an average value of $203 per ton, f.a.s. port of shipment, and $215 per ton, c.i.f. U. S. ports.

Table 12.—Average value of U.S. imports of crude and dried bauxite[1]

(Per metric ton)

Country	1984		1985	
	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)	Port of shipment (f.a.s.)	Delivered to U.S. ports (c.i.f.)
To U.S. mainland:				
Australia	$14.76	$23.70	$14.72	$23.35
Brazil	28.34	38.47	30.27	39.53
Guinea	28.85	36.42	29.76	36.26
Guyana	36.30	52.11	42.40	54.31
Jamaica	31.44	36.91	30.81	35.09
Suriname	38.22	48.27	37.09	48.26
Weighted average	29.79	36.99	28.95	35.72

[1]Computed from quantity and value data reported to U.S. Customs Service and compiled by the Bureau of the Census, U.S. Department of Commerce. Not adjusted for moisture content of bauxite or differences in methods used by importers to determine value of individual shipments.

Table 13.—Market quotations on alumina and aluminum compounds

(Per metric ton, in bags, carlots, freight equalized)

Compound	Dec. 31, 1984	Dec. 30, 1985
Alumina, calcined	$418.88	$418.88
Alumina, hydrated, heavy	209.44	209.44
Alumina, activated, granular, works	905.00	905.00
Aluminum sulfate, commercial, ground (17% Al_2O_3)	259.04	259.04
Aluminum sulfate, iron-free, dry (17% Al_2O_3)	439.82	439.82

Source: Chemical Marketing Reporter.

FOREIGN TRADE

Of the 7.9 million tons of crude and dried bauxite imported by the United States, Guinea supplied 47%; Jamaica, 29%; Australia, 10%; and Brazil, 7%. Although imports from Australia increased, compared with receipts in 1984, the quantity was not sufficient to offset the decline in imports from Brazil, Guyana, Jamaica, and Suriname.

China was the leading supplier of calcined refractory grade and abrasive grade bauxite imports, although a portion of the refractory bauxite was delivered to the NDS under a GSA purchase contract. Calcined abrasive grade bauxite imports from Australia were nearly the same as those of 1984. Guyana supplied a small amount of abrasive grade bauxite to the United States while imports from China more than doubled over those of 1984. Fused crude aluminum oxide, produced in Canada from calcined abrasive grade bauxite, was shipped to U.S. plants for the manufacture of abrasive and refractory end products.

Australia supplied 76% of the alumina imported for consumption and Jamaica, Suriname, and Canada, in order of decreasing quantities, accounted for most of the balance. Supplies from each of the four major source countries declined from the 1984 level.

Exports of dried bauxite totaled 31,819 tons, of which 59% was shipped to Canada and 37% to the Federal Republic of Germany. Of the 24,274 tons of calcined bauxite exported during the year, Mexico received 84%; France, 11%; and Canada, 5%. Exports of alumina dropped by 50% compared with 1984 exports, primarily as a result of reduced shipments to Norway. Canada and Mexico received about 72% of the exports. Other aluminum compounds exported included 5,700 tons of aluminum sulfate, 11,100 tons of aluminum oxide abrasives, and 32,400 tons of unclassified aluminum compounds, including aluminum fluoride and synthetic cryolite.

Table 14.—U.S. exports of alumina,[1] by country

(Thousand metric tons, calcined equivalent, and thousand dollars)

Country	1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	(2)	469	1	558	(2)	455
Belgium-Luxembourg	1	3,138	2	2,616	2	2,369
Brazil	21	5,881	(2)	268	1	821
Canada	25	19,664	80	37,238	132	36,185
France	3	3,474	2	3,412	1	2,717
Germany, Federal Republic of	3	6,086	3	6,008	4	6,732
Ghana	19	3,173	--	--	--	--
Japan	2	4,636	3	8,064	1	2,515
Mexico	99	29,697	111	33,376	104	29,115
Netherlands	2	2,690	11	4,017	3	4,021
Norway	265	59,794	369	81,228	45	7,417
Sweden	98	14,147	60	10,350	22	2,966
United Kingdom	4	4,195	3	4,014	3	5,361
Venezuela	52	12,287	4	2,833	1	1,192
Other	8	12,588	10	15,127	7	12,967
Total[3]	602	181,920	659	209,110	327	114,833

[1]Includes exports of aluminum hydroxide (calcined equivalent) as follows: 1983—8,100 tons; 1984—13,100 tons; and 1985—16,700 tons, and aluminum oxide abrasives.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 15.—U.S. imports for consumption of bauxite, crude and dried,[1] by country

(Thousand metric tons)

Country	1983	1984	1985
Australia	--	560	829
Brazil	555	786	560
Guinea	3,600	3,718	3,752
Guyana	167	264	225
Jamaica[2]	3,036	r4,559	2,325
Sierra Leone	--	--	56
Suriname	239	325	176
Other	4	15	20
Total[3]	7,601	r10,228	7,944

rRevised.
[1]Includes bauxite imported to the U.S. Virgin Islands from foreign countries.
[2]Dry equivalent of shipments to the United States.
[3]Data may not add to totals shown because of independent rounding.

Note: Total U.S. imports of crude and dried bauxite (including the U.S. Virgin Islands) as reported by the Bureau of the Census were as follows: 1983—7,903,202 tons; 1984—10,436,135 tons; and 1985—7,257,840 tons.

Source: Bureau of the Census.

Table 16.—U.S. imports for consumption of calcined bauxite, by country

(Thousand metric tons and thousand dollars)

Country	1984				1985			
	Refractory grade		Other grade		Refractory grade		Other grade	
	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]
Australia	(2)	281	24	2,928	--	--	23	3,705
China	78	7,428	18	1,389	169	13,131	41	2,077
Guyana	110	14,763	--	--	102	12,402	4	538
Suriname	1	154	(2)	4	(2)	8	(2)	11
Other	--	--	(2)	56	(2)	4	(2)	92
Total[3]	190	22,626	42	4,377	272	25,546	69	6,424

[1]Value at foreign port of shipment as reported to U.S. Customs Service.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 17.—U.S. imports for consumption of alumina,[1] by country

(Thousand metric tons, calcined equivalent, and thousand dollars)

Country	1983		1984		1985	
	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]
Australia	3,049	544,322	3,055	593,722	3,014	564,261
Brazil	3	1,565	39	7,123	50	10,142
Canada	159	67,762	204	91,603	177	76,133
France	6	10,982	9	14,455	7	11,968
Germany, Federal Republic of	13	15,797	20	24,080	18	19,480
Jamaica	399	87,973	572	125,974	372	66,171
Japan	25	7,927	3	3,680	4	4,918
Suriname	318	59,225	392	75,317	326	42,949
Venezuela	35	4,394	116	15,158	--	--
Other	24	11,073	55	25,253	11	13,640
Total[3]	4,030	811,021	4,466	976,364	3,979	809,664

[1]Includes imports of aluminum hydroxide, crude aluminum oxide, and refined and ground aluminum oxide.
[2]Value at foreign port of shipment as reported to U.S. Customs Service.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World production of bauxite by 23 countries totaled 85 million tons in 1985. Australia, Brazil, Guinea, and Jamaica, as in 1984, contributed about 68% of the world total, and these four countries also supplied about 94% of the U.S. crude and dried metal grade bauxite imports. Three of the world's 25 alumina-producing countries, Australia, the U.S.S.R., and the United States, accounted for nearly 50% of the 31.9 million tons of alumina produced.

In November, members of the International Bauxite Association (IBA) recommended minimum prices for bauxite and alumina. In 1986, the minimum for metal grade bauxite was to be 2.5% to 3.5% of a reference price for 99.5% primary aluminum ingot. The reference market price of metal was to be derived by using an average of spot prices and long-term prices from West European and U.S. markets. The minimum price range proposed for cell-grade alumina was 12% to 16% of the primary ingot price.

Australia.—Despite a sluggish year for the world aluminum industry, Australia increased bauxite production to 32.4 million tons from 32.2 million tons the previous year. Alumina production remained at about the same level as that of 1984. In Queensland, Comalco Ltd. produced 7.6 million tons of bauxite at its mining operations at Weipa. The calcining units at Weipa operated at about 86% of capacity, and the company shipped 230,000 tons of calcined abrasive grade bauxite. Reportedly, Comalco filed for a patent covering a new synthetic proppant with better physical characteristics than those of proppants currently produced from calcined bauxite. Queensland Alumina Ltd. (QAL)—owned by Comalco (30.3%), Kaiser (28.3%), Alcan Australia Ltd. (21.4%), and Pechiney (20%)—produced 2.1 million tons of alumina at the Gladstone, Queensland, refinery. QAL reduced production in April, but announced it was restarting the idle third unit during the last quarter of the year in order to meet commitments. At the Gove, Northern Territory, mine and refinery of Nabalco Pty. Ltd. (a Swiss Aluminium Ltd. subsidiary), bauxite production was 5.88 million tons, and alumina production, 1.26 million tons—both close to the 1984 output. More than one-half of the bauxite mined was locally processed into alumina.

Alcoa of Australia Ltd. announced that alumina production at its 1.4-million-ton-per-year Kwinana refinery in Western Australia would be reduced in the fourth quarter to an operating rate of about 70% of capacity. Production at the company's Pinjarra and Wagerup refineries was not affected, and Alcoa's total production for the year in Western Australia was 15.1 million tons of bauxite and about 4.6 million tons of alumina. Production by Worsley Alumina Pty. Ltd., owned by Reynolds Alumina Australia Ltd. (40%), Shell Co. of Australia Ltd. (30%), BHP Minerals Ltd. (20%), and Kobe Alumina Associates (Australia) Pty. Ltd. (10%), totaled 3.3 million tons of bauxite and 1.0 million tons of alumina. The Boddington gold deposit, discovered by the Worsley Alumina group during development of its bauxite reserves, reportedly could become one of Australia's major gold mining operations. Initial plans call for the annual production of more than 5,000 kilograms of gold per year. The company was reported to be awaiting approval of various permits after having been granted an environmental permit.

Brazil.—The 1985 bauxite production was about 6.7 million tons for this country controlling 10% of the world's bauxite reserves. Alumina production was approximately 1.0 million tons. Shell Brasil S.A. planned to invest $33 million in an expansion of the Alumínio do Maranhão S.A. (ALUMAR) refinery and primary smelter project at São Luis, in which the company held a 29% interest. The two other partners in ALUMAR were Alcoa Alumínio S.A. and Camargo Correa S.A. Bauxite was supplied to the 500,000-ton-per-year alumina plant from the Trombetas Mine under a contract with Mineração Rio do Norte S.A. (MRN), a consortium owned 46% by Cia. Vale do Rio Doce (CVRD) and a group of North American and West European companies. MRN, Brazil's only exporter of bauxite, produced and shipped an estimated 4.1 million tons of ore. At yearend, when the $28.50 per ton base price for Trombetas bauxite was due to expire, the Government, MRN, and its customers were negotiating to set a new contract price. Also in December, the 32 Japanese companies holding an interest in the Nippon Amazon Aluminium Co. (NAAC) postponed their decision for the third time on whether or not to proceed with the construction of the 800,000-ton-per-year Alumina do Norte do Brasil S.A. (ALUNORTE) alumina plant adjacent to the Alumínio Brasileiro S.A. (ALBRÁS) primary aluminum smelter that started production earlier in the year. ALBRÁS had signed contracts with the Suriname Aluminum Co. and Venezuela's Interamericana de Alúmina C.A. (INTERALUMINA) refinery to supply the smelter with alumina until 1990.

China.—The Government was reported to have signed an agreement calling for Pechiney of France to provide technical assistance for the Hejin alumina plant currently under construction in Shanxi Province. The refinery is expected to achieve the designed annual production rate of 660,000 tons by 1990. In 1985, bauxite deposits in Shanxi Province were reported to contain about 30% of China's resources. Contracts with foreign companies were being sought by the China National Nonferrous Metals Industry Corp. for the development of a number of mineral projects, including a mine, a 300,000-ton-per-year alumina plant, and a 100,000-ton-per-year primary aluminum smelter in Pingguo County, Guangxi Zhuang Autonomous Region. The $800 million vertically integrated project was planned to utilize power from a hydroelectric project on the Hong Shui River.

Ghana.—After the rebuilding of the railroad between the Awaso bauxite mine and the shiploading facilities at Takoradi on the coast was completed early in the year, ore production rose to 124,000 tons, a substantial increase over 1984 output, although considerably below the mine's annual capacity of 300,000 tons.

Greece.—The state agency, Hellenic Aluminium Industry S.A., responsible for the planned 600,000-ton-per-year alumina plant project, signed contracts under which the U.S.S.R. agreed to provide equipment and services for the construction of the plant and to buy 380,000 tons per year of the alumina produced for a period of 10 years. The foundation work for the plant had been started at Agia Efthimia, on the Gulf of Corinth, and the project was expected to take more than 4 years to complete.

Guinea.—Production from the three bauxite mines in Guinea was 13.1 million tons, with Compagnie des Bauxites de Guinée (CBG) contributing about 8.5 million tons of the total. Alumina production by the Frialco Co. was about 580,000 tons. Halco (Mining) Inc., 51% owner of CBG, continued discussions into December in an effort to persuade the Government of Guinea to reduce the $13 per ton levy currently imposed on Halco's bauxite production.

Guyana.—After 2 years in which bauxite production was slightly above 1 million tons, 1985 output increased to nearly 1.7 million tons. The U.S. firm, Green Construction Co., continued overburden removal under Government contract. No alumina was produced at the Linden refinery, which has remained dormant since it closed in 1982. However, Guyana entered negotiations during the year with the German Democratic Republic and a Brazilian company in a plan to reopen the 355,000-ton-per-year alumina plant. Estimated costs were reported to be between $12 and $20 million. Loans were being sought from the International Bank for Reconstruction and Development and from the European Economic Community to improve all areas of the country's bauxite and alumina industry. Guyana reported that it had reached an agreement to sell bauxite to the U.S.S.R. from 1986 through 1993. The final contract was to be signed early in 1986 and no terms or prices were announced in advance. In another agreement, the Bauxite Industry Development Co. (BIDCO), Guyana's state-owned sales organization, signed a 5-year contract with Reynolds International Services Inc., in which Reynolds was to serve as a consultant to BIDCO in technical, production, and marketing areas of the bauxite and alumina operations through 1989.

Hungary.—Bauxite production for the year was about 2.8 million tons, and alumina output was reported to be 801,000 tons. In November 1985, Hungary opened the Fenyoefoe No. 1 bauxite mine after 4 years of development and construction. At the designed production capacity of 650,000 tons per year, the reserves were expected to be depleted in approximately 40 years. About 70% of the ore production was to come from underground workings and the balance from open pit operations. Most of the output was expected to be processed at the Almasfuezitoe alumina plant. Production also started at Tatabanja's Nagyegyhaza bauxite mine in mid-1985. The open pit operation was expected to produce 150,000 tons by the end of the year, and 1986 production was scheduled to reach 350,000 tons. By 1987, after the underground operations started, output of 500,000 tons per year was planned. Ore from this mine was also to be processed at the Almasfuezitoe refinery.

India.—Bauxite production for the year was reported to be 2 million tons, and alumina output was about 560,000 tons. A substantial escalation in cost resulted from the delay in commissioning the Bharat Aluminium Co. (BALCO) bauxite mining project in Orissa. Officials associated with the project reported that instead of the planned May 1985 startup, the operation was expected to open in mid-1987. The Government of India approved new regulations to facilitate exports of bauxite and for the fiscal year 1986, exports totaling 400,000 tons of ore were scheduled. The U.S.S.R. agreed to provide both technical and financial help to India to assist in the bauxite and alumina project at Vishakapatnam. The project was to include a bauxite mine and refinery in Andhra Pradesh and a refinery in Orissa. Completion of the 800,000-ton-per-year facility in Orissa was scheduled for 1987 when the U.S.S.R. planned to start its annual purchases of 1 million tons of bauxite and 200,000 tons of alumina. The National Institute of Science, Technology, and Development issued a report recommending that India should develop Middle East alumina markets with smelters in Algeria, Bahrain, Dubai, Egypt, Iran, and Libya rather than increase its bauxite exports. The report noted that China could be a major potential market for India's aluminum industry after NAAC's new plant starts production in 1987.

Jamaica.—Bauxite production of 6.2 million tons and alumina production of 1.6 million tons were both lower than in 1984. When Alcoa closed its Claredon alumina plant for an indefinite period in February, the Government of Jamaica entered into negotiations with the company to bring the plant back into production. A 2-year contract was signed in which Alcoa was to operate the plant as a contractor to Clarendon Alumina Production Ltd., a newly formed state-owned company, and the refinery was reopened in August. Jamaica was reported to have found customers for the 200,000 tons of alumina produced during the balance of 1985 and was optimistic that 500,000 tons of the plant's 800,000 tons of annual capacity could be placed through European and Soviet sales in 1986. Kaiser and Reynolds Metals Co. bought out ARCO Metals Co.'s 27% share in the Alumina Partners of Jamaica (Alpart) refinery in mid-August and 2 weeks later announced the closing of the 1.3-million-ton-per-year plant.

Japan.—Alumina production in 1985 was reported to be 978,000 tons, the lowest since 1982. Sumitomo Aluminium Smelting Co. Ltd. announced that it was selling part of its 770,000-ton-per-year Kikumoto alumina plant to Sumitomo Chemical Co. and permanently closing down the major part of the facility. High operating costs were cited as the principal reason for the decision. Mitsui Aluminium Co. Ltd. closed its 400,000-ton-per-year Kitakyusha alumina plant after reaching an agreement with Nippon Light Metal Co. Ltd. to refine, under a tolling arrangement, the bauxite Mitsui had contracted to buy from Gove Alumina Ltd., Northern Territory, Australia.

Venezuela.—With initial funds allocated in 1984, C.V.G. Bauxita Venezolana C.A. (BAUXIVEN) began work in January 1985 on the development of the $360 million Los Pijiguaos bauxite mining project. Additional funding through a $108 million loan was approved by the Inter-American Development Bank late in 1985. In the first stage of development, the mine was to have an annual capacity of 3 million tons, and provision was made in the design of the mine and ore transport systems to expand output to 5 million tons per year. The first ore was expected to be barged down the Orinoco River to the INTERALUMINA plant at Puerto Ordaz in 1987, raising Venezuela's aluminum industry to a fully integrated status. The alumina plant was supplied with bauxite imported from Brazil, Guyana, Sierra Leone, and Suriname in 1985. Plans were reportedly under discussion for the expansion of the INTERALUMINA refinery by 300,000 to 500,000 tons per year to satisfy proposed increased capacity in the country's two primary aluminum smelters. In 1985, approximately 360,000 tons of alumina was exported and the balance of INTERALUMINA's 1.085-million-ton output was supplied to the local smelters.

Table 18.—Bauxite: World production, by country[1]

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Australia	25,441	23,625	24,372	32,182	32,400
Brazil	5,770	6,289	7,199	6,433	6,650
China[e]	1,500	1,500	1,600	1,600	1,650
Dominican Republic[2]	457	141	--	--	--
France	1,827	1,662	1,663	1,607	[3]1,484
Germany, Federal Republic of	(4)	(4)	(4)	(4)	(4)
Ghana	181	64	70	115	124
Greece	3,216	2,853	2,455	2,296	2,500
Guinea[5]	11,112	11,827	12,421	13,160	13,100
Guyana[2]	1,681	1,783	1,087	1,333	1,675
Haiti[2 6]	427	377	--	--	--
Hungary	2,914	2,627	2,917	2,994	[3]2,815
India	1,923	1,854	1,923	1,994	[3]2,038
Indonesia	1,203	700	778	1,003	[3]830
Italy	19	23	23	(7)	--
Jamaica[2 8]	11,682	8,361	7,683	8,734	6,239
Malaysia	701	589	502	680	540
Pakistan	2	[r]4	3	3	2
Romania[e]	[3]712	680	650	620	600
Sierra Leone	[e]610	[r]631	785	1,000	800
Spain	9	7	5	7	7
Suriname	[r]4,006	[r]4,205	3,400	3,454	3,000
Turkey	[r]590	508	306	132	132
U.S.S.R.[e 9]	4,600	4,600	4,600	4,600	4,600
United States[2]	1,510	732	679	856	[3]674
Yugoslavia	3,249	3,668	3,500	3,347	[3]3,250
Zimbabwe	5	8	23	23	23
Total	[r]85,347	[r]79,318	78,644	88,173	85,133

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 8, 1986.
[2]Dry bauxite equivalent of crude ore.
[3]Reported figure.
[4]Less than 1/2 unit.
[5]Dry bauxite equivalent of ore processed by drying plant.
[6]Shipments.
[7]Revised to zero.
[8]Bauxite processed for conversion to alumina in Jamaica plus kiln-dried ore prepared for export.
[9]In addition to the bauxite reported in the body of the table, the U.S.S.R. produces nepheline syenite concentrates and alunite ore as sources of aluminum. Estimated nepheline syenite production was as follows, in thousand metric tons: 1981—2,500; 1982—2,500; 1983—2,500; 1984—2,500; and 1985—2,500. Estimated alunite ore production was as follows, in thousand metric tons; 1981—605; 1982—610 (revised); 1983—615; and 1984—615. Nepheline syenite concentrate grades 25% to 30% alumina, and alunite ore grades 16% to 18% alumina; these commodities may be converted to their bauxite equivalent by using factors of 1 ton of nepheline syenite concentrate equals 0.55 ton of bauxite and 1 ton of alunite equals 0.34 ton of bauxite.

Table 19.—Alumina: World production,[1] by country[2]

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Australia	7,079	6,631	7,231	8,781	[3]8,792
Brazil	497	606	787	891	1,000
Canada	1,208	[e]1,127	1,116	1,126	1,020
China[e]	750	800	800	800	825
Czechoslovakia[e]	[r]90	[r]80	[r]80	[r]85	85
France	1,095	960	853	898	875
German Democratic Republic	45	46	42	43	44
Germany, Federal Republic of	1,651	1,510	1,580	1,701	1,700
Greece	[r]494	[r]404	410	482	500
Guinea	608	549	583	508	580
Guyana[4]	157	73	--	--	--
Hungary	792	710	836	811	[3]801
India[e]	500	500	450	560	560
Ireland	--	--	66	653	560
Italy	786	698	466	607	[3]555
Jamaica	2,556	1,758	1,851	1,749	1,622
Japan	1,344	959	1,065	1,172	[3]978
Romania[e]	540	514	512	510	480
Spain	695	[r]673	737	742	725
Suriname	1,165	1,055	1,129	1,208	1,000
Turkey	131	84	57	75	76

See footnotes at end of table.

Table 19.—Alumina: World production,[1] by country[2] —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
U.S.S.R.[e]	2,800	3,000	3,200	3,300	3,500
United Kingdom	90	88	93	105	100
United States[e]	5,960	4,130	4,000	[r]4,545	3,465
Venezuela	--	--	560	1,139	1,085
Yugoslavia	1,037	1,017	1,010	[e]1,000	1,000
Total	[r]32,070	[r]27,972	29,514	33,491	31,928

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Figures presented generally represent calcined alumina; exceptions are noted individually.
[2]Table includes data available through July 8, 1986.
[3]Reported figure.
[4]Calcined alumina, plus calcined alumina equivalent of alumina hydrate.

Table 20.—World annual alumina capacity, by country

(Thousand metric tons, yearend)

Country	1983	1984	1985
Australia	7,910	9,750	9,750
Brazil	650	1,150	1,150
Canada	1,225	1,225	1,225
China	850	850	850
Czechoslovakia	100	100	100
France	1,320	[r]1,060	1,060
German Democratic Republic	65	65	65
Germany, Federal Republic of	1,745	1,745	1,745
Greece	500	500	500
Guinea	700	700	700
Guyana	355	355	355
Hungary	895	895	895
India	675	675	675
Ireland	800	800	800
Italy	920	920	920
Jamaica	2,825	2,825	2,825
Japan	2,615	[r]2,390	1,605
Romania	540	540	540
Spain	800	800	800
Suriname	1,350	1,350	1,350
Taiwan	(1)	(1)	--
Turkey	200	200	200
U.S.S.R.	4,500	4,500	4,500
United Kingdom	140	140	140
United States	7,145	6,345	4,410
Venezuela	1,000	1,000	1,000
Yugoslavia	1,635	1,635	1,635
Total	[r]41,460	[r]42,515	39,795

[r]Revised.
[1]Revised to zero.

TECHNOLOGY

The Bureau of Mines continued research on recovery of alumina from kaolinitic clay using hydrochloric acid. Because the calcining of the clay was estimated to consume about 12% of the total energy required to produce alumina, the Bureau examined direct pressure leaching of uncalcined clay as a possible means of reducing processing costs. Alumina extraction in excess of 90% was achieved at digestion temperatures ranging from 108° C to 225° C; however, some problems in filtering were encountered.[4] A technique was developed by the Bureau to dewater the red mud waste residue generated by Bayer process alumina plants. A red mud slurry sample from the processing of Jamaican bauxite was diluted to 10% from 20% solids and treated with a mixture of two commercial anionic, high-molecular-weight, polymer flocculants. The red mud and flocculants were mixed in a baffled vessel that discharged the flocculated slurry into a stainless steel trommel where the material was dewatered to a density of 27% solids. After 15 days of draining in a screen-capped column, the solids content increased to more than 40%.[5]

Laboratory and pilot plant research on the use of Jamaican clay and red muds from local alumina plants to produce ceramic products was described.[6] The author estimated that the world's Bayer plants were producing 40 million tons of red mud (dry basis) per year and stressed that new methods of disposing of this growing environmental problem must be found. Red mud from three different Bayer plants in Jamaica was blended with local clay, granulated in a heated atomizer, and pressed into tiles prior to firing at 1,180° C to 1,190° C in a kiln. The tests indicated that the ceramic products could have a content of more than 50% red mud.

Beneficiation of Guyana bauxite by washing to reduce total silica (SiO_2) content to 4.5% or less traditionally has resulted in the loss of 30% to 50% of the crude ore. The staff of Guyana Mining Enterprises Ltd. reported that froth flotation with carefully controlled pH limits could selectively recover a high-alumina, 2.5% SiO_2, 0.7% Fe_2O_3 concentrate from the plus 325-mesh fraction of the washer tailings. Such a concentrate was considered acceptable as chemical-grade bauxite or, after additional processing, as premium-grade calcined refractory bauxite.[7]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Mineral data assistant, Division of Nonferrous Metals.

[3]All quantities in this chapter are given in metric tons unless otherwise specified.

[4]Sawyer, D. L., Jr., and T. L. Turner. Pressure Leaching Alumina From Raw Kaolinitic Clay Using Hydrochloric Acid. BuMines RI 8978, 1985, 20 pp.

[5]Hood, G. D., G. M. Wileman, D. A. Stanley, and B. J. Scheiner. Dewatering of Red Mud. Paper in Recycle & Secondary Recovery of Metals, ed. by P. R. Taylor, H. Y. Sohn, and N. Jarrett. Metall. Soc., AIME, Warrendale, PA, 1985, pp. 655-664.

[6]Puskas, F. New Possibilities for the Utilization of Red Mud From Alumina Refineries. Int. Bauxite Assoc. Q. Rev., v. 10, No. 3, Jan.-Mar. 1985, pp. 25-27.

[7]Hinds, S. A., K. Husain, and N. Liu. Beneficiation of Bauxite Tailings. Paper in Light Metals 1985, ed. by H. O. Bohner. Metall. Soc. AIME, New York, 1985, pp. 17-30.

Beryllium

By Deborah A. Kramer[1]

The United States continued to be the leading world producer of beryllium ores and the leading producer and consumer of beryllium metal, alloys, and oxide. However, weak demand in the electronics industry, especially for beryllium-copper alloys, contributed to a decrease in domestic beryllium consumption. As a result, U.S. mine production declined moderately, and world production fell slightly.

Beryl imports, mainly from Brazil, increased moderately from the low level in 1984, and metal imports increased about 150%. Exports of beryllium metal increased dramatically to over three times those of 1984.

Domestic Data Coverage.—Domestic production data for beryllium are developed by the Bureau of Mines from two separate, voluntary surveys of U.S. operations. Typical of these surveys is the "Beryllium Mineral Concentrate and Beryllium Ore" survey. Of the 14 operations to which a survey request was sent, 13 responded, representing 100% of the total mine shipments shown in tables 1 and 5.

Table 1.—Salient beryllium mineral statistics

(Short tons of beryllium metal equivalent unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Beryllium-containing ores:					
Mine shipments	293	218	267	241	230
Imports for consumption, beryl[1]	86	106	88	53	66
Consumption, reported	326	215	280	360	316
Price, approximate, per short ton unit BeO, imported cobbed beryl at port of exportation	$94	$121	$126	$88	$87
Yearend stocks	98	214	281	226	199
World: Production[1]	424	360	398	[p]395	[e]387

[e]Estimated. [p]Preliminary.
[1]Based on a beryllium metal equivalent of 4% in beryl.

Legislation and Government Programs.—The General Services Administration added 30 short tons of beryllium metal to the National Defense Stockpile in 1985. At yearend, Government stocks were beryl, 17,987 tons; beryllium-copper master alloy, 7,387 tons; and beryllium metal, 290 tons. The National Defense Stockpile goals for these materials remained at 18,000 tons, 7,900 tons, and 400 tons, respectively.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, beryllium would be categorized in tier II, and the goal would be 437 tons of beryllium metal equivalent. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The Environmental Protection Agency issued final regulations under the Clean Water Act for specified nonferrous metals manufacturing operations that limit the discharge of pollutants by existing and new operations into navigable waters and into publicly owned treatment works. Daily and monthly average maximum effluent limits for beryllium varied according to type of manufacturing operation and effluent source.[2]

DOMESTIC PRODUCTION

Shipments of beryllium ores declined slightly from those of 1984. Production of beryllium metal and beryllium oxide ceramic material increased slightly, but beryllium-copper master alloy production declined significantly.

Brush Wellman Inc. remained the only major domestic producer of beryllium-containing ores. The company mined bertrandite ore from its Spor Mountain, UT, open pit and processed the ore and imported beryl into beryllium hydroxide at its Delta, UT, mill. According to its annual report, Brush Wellman processed 95,000 tons of bertrandite ore and recovered 377,000 pounds of beryllium contained in concentrate. At yearend, the company's ore reserves were estimated to be 5.65 million tons, with an average beryllium grade of 0.23%, which is equivalent to 0.64% beryllium oxide. A small quantity of beryl also was produced domestically.

Brush Wellman began excavation of two new pits at its Utah mine to develop reserves. The project, expected to cost about $10 million, was scheduled for completion in 1986.

The Cabot Wrought Products Div. of Cabot Corp. produced beryllium-copper and other beryllium alloys at its Reading, PA, plant. In October 1985, Cabot announced that it would sell most of its alloys and metals facilities, including its beryllium-copper alloy sector, as part of a restructuring program. The divestiture reportedly would include beryllium-copper alloy facilities at Reading, PA, and Kokomo, IN, as well as the recently completed rolling mill at Elkhart, IN.[3]

In November, Emery Energy Inc. acquired Moody Beryllium Corp., which owned a deposit of beryllium ore near the Brush Wellman mine in Utah. Depending on the availability of financing, the company planned to develop the deposit, containing an estimated 500,000 tons of ore, grading 0.64% beryllium oxide.

CONSUMPTION AND USES

Beryllium consumption in 1985 declined from that of 1984, partially owing to a weakened demand in the electronics industry, a major consumer of beryllium-copper alloys.

Copper-based beryllium alloys, containing 0.5% to 2% beryllium, continued to be the most widely used beryllium products. These alloys were manufactured in a wide variety of shapes including bar, casting ingots, extrusions, plate, rod, strip, tube, and wire. Although properties differ depending on the alloy composition, they normally include high electrical and thermal conductivities and high resistance to corrosion, wear, and fatigue. Beryllium-copper alloy strip was used primarily to produce small parts for electronic and electrical applications by high-speed stamping methods. These parts, which include connectors, springs, and contact parts, were used in automotive, aerospace, radar, and telecommunications systems. Large-diameter beryllium-copper alloy rod and tube were used in oil and gas exploration equipment, marine equipment, and industrial equipment. Specific applications of the large-diameter products include drill collars, instrument housings, housings for undersea communications signal boosters, and heavy load bearings and bushings. Beryllium-copper alloy wire was used to manufacture current-carrying springs, electronic sockets, and test probes. Beryllium-copper alloy bar and plate were used in systems such as robotic welding machines and materials handling devices.

Beryllium also was used to make nickel- and aluminum-based alloys. Nickel-based alloys were used for electrical and electronic components that are subjected to elevated temperatures, including bellows, diaphragms, and thermostats. The beryllium-aluminum alloys were used to reduce magnesium losses during preparation of aluminum and magnesium alloys by forming a protective oxide coating that prevents air exposure of the molten alloy surface.

Metallic beryllium was used primarily in aerospace and defense applications such as optical systems for satellites, inertial guidance systems, X-ray sources, and detector windows. Beryllium's light weight, excellent thermal conductivity, and high stiffness-to-weight ratio were important for these applications.

Beryllium oxide ceramic material was used mainly as integrated circuit substrates in high-performance computers, microwave systems, automotive and defense electronics, aircraft engine components, and telecommunications systems. Properties of beryllium oxide ceramics that were important to these applications were excellent electrical insulating properties and high mechanical strength and hardness.

PRICES AND SPECIFICATIONS

At the beginning of the year, the price quoted in Metals Week for beryl ore was $96 to $106 per short ton unit (20 pounds) of contained beryllium oxide. Late in December, this price was reduced to $85 to $100 per short ton unit.

At yearend, the following prices for beryllium materials were quoted in American Metal Market, in dollars per pound, except for beryllium-copper master alloy, which was given in dollars per pound of contained beryllium:

Vacuum cast ingot, 97% pure	$225
Metal powder, in 5,000-pound lots and 97% pure	196
Beryllium-copper master alloy	144
Beryllium-copper casting alloy	$5.10- 5.70
Beryllium-copper in rod, bar, wire	8.05
Beryllium-copper in strip	7.25
Beryllium-aluminum alloy, in 100,000-pound lots	236
Beryllium oxide powder	55.70

FOREIGN TRADE

Exports of beryllium alloys increased dramatically in quantity from those of 1984, but the average value declined. The Federal Republic of Germany, Spain, Sweden, and the United Kingdom were the primary destinations, accounting for 80% of the total U.S. exports.

Table 2.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap,[1] by country

Country	1984		1985	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Belgium-Luxembourg	79	$1	1,256	$126
Brazil	1,125	8	--	--
Canada	2,824	208	2,233	336
Finland	47	6	35	5
France	8,062	937	4,632	802
Germany, Federal Republic of	2,627	325	17,685	1,674
Hong Kong	3,114	32	3,067	24
India	100	1	440	37
Ireland	1,497	26	--	--
Israel	246	4	3	1
Italy	6,726	52	382	12
Japan	7,386	609	2,279	489
Korea, Republic of	772	34	3	1
Malaysia	--	--	2,000	12
Mexico	1,227	12	643	11
Netherlands	4	15	271	65
Portugal	490	7	--	--
South Africa, Republic of	--	--	200	4
Spain	--	--	49,010	280
Sweden	6	1	17,450	73
Switzerland	433	23	1,642	209
Taiwan	1,051	14	4,405	51
United Kingdom	1,493	246	11,785	2,158
Other	r6	r1	7	5
Total	39,315	2,562	119,428	6,375

rRevised.

[1]Consisting of beryllium lumps, single crystals, powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.

Source: Bureau of the Census.

Beryl was the only beryllium raw material imported into the United States. Beryl imports increased from those of 1984, but the average value remained about the same. The average value of imported beryl in 1985 was $867 per ton; the value in 1984 was $884. Brazil continued to be the principal import source, representing over 76% of total beryl ore imports in 1985. In addition to ore imports, 111,458 pounds of wrought, unwrought, and waste and scrap beryllium valued at $265,029 were imported into the United States, of which 89% was imported from Brazil and 10% came from the United Kingdom. Imports of beryllium oxide or carbonate and other compounds, totaling 9,864 pounds and valued at $258,467, were received from the Federal Republic of Germany and the United Kingdom. Beryllium-copper master alloy imports of 15,930 pounds, valued at $66,579, were received from China.

Table 3.—U.S. import duties for beryllium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1985	Jan. 1, 1987	Jan. 1, 1985
Ore and concentrate	601.09	Free	Free	Free.
Unwrought beryllium waste and scrap.	628.05	8.5% ad valorem	8.5% ad valorem	25% ad valorem.
Beryllium, wrought	628.10	9% ad valorem	9% ad valorem	45% ad valorem.
Beryllium-copper master alloy	612.20	7.2% ad valorem	6% ad valorem	28% ad valorem.
Beryllium oxide or carbonate	417.90	3.7% ad valorem	3.7% ad valorem	25% ad valorem.
Other beryllium compounds	417.92	4% ad valorem	do	Do.

Table 4.—U.S. imports for consumption of beryl, by country

Country	1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	113	$107
Brazil	744	$680	1,262	1,077
China	264	238	102	96
Madagascar	--	--	11	13
Portugal	33	31	--	--
Rwanda	--	--	33	23
South Africa, Republic of	93	58	39	38
Switzerland	112	98	66	59
Zimbabwe	86	72	20	14
Total	1,332	1,177	1,646	1,427

Source: Bureau of the Census.

WORLD REVIEW

The United States was the world's largest mine producer of beryllium. World beryl production, led by the U.S.S.R. and Brazil, was slightly higher than that of 1984. China also was thought to be a substantial producer, but production data were unavailable.

Canada.—Highwood Resources Ltd. completed a 1,600-foot decline at its Thor Lake beryllium-rare earth prospect near Yellowknife, Northwest Territory. Approximately 60% of the material extracted from the decline was considered to be ore grade, and bulk samples of this ore were to be tested in order to determine optimum beryllium and rare-earth recovery methods. Ore reserves at this deposit were estimated to be 1.8 million tons grading 0.85% beryllium oxide. Highwood Resources planned to begin plant construction in 1986.

China.—China planned to double its nonferrous metal production over the next 5 years. As a part of this development, China planned to construct a beryllium oxide plant in the Xinjiang Uygur autonomous region.

Japan.—Working through its Japanese subsidiary, Brush Wellman planned to construct a plant near Tokyo to manufacture beryllium-copper alloy coil, clad metals, and other copper alloys. The company planned to begin production in the fall of 1986, with the metals targeted towards the electronics market. Japan currently imports most of its requirements for beryllium-copper alloys.

Table 5.—Beryl: World production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina	8	7	26	[e]17	17
Brazil	[r]940	[r]1,251	1,039	1,551	1,650
Madagascar[2]	[r e]55	75	(3)	51	55
Mozambique	[r]8	[r]9	7	[r e]7	7
Portugal	[r]19	[r]13	3	11	11
Rwanda	65	76	35	49	55
South Africa, Republic of	134	64	23	1	--
U.S.S.R.[e]	2,000	2,000	2,100	2,100	2,100
United States[4] (mine shipments)	7,334	5,451	6,665	6,030	[5]5,738
Zimbabwe	46	57	52	21	55
Total	[r]10,609	[r]9,003	9,950	9,838	9,688

[e]Estimated. [p]Preliminary. [r]Revised.
[1]In addition to the countries listed, China produced beryl, and Bolivia and Namibia may also have produced beryl, but available information is inadequate to formulate reliable estimates of production. Nepal reports producing small amounts. Table includes data available through Apr. 15, 1986.
[2]Includes ornamental and industrial products.
[3]Less than 1/2 unit.
[4]Includes bertrandite ore, calculated as equivalent to beryl containing 11% BeO.
[5]Reported figure.

TECHNOLOGY

A 6-pound beryllium structure was developed to support a 95-pound sensor system mounted on the U.S. Army's Scout helicopter. Brush Wellman received a contract to supply 1 year's requirement of these support blanks, which is estimated to be about 100 pieces worth approximately $2 million. This is one of the first large-scale applications of beryllium metal in a conventional weapons system. Beryllium was selected over aluminum alloy or graphite-epoxy composite material because of its light weight and rigidity, which eliminates shaking that could impair visual accuracy. As a result of this program, Brush Wellman invested $3 million in hot isostatic pressing capability at its Elmore, OH, plant.[4]

Cabot reportedly installed a direct chill casting unit at its Reading, PA, laboratory. This casting unit was the first unit installed as part of a $750,000 melting and casting pilot plant that will be used to experiment on high-quality beryllium-copper alloys. Castings produced by the direct chill method are expected to have a maximum weight of 5,000 pounds.

A review of the world beryllium industry was published that discussed the supply, demand, uses, and new developments in alloy, ceramic, and metallic products.[5]

[1]Physical scientist, Division of Nonferrous Metals.
[2]Federal Register. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 50, No. 183, Sept. 20, 1985, pp. 38276-38402.
[3]Crisafulli, T. Cabot Undertakes Major Revamping. Am. Met. Mark., v. 93, No. 201, Oct. 17, 1985, pp. 1, 11.
[4]Weiss, B. Beryllium Structure Being Used To Support Scout Sensor System. Am. Met. Mark., v. 93, No. 228, Nov. 25, 1985, p. 14.
[5]Griffiths, J. Beryllium minerals—demand strong for miniaturization. Ind. Miner. (London), No. 213, June 1985, pp. 41-51.

Bismuth

By James F. Carlin, Jr.[1]

Domestic production of bismuth was derived by processing bismuth-rich residues from the production of intermediate metallurgical products, such as lead bullion, which contain bismuth as a minor constituent. One company accounted for all domestic primary production. Consumption continued to be mostly in the Northern and Eastern United States. The aluminum, chemical, cosmetic, pharmaceutical, and steel industries were major users. Domestic consumption remained about the same, and the price generally declined during 1985.

Domestic Data Coverage.—Domestic production data for bismuth metal are developed by the Bureau of Mines from a voluntary survey of the only U.S. bismuth refinery. Production data are not published to avoid disclosing company proprietary data.

Legislation and Government Programs.—Government stocks remained at 2,081,298 pounds. The National Defense Stockpile goal remained at 2,200,000 pounds.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. The status of bismuth was deferred until further detailed studies could be made. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act of 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

Federal income tax laws provided a depletion allowance of 22% for domestic operations and 14% for U.S. companies producing in foreign countries.

Table 1.—Salient bismuth statistics

(Thousand pounds unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Consumption	2,393	1,876	2,285	2,648	2,643
Exports[1]	79	53	306	312	269
Imports, general	2,436	2,026	1,972	1,948	1,999
Price, average, domestic dealer, per pound	$2.32	$1.61	$1.72	$4.27	$5.18
Stocks, Dec. 31: Consumer	509	542	577	480	507
World: Mine production[2]	[r]8,263	8,733	8,461	[p]8,415	[e]9,175

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Includes bismuth, bismuth alloys, and waste and scrap.
[2]Excludes the United States.

DOMESTIC PRODUCTION

A single primary refinery operated by ASARCO Incorporated at Omaha, NE, accounted for all primary production. Small quantities of secondary bismuth were produced by several firms from bismuth scrap materials.

CONSUMPTION AND USES

Domestic consumption remained at about the same level as that of 1984, which was the highest level since 1979, reflecting a continuation of the general economic improvement. The category of metallurgical additives registered a significant increase in usage, while the category of chemicals showed a moderate decrease.

Table 2.—Bismuth metal consumed in the United States, by use

(Thousand pounds)

Use	1984	1985
Chemicals[1]	1,573	1,325
Fusible alloys	609	610
Metallurgical additives	424	668
Other alloys	20	21
Other[2]	22	19
Total	2,648	2,643

[1]Includes industrial and laboratory chemicals, cosmetics, and pharmaceuticals.
[2]Includes experimental.

PRICES

During the first 2 months of the year, the quoted dealer price of bismuth continued at the relatively high level that prevailed at the end of 1984, reportedly reflecting a tightened supply situation caused by several leading world producers diverting their bismuth to centrally planned economy countries at premium prices. By March, the price started a steady decline that continued throughout most of the year. Domestic dealer quotations were $6.50 to $6.70 per pound at the beginning of the year and finished the year at $3.50 to $3.80 per pound. The published price of a major foreign producer, Mining and Chemical Products Ltd. (United Kingdom), was $6.50 per pound until November when the firm suspended its list price.

FOREIGN TRADE

Exports of bismuth declined moderately but still remained at the relatively high levels of the past 3 years. The United Kingdom remained the major export destination, accounting for about two-thirds of the exports. Imports continued to be the major supply for domestic consumption. Mexico remained the major source of U.S. imports, with Belgium-Luxembourg and the United Kingdom being substantial contributors.

Starting January 1, 1985, the U.S. import duties for bismuth were unwrought metal (TSUS 632.10), free for most favored nations (MFN) and 7.5% ad valorem for non-MFN; alloys (TSUS 632.66), 6.4% ad valorem for MFN and 45% ad valorem for non-MFN; and compounds (TSUS 418.00 and 423.80), 8.8% ad valorem for MFN and 35% ad valorem for non-MFN.

Table 3.—U.S. exports of bismuth, bismuth alloys, and waste and scrap, by country

Country	1984 Quantity (pounds)	1984 Value (thousands)	1985 Quantity (pounds)	1985 Value (thousands)
Belgium-Luxembourg	--	--	41,850	$160
Brazil	--	--	377	3
Canada	45,855	$290	17,235	147
Chile	--	--	780	8
China	--	--	7,202	64
Colombia	98	1	--	--
Germany, Federal Republic of	47,690	172	--	--
Greece	2,000	6	--	--
Hong Kong	10	1	380	2
India	--	--	1,226	8
Ireland	100	1	32	16
Israel	245	2	957	6
Italy	--	--	245	3
Japan	2,462	14	7,532	51
Korea, Republic of	188	15	--	--
Mexico	1,200	17	--	--
New Zealand	40	1	--	--
Peru	300	3	--	--
Singapore	863	28	1,385	5
South Africa, Republic of	136	2	247	10
Spain	22,267	95	88	1
Switzerland	66,431	251	--	--
Taiwan	1,099	27	529	12
Thailand	32	4	--	--
United Kingdom	120,495	161	187,433	100
Venezuela	--	--	1,171	7
Total	311,511	1,091	268,669	603

Source: Bureau of the Census.

Table 4.—U.S. general imports[1] of metallic bismuth, by country

Country	1984 Quantity (pounds)	1984 Value (thousands)	1985 Quantity (pounds)	1985 Value (thousands)
Belgium-Luxembourg	75,807	$218	460,842	$2,388
Canada	242,582	793	127,868	897
China	11,204	27	44,888	181
Germany, Federal Republic of	77,167	345	96,060	585
Hong Kong	--	--	7,725	38
Japan	209,193	557	99,430	496
Korea, Republic of	124,943	410	29,761	119
Mexico	430,518	1,124	678,155	2,928
Peru	391,813	924	173,306	910
Spain	493	2	--	--
United Kingdom	384,674	1,492	280,830	1,630
Total	1,948,394	5,892	1,998,865	10,172

[1]General imports and imports for consumption were the same in 1984 and 1985.

Source: Bureau of the Census.

WORLD REVIEW

World production of bismuth rose slightly in response to increased demand. Australia remained the major producer of bismuth, although reportedly, bismuth-rich residues in Australia have been stockpiled in recent years.

Major world refiners included Dowa Mining Co. Ltd. and Mitsui Mining & Smelting Co. Ltd. in Japan, Empresa Minera del Centro del Perú in Peru, Industria Minera México S.A. and Industrias Peñoles S.A. de C.V. in Mexico, Korea Tungsten Mining Co. Ltd. in the Republic of Korea, Mining and Chemical Products in the United Kingdom, and Métallurgie Hoboken-Overpelt SA and Société Industrielle d'Etudes et d'Exploitations Chimique in Belgium.

Table 5.—Bismuth: World mine production, by country[1]

(Thousand pounds)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Australia (in concentrates)[e 3]	2,600	3,310	[r]3,110	[r]2,980	3,090
Bolivia (in concentrates)	24	11	13	[e]7	220
Canada[4]	370	417	445	485	440
China (in ore)[e]	570	570	570	570	570
Japan (metal)	1,054	1,071	1,263	1,241	1,370
Korea, Republic of (metal)	220	209	220	278	220
Mexico[5]	1,446	1,336	1,202	955	1,100
Peru[5]	1,409	1,351	1,179	1,473	1,650
Romania (in ore)[e]	180	180	180	180	180
U.S.S.R. (metal)[e]	[r]165	170	180	180	185
United States (metal)	W	W	W	W	W
Yugoslavia (metal)	225	108	99	66	[6]150
Total	[r]8,263	8,733	8,461	8,415	9,175

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1]Table includes data available through Apr. 8, 1986.

[2]In addition to the countries listed, Brazil, Bulgaria, France, the German Democratic Republic, the Federal Republic of Germany, and Namibia are believed to have produced bismuth, but available information is inadequate for formulation of reliable estimates of output levels.

[3]In recent years, bismuth-rich residues have reportedly been stockpiled owing to weak demand and low prices.

[4]Refined metal and bullion plus recoverable bismuth content of exported concentrate.

[5]Bismuth content of refined metal, bullion, and alloys produced indigenously plus recoverable bismuth content of ores and concentrates exported for processing.

[6]Reported figure.

TECHNOLOGY

A new procedure was developed to enhance high-quality, low-temperature soldering of electronic components on printed circuit boards. The procedure employs a 58% tin-42% bismuth eutectic alloy melting at 138° C and a rosin-free flux based on a sulfonated aromatic organic acid. These materials were shown to give superior mechanical joints.[2]

[1]Physical scientist, Division of Nonferrous Metals.

[2]The Bulletin of the Bismuth Institute. No. 49, 1986, pp. 1-4.

Boron

By Phyllis A. Lyday[1]

U.S. production and sales of boron minerals and chemicals decreased during the year. Glass fiber insulation continued to be the largest use for borates, followed by textile-grade glass fibers, miscellaneous, and borosilicate glasses.

California was the only domestic source of boron minerals, mostly in the form of sodium borate, but also as calcium borate and calcium-sodium borates. The United States continued to provide essentially all of its own supply while maintaining a strong position as a source of sodium borate products and boric acid to foreign markets.

Supplementary U.S. imports of Turkish calcium borate and calcium-sodium borate ores and boric acid, primarily for various glass uses, continued.

Domestic Data Coverage.—Domestic data for boron are developed by the Bureau of Mines from two separate, voluntary surveys of U.S. operations. Of the three operations to which a production survey request was sent, all responded, representing 100% of the total boron sold or used shown in tables 1 and 7. A Bureau canvass of the three U.S. producers also collected data on domestic consumption of boron minerals and compounds shown in tables 2 and 3.

Table 1.—Salient statistics of boron minerals and compounds

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Sold or used by producers:					
Quantity:					
Gross weight[1]	1,481	1,234	1,303	1,367	1,269
Boron oxide (B_2O_3) content	740	607	637	667	636
Value	$435,387	$384,597	$439,181	$456,687	$404,775
Exports:					
Boric acid:					
Quantity[2]	46	35	38	45	49
Value	$24,602	$19,082	$20,688	$24,402	$21,598
Sodium borates:					
Quantity[3]	[4]228	[4]227	[4]225	[r]576	623
Value[e]	$58,000	$59,000	$51,000	$134,000	$151,000
Imports for consumption:[5]					
Boric acid:					
Quantity	1	[r]2	[r]4	[r]4	6
Value	$763	$1,903	$3,456	$3,449	$5,121
Colemanite:					
Quantity	[r]22	[r]2	[r]16	[r]20	33
Value	$15,202	$6,386	$8,309	$12,123	$24,620
Ulexite:					
Quantity	[r]18	[r]14	11	[r]47	31
Value	$2,690	[e]$2,800	$3,116	$10,202	$11,120
Consumption: Boron oxide (B_2O_3) content[6]	373	266	341	375	360
World: Production	2,820	2,503	2,464	[p]2,775	[e]2,679

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Minerals and compounds sold or used by producers, including both actual mine production and a marketable equivalent of brine products.
[2]Includes domestic and imported orthoboric and anhydrous boric acid.
[3]Sources: 1981-83, U.S. Exporters; 1984-85, The Journal of Commerce Port Import/Export Reporting Service.
[4]Refined.
[5]Boron oxide (B_2O_3) content. Data for 1981-84 revised to indicate conversion to B_2O_3 content.
[6]See table 2.

Legislation and Government Programs.—A U.S. Environmental Protection Agency standard of emission performance for new stationary sources of nonmetallic mineral processing plants included new, modified, and reconstructed boron facilities. The affected facilities were each crusher, grinding mill, screening operation, bucket elevator, belt conveyor, bagging operation, storage bin, and enclosed truck or railcar loading station.[2]

DOMESTIC PRODUCTION

Boron minerals, sold or used, decreased in quantity and value during the year. The majority of the output continued to be from Kern County, CA, with the balance from San Bernardino and Inyo Counties, CA.

American Borate Co., a wholly owned subsidiary of Owens-Corning Fiberglas Corp., continued to mine colemanite, a calcium borate, and probertite-ulexite, two similar calcium-sodium borates mined and sold as one, at its Billie Mine in Death Valley National Monument. The mine had a capacity of 350,000 short tons of ore containing 130,000 tons of salable product per year. Colemanite was ground and processed at the washing and calcining plant at Amargosa, NV. The plant had a capacity of 6,300 tons per month of concentrate. A flotation plant adjacent to existing facilities at Amargosa prepared colemanite by a patented process. The colemanite product was trucked to Dunn, CA, for blending, storing, and shipping by rail primarily to manufacturers of textile-grade glass fibers. Probertite-ulexite ore also was trucked to Dunn, where it was ground, screened, and blended to specification, stored, and shipped by rail to customers. Most shipments of the blended probertite-ulexite were to manufacturers of glass fiber insulation. American Borate announced a temporary closure of all borate mining and processing operations that would be in effect during 1986. The closure would affect about 300 employees at 4 locations, including the headquarters at Las Vegas, NV. The reasons cited for the closure were the strength of the U.S. dollar, which had the effect of increasing worldwide prices of boron minerals, and the increase in world supply. The length of the closure would depend upon future market conditions.

Kerr-McGee Chemical Corp. operated the Trona and Westend plants at Searles Lake, in San Bernardino County, to produce refined sodium borate compounds and boric acid from the mineral-rich lake brines. At the Trona plant, a differential evaporative process was used to produce boric acid, pentahydrate borax, and anhydrous borax. Byproducts included potassium compounds. One of the evaporative boilers continued to produce pentahydrate borax by extracting heat from process steam used in other operations to produce distilled water that could be recycled through a closed loop system. The Westend plant continued production of boric acid and produced sodium borates by a carbonation process that also produced lime, soda ash, and sodium sulfate. Production capacity was 210 tons per day of the combined borate products. Screening and grinding facilities were at both plants. Shipments were by rail via a company-owned spur to the Santa Fe Railroad at Ridgecrest, CA. Borates were marketed by Kerr-McGee under the trade names Three Elephant Borax, Three Elephant V-Bor, and Three Elephant Pyrobor.

United States Borax & Chemical Corp., a member of the RTZ Group of London, United Kingdom, continued to be the primary world supplier of sodium borates. U.S. Borax mined and processed crude and refined hydrated sodium borates, their anhydrous derivatives, and anhydrous boric acid at Boron, in Kern County, CA. Production of crude sodium borates—Rasorite 46, a pentahydrate, and its anhydrous derivative—were discontinued for sale in foreign markets because new trade laws allowed refined borax to enter Europe duty-free. Installation of equipment to improve the recovery of borax from the tailings was completed in 1984, becoming operational in 1985. Centrifuges separated clay matter from borax in aqueous solution. The borax was recovered by evaporating in solar ponds. The process increased borax recovery by 6% to an estimated total recovery of 91% of the ore processed.

A second plant at Boron used a proprietary process to produce technical-grade boric acid and waste sodium sulfate from U.S. Borax's extensive kernite ore reserves. Boric acid was produced to compete with the colemanite used in glass manufacture. The boric acid plant, the world's largest, lowered energy requirements by using kernite ore as feed. Kernite required less energy than borax because it was processed into boric acid as an ore.

Shipments from Boron were via the Santa Fe Railroad. The majority of material was shipped to U.S. Borax's storage, loading, and shipping facilities at Wilmington, CA. The Wilmington facility also produced some boron specialty chemicals and borated soap products. U.S. Borax marketed domestic borates under the Twenty Mule Team trade name.

Duval Corp., which was dissolved and renamed Pennzoil Sulphur Co. in 1985, sold its solution mining project at Newberry Springs, CA, to Mountain States Mineral Enterprises Inc. Mountain States was able to obtain private investors to proceed with the boric acid pilot project.

CONSUMPTION AND USES

U.S. consumption of borates decreased. Glass fiber insulation and glass fiber reinforcement for plastics continued to be the largest consuming industries.

The use of borates in thermal insulation for new construction decreased. Glass fiber insulation was the largest area of demand for borates. Cellulosic insulation, the fifth largest area of demand, also decreased. Owens-Corning, a major glass fiber producer, acquired Armco Inc.'s Aerospace and Strategic Materials Group, which included Hitco Fabricated Composites Div., for $415 million. The purchase made Owens-Corning a producer of advanced composite materials. Composites are glass, graphite, boron, and aromatic polyamide (aramid) fibers with organic matrix resins. Hitco, which was fully integrated in composites, supplied resins, fibers, fabrics, preimpregnated fabrics, and shapes.[3]

The second major market for borates, manufacturing high-tensile-strength glass fiber materials for use in a range of products, showed an increase in demand. Composites allowed the designer to tailor structures to meet applied loads more effectively through deliberate fiber orientation, and more efficiently by reducing fiber content where loads are moderate. Composites in aerospace have been growing for more than 30 years because of their high specific strength and specific modulus, excellent corrosion and fatigue resistance, and design flexibility. These qualities have made composites ideally suited to numerous aerospace primary and secondary structures. Thus, weight may be decreased in certain structures by 20% to 50%. Typical glass fiber tensile strengths can exceed 400,000 pounds per square inch (psi) and elastic modulus of 10 million psi. Glass fibers tend to limit flight speeds to less than 200 miles per hour. In comparison, boron filaments, created by slow deposition of boron vapor on tungsten filaments, offer nearly 60-million-psi elastic modulus and about 500,000-psi tensile strength.[4]

Other uses of boron in glass fibers included asphalt roofing shingles, accounting for about 60% of asphalt-roofing sales in 1983. Glass fiber screens accounted for about 65% of the market in window and door screens, particularly in the Sunbelt States.[5]

White Consolidated Industries Inc. redesigned its dishwasher line and all of its brands, which included White-Westinghouse Appliance Co., Frigidaire Co., Gibson Appliance Co., and Kelvinator Appliance Co., and which were expected to use glass fiber composites on the inner door.

Consumption of borates in borosilicate glasses remained the fourth major end use, and demand increased. Complex glass batch calculations for borosilicate glasses were performed on microcomputers. The computerized glass formulations procedure had the advantages of improved accuracy of formulation when many complex raw materials were employed, established tolerance limits for each oxide level, and the capability to incorporate physical and chemical parameters into the batch formulation process.[6]

Boron compounds in cleaning and bleaching were also an important consumption sector. In addition, boron compounds continued to find application in the manufacture of biological growth control chemicals for use in water treatment, algicides, fertilizers, herbicides, and insecticides.

Table 2.—U.S. consumption of boron minerals and compounds, by end use

(Short tons of boron oxide content)[1]

End use	1984	1985
Agriculture	15,003	15,003
Borosilicate glasses	32,418	34,629
Enamels, frits, glazes	11,172	12,295
Fire retardants:		
Cellulosic insulation	29,150	26,522
Other	1,752	298
Glass fiber insulation	117,451	103,490
Metallurgy	4,132	3,307
Miscellaneous uses	20,615	22,521
Nuclear applications	1,107	1,088
Soaps and detergents	28,705	24,548
Sold to distributors, end use unknown	43,226	44,147
Textile-grade glass fibers	69,870	71,785
Total	374,601	359,633

[1]Includes imports of boric acid, colemanite, and ulexite.

Table 3.—U.S. consumption of orthoboric acid, by end use

(Short tons of boron oxide content)

End use	1984	1985
Agriculture	142	194
Borosilicate glasses	5,730	11,015
Enamels, frits, glazes	410	1,335
Fire retardants:		
Cellulosic insulation	6,598	4,770
Other	1,694	274
Insulation-grade glass fibers	516	144
Metallurgy	703	382
Miscellaneous uses	11,998	11,284
Nuclear applications	926	932
Soaps and detergents	605	424
Sold to distributors, end use unknown	15,864	16,181
Textile-grade glass fibers	17,403	18,360
Total	62,589	65,295

Table 4.—Borate prices per short ton[1]

Product	Price, Dec. 31, 1985 (rounded dollars)
Borax, technical, anhydrous, 99%, bulk, carlots, works[2]	602
Borax, technical, anhydrous, 99%, bags, carlots, works[2]	647
Borax, technical, granular, decahydrate, 99.5%, bags, carlots, works[2]	232
Borax, technical, granular, decahydrate, 99.5%, bulk, carlots, works[2]	187
Borax, technical, granular, pentahydrate, 99.5%, bags, carlots, works[2]	259
Borax, technical, granular, pentahydrate, 99.5%, bulk, carlots, works[2]	214
Boric acid, technical, granular, 99.9%, bags, carlots, works[2]	614
Boric acid, technical, granular, 99.9%, bulk, carlots, works[2]	569
Boric acid, United States Borax & Chemical Corp., high-purity anhydrous, 99% B_2O_3, 100-pound bags, carlots, Boron, CA	2,297
Colemanite, American Borate Co., calcined, minus 70-mesh, 45% B_2O_3, bulk, f.o.b. railcars, Dunn, CA	502
Colemanite, American Borate Co., concentrate (uncalcined), minus 70-mesh, 38% B_2O_3 f.o.b., Dunn, CA	327
Colemanite, Turkish, 40% to 42% B_2O_3, ground to a minus 70-mesh, f.o.b. railcars, Kings Creek, SC	400

[1]U.S. f.o.b. plant or port prices per short ton of product. Other conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and/or somewhat different price quotations.
[2]Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 228, No. 25, Dec. 16, 1985, p. 41.

Boron compounds were also used in metallurgical processes as fluxes, as shielding slag in the nonferrous metallurgical industry, and as components in electroplating baths. Small amounts of boron and ferroboron were constituents of certain nonferrous alloys and specialty steels, respectively. Milward Alloy Inc. of Lockport, NY, began construction of a plant to produce titanium-boron master alloy rod that is widely used in the grain refining of wrought aluminum products. The plant was scheduled to begin production on January 1, 1986. General Motors Corp. (GM) announced the construction of a manufacturing plant for the production of a neodymium-iron-boron magnet that has been trademarked Magnequench. The facility was to be completed in May 1986. The new magnet would substitute for the traditional copper-coil-wound electromagnets used in starter motors for automobile engines. Weight savings of approximately 5 pounds per motor were expected. GM also planned to offer the magnets for nonautomotive uses.[7]

Many important but low volume end uses of borates and boron-containing chemical derivatives comprised a diverse miscellaneous category that included ceramics. Dow Corning Corp. purchased a ceramics firm, Boride Products Inc., that manufactured boron carbide devices used in industrial nozzles and other structural applications. Dow announced plans to spend $5 to $25 million to become established in ceramics. Other major companies that reported use of boron in ceramics were Advanced Refractory Technologies, Babcock & Wilcox Co., Corning Glass Works, PPG Industries Inc., and United Technologies Corp.[8]

FOREIGN TRADE

Owens-Corning, through its American Borate subsidiary, imported boric acid, colemanite, and ulexite from Turkey, principally for use in textile-grade and insulation-grade fibers. Brokers also imported Turkish colemanite.

Table 5.—U.S. exports of boric acid and refined sodium borate compounds, by country

Country	1984			1985		
	Boric acid[1]		Refined sodium borates[2] (short tons)	Boric acid[1]		Sodium borates[2] (short tons)
	Quantity (short tons)	Value (thousands)		Quantity (short tons)	Value (thousands)	
Argentina	1	$1	--	--	--	--
Australia	1,145	635	6,917	1,428	$826	8,326
Belgium-Luxembourg	--	--	--	--	--	74
Brazil	160	128	3,187	8	5	3,387
Canada	7,657	3,902	[3]54,398	4,826	2,560	[3]51,392
Chile	2	4	783	--	--	138
China	--	--	--	20	12	11,353
Colombia	299	191	2,237	239	147	5,024
Costa Rica	7	6	42	--	--	438
Denmark	21	12	--	64	37	--
Dominican Republic	--	--	--	--	--	44
Ecuador	64	37	563	4	3	845
El Salvador	2	3	22	10	6	40
Finland	--	--	2	--	--	--
France	44	82	[r]1	3	1	--
German Democratic Republic	--	--	1	--	--	--
Germany, Federal Republic of	168	278	--	6	13	--
Guatemala	--	--	173	--	--	62
Haiti	12	5	--	--	--	77
Honduras	37	13	--	--	--	62
Hong Kong	329	180	3,037	209	122	2,323
India	9	3	6,884	--	--	11,590
Indonesia	81	46	4,834	144	73	5,126
Iran	--	--	--	21	12	--
Israel	36	21	376	25	15	309
Italy	--	--	2	--	--	--
Jamaica	13	11	--	25	3	--
Japan	23,748	13,732	52,464	21,701	12,796	61,073
Kenya	--	--	27	--	--	--
Korea, Republic of	1,223	685	8,113	1,186	731	18,209
Madagascar	--	--	--	--	--	78
Malaysia	24	26	2,237	18	16	3,866
Mexico	3,002	1,336	[3]21,741	3,815	1,868	[3]21,678
Netherlands	40	68	341,325	--	--	360,264
New Zealand	1,914	837	3,318	2,113	972	3,250
Nicaragua	--	--	91	--	--	66
Pakistan	--	--	305	--	--	233
Panama	10	10	59	20	6	9
Papua New Guinea	128	57	[r]183	84	42	193
Peru	3	2	46	6	4	34
Philippines	252	222	1,360	63	46	1,065
Puerto Rico	--	--	605	--	--	--
Saudi Arabia	--	--	--	--	--	465
Singapore	199	111	1,690	7	5	2,947
South Africa, Republic of	787	8	3,818	11	26	3,866
Spain	--	--	42,415	--	--	42,323
Sri Lanka	7	4	12	12	7	8
Sweden	64	37	114	--	--	--
Taiwan	1,537	861	10,377	1,664	936	--
Thailand	157	107	667	167	110	1,454
Trinidad	--	--	--	11,200	5	78
United Kingdom	20	15	122	--	--	123
Uruguay	131	43	25	4	4	36
Venezuela	1,378	680	1,648	354	189	1,107
Zimbabwe	--	--	--	--	--	339
Other	16	6	11	--	--	--
Total[4]	44,728	24,402	[r]576,231	49,457	21,598	623,375

[r]Revised.
[1]Bureau of the Census.
[2]The Journal of Commerce Port Import/Export Reporting Service data.
[3]U.S. exporters of sodium borates.
[4]Data may not add to totals shown because of independent rounding.

Table 6.—U.S. imports for consumption of boric acid, by country

Country	1984 Quantity (short tons)	1984 Value[1] (thousands)	1985 Quantity (short tons)	1985 Value[1] (thousands)
Canada	(2)	(2)	73	$56
France	139	$110	219	196
Germany, Federal Republic of	86	87	51	63
Italy	2,287	965	1,873	1,039
Japan	(2)	7	--	--
New Zealand	--	--	44	25
Turkey	5,236	2,280	8,058	3,665
United Kingdom	(2)	(2)	(2)	(2)
U.S.S.R.	--	--	105	76
Total	7,748	3,449	10,423	[3]5,121

[1]U.S. Customs declared values.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

Borates in the form of borax and ulexite occur in two geologic types of deposits in Peru, Argentina, Bolivia, and Chile. Thirty-five "salars" and fifteen "spring apron" type deposits have been identified. The distinction between the two was theorized to be a function of the distance that boron-bearing fluids traveled from the source to deposition of the boron minerals.[9]

Bolivia.—The Government authorized the Complejo Industrial de los Recursos Evaporíticos del Salar de Uyuni to seek international bids for the exploration, development, industrialization, and marketing of the salts of the Salar de Uyuni. The 7,000-square-kilometer area in southwestern Bolivia was reported to contain the largest and highest grade reserves of lithium salts in the world, and boron reserves were estimated at 3.5 million tons.

Chile.—A second major brine project in the Salar de Atacama in northern Chile was planned for production of boric acid, lithium carbonate, potassium chloride, and potassium sulfate. Negotiations commenced in 1984 and an agreement was reached in 1985 between AMAX Exploration Inc. and Molíbdenos y Metales S.A. to begin a feasibility study.

China.—A complex to be built in Kaifeng for the manufacture of glass fiber, which uses boron, was projected to cost between $75 and $90 million. Design of the complex was to be a joint venture named Heery/ITL of Heery International, and Innovative Engineers Ltd., both of Atlanta, GA. The complex was to be the first in the world to make glass fiber, thermosetting resins, and finished products in the same location. Initially about one-half of the production was planned for the domestic market, with 100% expected to be used in China within 7 years.

India.—The only source of borax in the country was in the Puga Valley in the Province of Kashmir at an altitude of 14,500 feet. Associated with the borax was gypsum, which was used to produce sulfur. Over 6 tons per day of borax was processed in plants in Jammu.

Turkey.—The borate mines were operated by Etibank, the Turkish state mining organization. Exports in 1984 totaled $101.77 million, or 35% of Turkish mineral export revenues. A new mining law was enacted on June 15, 1985, that replaced the 1954 legislation and amended both the 1978 law that nationalized many mining activities, including borates, and the 1983 law that returned some mines for exclusive State development, excluding borates. Development of foreign investment in Turkish minerals remained optimistic. After the change in the mining law, the Government became more oriented towards private sector investment by allowing exploration for borates, although the existing borate mining operations continued to be excluded from foreign investment. Newly discovered reserves of boron could be privately owned, but the mined output must be sold to Etibank for marketing. Because of Turkey's limited resources and extensive needs, the availability of external financing for public and private capital investment was expected to be a crucial factor in the future.

The boron derivatives plant at Kirka was continuing through a startup phase. The feed was from a surface tincal mine with an annual capacity of 1.3 million tons of ore, from which was produced about 830,000 tons of concentrate. The average ore content was 25% boron oxide (B_2O_3). The 10% clay fraction of the ore was removed by cyclones, classifier, and centrifuge dryer to produce a concentrate that averages 32% B_2O_3. About 55 tons per hour of concentrate was fed into the plant at full capacity. The plant, which produces anhydrous borax, was designed by Garrett AiResearch Manufacturing Co., of the United States, and engineered by a Turkish company. A 3.2-million-kilowatt-per-hour powerplant supplied the energy needs of the plant. Etibank planned to be capable of operating at full capacity by yearend 1985.[10]

Table 7.—Boron minerals: World production, by country[1]

(Thousand short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina	138	136	125	157	155
Chile	4	([2])	1	4	4
China[e]	30	30	30	30	30
Peru[e]	18	15	11	11	11
Turkey	929	868	774	986	990
U.S.S.R.[e]	220	220	220	220	220
United States[3]	1,481	1,234	1,303	1,367	[4]1,269
Total	2,820	2,503	2,464	2,775	2,679

[e]Estimated. [p]Preliminary.
[1]Table includes data available through May 27, 1986.
[2]Less than 1/2 unit.
[3]Minerals and compounds sold or used by producers, including both actual mine production and a marketable ore equivalent of brine products.
[4]Reported figure.

TECHNOLOGY

A new process for producing kraft pulp for paper production was developed by the Finnish Paper Institute. The lime circuit of the kraft process can be eliminated and the process simplified by using 20 pounds of borax for every ton of pulp produced. About 80% of the North American production of about 40 million tons per year of pulp was by the kraft process. The process would be economical for new plant construction or replacement of kilns.[11]

Amorphous boron transformer materials, usually alloys composed of iron, boron, and silicon with optional additions of cobalt or nickel, showed greatly reduced magnetic losses at high frequencies. The cobalt, iron, silicon, and boron materials are useful for magnetic recording head applications.[12]

Owing to their stiffness-to-weight and strength-to-weight ratios, boron-aluminum composites were considered as a structural replacement for titanium in advanced gas turbine engines. One approach to improving metal matrix composite toughness was to develop stronger and larger diameter fibers by secondary fiber treatment. Larger diameter boron fibers were produced by chemical vapor deposition; however, these fibers have generally displayed tensile strengths of the commercial boron fiber standard.[13]

U.S. Borax began production on a film in cooperation with the Bureau of Mines entitled "Boron—the Light-Heavyweight." Prints of the film are available for circulation to secondary schools, colleges, and other interested organizations.[14]

A conference on Advanced and Engineered Ceramics, held at Tuscaloosa, AL, discussed boron nitride powders for advanced applications. Also included were titanium-boride materials for applications in severe conditions of temperature, pressure, and environment.[15]

Boride ceramics tailored to meet particular applications showed properties of hardness, strength, and chemical stability. The annual production of boron carbides has been about 500 tons per year, with the dominant production process being carbothermic reduction. The chemical stability of diborides in Hall-Heroult cells for aluminum production, together with their wettability by liquid aluminum and high electrical conductivity, was promising. Energy savings of 25% have been demonstrated using titanium-boride replacement for graphite cathodes.[16]

Two finer grades of zinc borate synergist were in experimental production. The 3- to 15-micrometer material was intended for use as a flame retardant and smoke suppressant where nonimpairment of physical characteristics is critical. A zinc borate coated with a proprietary epoxy material was used in the wire and cable industry.[17]

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Bromine

By Phyllis A. Lyday[1]

Of the 835 million pounds of bromine produced worldwide in 1985, the United States produced 38%, followed by Israel, 26%; the U.S.S.R., 18%; the United Kingdom, 7%; six other countries accounted for the remainder of world output. The U.S. portion of world production has decreased since 1973, when the United States produc-

Table 1.—Salient bromine and bromine compound statistics

(Thousand pounds and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Bromine sold:[1]					
Quantity	60,790	(2)	(2)	(2)	(2)
Value	$11,000	(2)	(2)	(2)	(2)
Bromine used:					
Quantity	316,307	(2)	(2)	(2)	(2)
Value	$75,100	(2)	(2)	(2)	(2)
Exports:					
Elemental bromine:					
Quantity	W	NA	[3]4,500	[4]68,200	[4]6,252
Value	W	NA	[3]$1,000	[e]$15,200	[e]$1,400
Bromine compounds:					
Gross weight	67,500	[5]55,600	[5]61,300	[5]53,200	[5]61,000
Contained bromine	56,000	[5]47,200	[5]52,000	[5]45,100	[5]51,900
Value	$33,100	[5]$21,100	[5]$21,600	[5]$16,200	[5]$23,400
Imports:					
Ammonium bromide:					
Gross weight	678	1,599	1,634	1,450	2,786
Contained bromine	553	1,304	1,333	1,183	2,729
Value	$436	$989	$962	$854	$1,593
Calcium bromide:					
Gross weight	22	82	1,722	1,598	5,093
Contained bromine	18	65	1,377	1,278	4,072
Value	$6	$40	$900	$203	$917
Potassium bromate:					
Gross weight	[r]362	390	679	661	1,069
Contained bromine	174	187	325	350	512
Value	$323	$336	$572	$610	$899
Potassium bromide:					
Gross weight	107	281	436	367	968
Contained bromine	72	189	293	246	650
Value	$80	$204	$303	$268	$685
Sodium bromide:					
Gross weight	20	645	2,534	1,916	2,901
Contained bromine	16	501	1,927	1,488	2,253
Value	$12	$423	$971	$851	$1,108
Other:					
Gross weight	7,933	6,191	12,070	15,150	10,087
Contained bromine	4,755	4,060	10,241	11,535	6,863
Value	$4,068	$3,953	$8,105	$8,210	$5,863
World: Production	758,346	[r]843,963	801,863	[p]873,550	[e]835,090

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Elemental bromine sold as such to nonproducers, including exports, or used in the preparation of bromine compounds by primary U.S. producers.

[2]Bromine sold or used estimated at 401 million pounds in 1982, valued at $103 million; 370 million pounds in 1983, valued at $91 million; 385 million pounds in 1984, valued at $95 million; and 320 million pounds in 1985, valued at $80 million.

[3]Bureau of the Census.

[4]The Journal Commerce Port Import/Export Reporting Service.

[5]Bureau of the Census. Includes methyl bromide and ethylene dibromide.

ed 71% of the world supply. The decrease in world share has been a result of environmental regulations and the emergence of Israel as a major producer. In 1985, five companies operated nine bromine producing plants in Arkansas and Michigan. The quantity of bromine sold or used in the United States was about 320 million pounds valued at $80 million. Exports of bromine contained in compounds amounted to 52 million pounds. Prices of elemental bromine in bulk were listed between 33 and 34.5 cents per pound. Primary uses of bromine compounds were as a scavenger for lead in gasoline, oil and gas well fluids, and flame retardants.

Domestic Data Coverage.—Domestic data for bromine are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the nine operations to which a survey request was sent, all responded, representing 100% of total elemental bromine sold or used.

Legislation and Government Programs.—The Environmental Protection Agency (EPA) ordered the quantity of lead in gasoline to be reduced to 0.1 gram per gallon by January 1, 1986.[2] Regulated lead reductions posed a concern to the bromine industry because they had the effect of decreasing demand for a major bromine chemical, ethylene dibromide (EDB), as a lead scavenger in automotive engines.

On March 12, use of EDB as a fumigant on certain fruits and vegetables was canceled.[3] An extension for use of EDB on mangoes was denied. An EPA position paper to the U.S. Department of State stated that as of September 1, "Imported mangoes with EDB residues would be prohibited from entry into the United States."[4]

The U.S. Department of Agriculture was in the process of computerizing a directory of ground water research projects. The data were being compiled on 46 Federally funded projects. Included in the study were four reports on EDB and three reports on dibromochloropropane (DBCP).[5]

Yearend legislation to renew the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), which had expired at yearend 1984, was still under consideration. One of the concerns was the inequities of the law that allowed taxes to be avoided on imported chemical intermediates. During 1984, only 7 of the 20 largest volume organic chemical imports had been taxed under the existing law, yet these chemicals contribute to pollution.[6]

EPA proposed to amend regulations under the Resource Conservation and Recovery Act (RCRA) by listing two wastes generated during the production of methyl bromide.[7]

The Occupational Safety and Health Administration (OSHA) determined that the current permissible workplace exposure limit of 20 parts per million (ppm) of EDB did not provide workers adequate protection against cancer and other adverse health effects. OSHA was in the process of reviewing provisions to be included in the final standard.[8]

EPA granted Arkansas final RCRA authorization effective January 25 that delegated to the State dual State-Federal regulatory authority. EPA was to continue administering and enforcing the prohibition requirements of the Hazardous and Solid Waste Amendments until the State receives authorization.[9]

Great Lakes Chemical Corp. filed a third-party complaint against EPA in the U.S. District Court for the Western District of Washington at Seattle alleging that the agency was liable for damages the plaintiffs assert resulted from contamination of ground water with EDB. The three causes of action against the agency were as follows: breach of contract and implied warranties; exceeding statutory authority; and negligence, trade libel, and commercial disparagement.[10]

DOMESTIC PRODUCTION

Three companies comprising the U.S. Bromine Alliance accounted for over 99% of U.S. elemental bromine capacity. Great Lakes had become the largest producer in 1981 with its acquisition of the bromine assets of Velsicol Chemical Corp., giving Great Lakes a major control of total domestic plant capacity that included Arkansas Chemicals Inc. In 1985, Great Lakes, The Dow Chemical Co., and Ethyl Corp. accounted for 43%, 32%, and 24% respectively, of plant capacity. Plant capacity did not reflect production capacity, which was dependent upon brine supplies, bromine concentration in the brine, and individual plant extraction processes. Arkansas brines contained about 5,000 ppm and Michigan brines about 2,600 ppm of bromine. The only other domestic elemental bromine producer was Morton Thiokol Inc., which was the only domestic producer of some inorganic bromides.

Dow operated one plant in Arkansas and two in Michigan. Plans continued to phase out brine production at the Midland, MI, plant in 1986 and to continue brine operations at Ludington, MI, and Magnolia, AR.

Table 2.—Bromine producing plants in the United States in 1985

State and company	County	Plant	Production source	Elemental bromine plant capacity[1] (million pounds)
Arkansas:				
Arkansas Chemicals Inc	Union	El Dorado	Well brines	50
The Dow Chemical Co	Columbia	Magnolia	do	110
Ethyl Corp	do	do	do	160
Great Lakes Chemical Corp	Union	El Dorado	do	105
Do	do	Marysville	do	80
Do	do	El Dorado	do	50
Michigan:				
The Dow Chemical Co	Mason	Ludington	do	20
Do	Midland	Midland	do	85
Morton Thiokol Inc	Manistee	Manistee	do	5
Total				665

[1]Chemical Marketing Reporter. Chemical Profile. V. 228, No. 4, 1985, pp. 53-54.

CONSUMPTION AND USES

Demand for EDB decreased because of reduced demand for leaded gasoline as a consequence of the regulation of lead concentration. New regulations were to begin January 1, 1986, that would allow 0.1 gram of lead per gallon of gasoline. The bromine-to-lead ratio in gasoline used in the United States has averaged 0.386, or 1 pound of bromine for approximately every 2.59 pounds of lead. Domestic production in 1985 was estimated at 103 million pounds of EDB containing about 88 million pounds of bromine for domestic and exported consumption. Ethyl closed its remaining Baton Rouge, LA, antiknock manufacturing units and exported leaded antiknock products produced by E. I. du Pont de Nemours & Co. Inc. through a joint venture agreement that included all domestically produced antiknocks.

The 1983 ban on EDB for fumigant and certain pesticide uses had brought about substitution with methyl bromide. Domestic methyl bromide consumption was estimated at 42.5 million pounds in 1985. Ethyl and Great Lakes were the sole domestic producers with 8 and 36 million pounds of capacity, respectively. Dow had closed 21 million pounds of capacity at Midland, MI, in 1983. Distribution of methyl bromide in 1985 was as follows: soil fumigant, 65%; space fumigant, 15%; chemical manufacturing, 10%; and exports, 10%.[11]

Inorganic synergists containing bromine fulfilled a need to produce fire retardant products that reduce smoke by enhancing the effectiveness of the active agent. The emphasis was on brominated compounds that boost performance but do not affect basic properties. Brominated compounds were used to make fire retardants for a wide variety of thermoplastics such as polycarbonate, polypropylene, nylon, polystyrene, epoxies, polyesters, urethanes, and polyethylene terephthalate. For example, alkyl ethers and methacrylate esters of brominated bisphenol-A and vinyl bromide were used in the production of fire retardants for thermoplastics. During 1985, domestic consumption of bromine compounds in flame retardants, reported by the Fire Retardant Chemicals Association, was 37.4 million pounds. Bromofluorocarbon fire extinguishers were more versatile than sodium bicarbonate or carbon dioxide extinguishers because they could be used on all classes of fires, were nontoxic, and left no residues.[12]

Solids-free bromide solutions formulated in densities of 11 to 15.5 pounds per gallon were used alone or in combination with calcium chloride in "completion" and "workover" fluids for oil and gas wells. Accounting for between 25% and 30% of domestic bromine consumption, the fluids have been developed to only about 5% of their potential market in oil and gas drilling.[13] However, the plunge in oil prices reduced well completions and decreased consumption of bromine compounds in drilling. Until 1982, sodium bromide had been used mainly in chemicals for photography, water treatment, pharmaceuticals, bleaching agents, and the formulation of other inorganic and organic chemicals; its usage in well completion had been limited to wells in Alaska and offshore California. Bromide well completion fluids were often used in the last 100 feet of drilling as a substitute for barite mud because they are clear, do not contaminate the oil-bearing formation, and have enough density to contain the formation pressures. Drillers commonly used sodium bromide, calcium bromide, or zinc-calcium bromide. If calcium was present in the formation, the introduction of calcium bromide could cause the well to plug in some instances; therefore, sodium bromide was used most widely. About 80% of the demand for sodium bromide in 1985 was in well drilling.

Bromine chloride was considered more effective than other chlorine chemicals in killing microorganisms and was nonirritative to the eyes and nose. Bromochlorodimethyl hydantoin was being sold as a sanitizer for pools, spas, and hot tubs. A brominated compound was also used as a preservative-inhibitor in emulsions and dispersions.

AmeriBrom Inc. was seeking registration of dibromonitrilopropionamide as a biocide. Consumption of chemicals in water and waste water treatment was estimated at $2 billion. A report by Frost & Sullivan Inc. forecast the market to rise by 6.5% per year. Chlorine was forecast to continue to be the most widely used disinfectant, but use of hypochlorites and other halogens such as bromine was expected to grow four times as fast.[14]

Other uses of bromine included a bromine compound used as an intermediate in the manufacture of metaphenoxybenzaldehyde for production of synthetic pyrethroids, such as fenvalerate, cypermethion, decamethrin, and permethrin. Potassium bromide and sodium bromide emulsions were used in photographic films, plates, and papers. Potassium bromate was also used in photographic film development.

One brominated dye was reported in use as an organic pigment in "Synthetic Organic Chemicals, 1984," published by the U.S. International Trade Commission. Pigment Red No. 168 was reported to have been produced by Mobay Chemical Corp., Dyes and Pigments Div.

PRICES

Bromine was sold under contracts negotiated between buyer and seller. Price quotations do not necessarily represent prices at which transactions actually occurred, nor do they represent bid and asked prices. They were quoted here to serve only as a guide to yearend price levels.

Table 3.—Yearend 1985 prices for elemental bromine and selected compounds

Product	Value per pound (cents)
Ammonium bromide, National Formulary (N.F.), granular, drums, carlots, truckloads, freight equalized	131
Bromine, purified:	
Carlots, truckloads, delivered	75
Drums, carlots, truckloads, delivered east of the Rocky Mountains[1]	87
Bulk tank car, tank trucks (45,000-pound minimum), delivered east of the Rocky Mountains[1]	33- 34.5
Bromochloromethane, drums, carlots, f.o.b. Midland, MI	112
Calcium bromide, bulk, 14.2 pounds per gallon at 60° F, f.o.b. works[2]	21- 36
Ethyl bromide, technical, 98%, drums, carlots, freight allowed, East	76
Ethylene dibromide, drums, carlots, freight equalized	38- 46
Hydrobromic acid, 48%, drums, carlots, truckloads, f.o.b. works	38.5
Hydrogen bromide, anhydrous, cylinders, extra 30,000 pounds, f.o.b. works	700
Methyl bromide, distilled, tanks, 140,000-pound minimum, freight allowed	56.75
Potassium bromate, granular, powdered, 200-pound drums, carlots, f.o.b. works	106
Potassium bromide, N.F., granular, drums, carlots, f.o.b. works	112
Sodium bromide, 99% granular, 400-pound drums, freight, f.o.b. works	104

[1]Delivered prices for drums and bulk shipped west of the Rocky Mountains, 1 cent per pound higher. Bulk truck prices 1 to 2.5 cents per pound higher for 30,000-pound minimum and 4 to 5.5 cents per pound higher for 15,000-pound minimum.
[2]Reported to the Bureau of Mines by primary producers.

Source: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 228, No. 25, Dec. 16, 1985, pp. 40-48.

FOREIGN TRADE

EPA granted a one-time extension of 4 months for exports to Japan of domestic citrus fruit treated with EDB. Japan had refused to accept cold-treated citrus as a substitute because of the damage cold treatment had caused to 1984 shipments.[15]

Israel has enjoyed a margin of tariff preference for imports of bromine compounds into Japan of 7.9% to 9.6% more than U.S. producers. When the staged reductions agreed to during the Multilateral Trade Negotiations are completed, the range in the margin of preference was expected to be reduced to between 3.8% and 7.9% because Israeli bromine chemicals enter Japan duty free. U.S. producers had increased tetrabromobisphenol-A prices to Japan by 12% in 1983 and by 17% in 1984. A similar pattern of price increases had prevailed for other major flame retardants. U.S. producers, in effect, set their prices, c.i.f. Japanese port, to be competitive with the Japanese import price of Israeli products.[16] For all products, U.S. prices, excluding duty, increased more rapidly but, nevertheless, remained below Israeli prices. Adding the duty differentials to U.S. prices actually raised them above the Israeli prices.[17] Israeli flame retardants had been sold out until 1984, but increased Israeli production capacity was expected to change the market share in Japan in favor of Israel.

On June 11, the United States-Israeli Free Trade Area Agreement (Public Law 99-47) was signed into law. The agreement will eliminate customs duties on all trade between the two countries during a 10-year reduction in duties beginning on September 1, 1985, and ending on January 1, 1995. The phaseout covered most of the significant products manufactured by the domestic bromine industry. For most of the high-profit brominated flame retardants, tariffs will remain for at least 5 years because they were among the products most affected by the agreement. Protected bromine chemicals included primarily brominated fire retardants such as tetrabromobisphenol-A, decabromodiphenyl oxide, and octabromodiphenyl oxide. A number of domestic producers of bromine compounds could be adversely impacted by unfair competition from imports from Israel. On June 13, 1985, an amendment to the Generalized System of Preferences (GSP), Executive Order 12519, provided separate import categories for selected bromine compounds, thereby allowing the Government to monitor imports. Ammonium bromide and calcium bromide were each given separate numbers for the Tariff Schedule of the United States (TSUS), and eight other brominated compounds collectively were given one number.[18] The U.S. Bromine Alliance composed of Dow, Ethyl, and Great Lakes had proposed a total exemption, alleging that a free-trade pact could cause the domestic industry damage because of the collateral effects of the phasedown of EDB as an additive in leaded gasoline. The alliance predicted imports of Israeli bromine products would rise from $9.7 million in 1983 to more than $40 million by the end of the decade. It claimed that the U.S. industry could not compete because of Israel's state-supported bromine industry, access to cheap raw materials, and Government-owned shipping.[19]

WORLD REVIEW

The Pesticide Action Network (PAN), an international coalition of about 300 environmental and consumer groups, launched a worldwide campaign to put tighter controls on the export and labeling of pesticide products. PAN listed 12 pesticides, including DBCP as the greatest polluters.[20]

Australia.—The Australian Transport Advisory Council (ATAC), representing each State and the Commonwealth, recommended that unleaded gasoline be made available beginning July 1, 1985. ATAC also agreed that automobiles manufactured after January 1, 1986, and most other vehicles, after July 1, 1988, should be designed to run on unleaded gasoline. In New South Wales, compliance of all motor vehicles was to become compulsory on January 1, 1986. These decisions could adversely affect the use of EDB as a scavenger for lead in gasoline and decrease the demand for bromine.[21]

Canada.—Legislation that reduced the limit for leaded gasoline from 0.77 gram per liter (g/l) to 0.29 g/l beginning January 1, 1987, was expected to have the effect of decreasing the use of EDB as a lead scavenger by about 23% the first year.[22]

China.—A 1-million-pound-per-year bromine extraction unit began operation in October at the Laizhou Bromine Works, Jinan, Shandong. The unit was supplied with brines from wells in the area. Four additional units were scheduled for construction at the plant between 1986 and 1990.

European Economic Community.—The trend toward a lead-in-gasoline limit of 0.15 g/l continued to affect the consumption of bromine in Europe. At the beginning of the year, Austria, the Federal Republic of Germany, Norway, Sweden, and Switzerland were enforcing the 0.15-g/l limit for all leaded gasoline. In Denmark, the limit applied initially to regular gasoline only, but was extended to premium gasoline in July. Belgium, Finland, the Netherlands, and the United Kingdom planned to reduce lead limits to the same level in the near future, and the European Economic Community issued a proposal for a directive requiring all member states to enforce a maximum lead limit of 0.15 g/l by July 1, 1989.[23]

Israel.—Israel Chemicals Ltd. (ICL) was interested in selling a 26% share of the firm to offset an investment program. ICL also agreed, in principle, to issue shares of its Dead Sea Bromine Co. Ltd. (DBC) subsidiary on the American Stock Exchange to raise capital for major expansion projects. These projects included the Dead Sea Works Ltd.'s (DSW) planned expansion of potash production capacity, which would increase the supply of brines for production of bromine by 43%. Total investment was announced at nearly $1 billion and also included expanded chlorine production. Brines from the potash process, containing about 14,000 ppm bromine, were processed at a bromine plant at Sdom. DBC completed an expansion of bromine and bromine compounds production to 120,000 and 100,000 tons per year, respectively, and was actively developing markets for bromine compounds, such as fire retardants, agricultural chemicals, and oilfield chemicals. ICL announced record-high total earnings for the 1984-85 fiscal year, up nearly 50% to $56 million. The company was spared the economic effects of the declining market for EDB. Much of the increase was attributed to a move into downstream operations, including the bromine and bromine compounds operations of DBC. The effort was designed to increase the group's foreign sales rapidly from $381 million in 1984-85 to an annual level of more than $700 million. Exports of the group expanded by 15% in 1984 and were projected to double within 5 years. In addition, the complex also produced salt and magnesium oxide as byproducts. DSW was installing two plants to produce 300,000 tons per year of potassium sulfate as another byproduct.

Table 4.—World bromine plant capacities and sources

Country and company	Location	Capacity (million pounds)	Source
China:			
Laizhou Bromine Works	Shandong	1	Underground brines.
France:			
Atochem	Port-de-Bouc	30	Seawater.
Mines de Potasse d'Alsace S.A	Mulhouse	19	Bitterns of mined potash production.
Germany, Federal Republic of:			
Kali und Salz AG:			
Bergmannssegen-Hugo Mines	Lehrte	8	Do.
Salzdetfurth Mine	Bad Salzdetfurth.		
India:			
Hindustan Salts Ltd	Jaipur	1.6	Seawater bitterns from salt production.
Mettur Chemicals	Mettur Dam		
Tata Chemicals	Mithapur		
Israel:			
Dead Sea Bromine Co. Ltd	Sdom	220	Bitterns of potash production from surface brines.
Italy:			
Società Azionaria Industrial Bromo Italiana	Margherita di Savoia.	2	Seawater bitterns from salt production.
Japan:			
Asahi Glass Co. Ltd	Kitakyushu	9	Seawater bitterns.
Toyo Soda Manufacturing Co. Ltd	Nanyo	26	Do.
Spain:			
Derivados del Etilo S.A	Villaricos	2	Seawater.
U.S.S.R.:			
NA	NA	150	Well brines.
United Kingdom:			
Associated Octel Co. Ltd	Amlwch	66	Do.

NA Not available.

New Zealand.—The Government planned to reduce the present lead limit in gasoline from 0.84 to 0.45 g/l at a future date. The implementation could result in decreased consumption of bromine by about 15% the first year.[24]

U.S.S.R.—A new complex to produce tetrabromobisphenol was planned at Nebit-Dag. Scientists of the Turkmen Academy of Sciences Institute of Chemistry researched ways to extract other coproducts from the bromine and iodine brines. The production of bromine and iodine at another plant was also to be expanded. The completion of the new plant and the expansion of existing halogen production capacity would make the complex the largest enterprise in the chemical sector.[25] Another iodine plant at Neftechala was to include ion-exchange equipment through which the product would cascade to processing equipment at a lower level, but footings for the equipment had been installed for only one level.[26]

Table 5.—Bromine: World production, by country[1]

(Thousand pounds)

Country[2]	1981	1982	1983	1984[p]	1985[e]
France[e]	36,000	[r]37,000	[r]35,000	[r]37,000	44,000
Germany, Federal Republic of	7,864	6,775	6,914	7,288	6,000
India[e]	770	770	770	770	770
Israel[e]	[3]97,047	154,000	154,000	198,400	220,000
Italy[e]	1,320	1,320	1,100	1,100	1,320
Japan[e]	26,500	26,500	26,500	26,500	26,500
Spain[e]	900	800	700	660	800
U.S.S.R.[e]	150,000	150,000	150,000	154,000	154,000
United Kingdom	60,848	65,698	56,879	62,832	61,700
United States[e] [4]	[3]377,097	401,100	370,000	385,000	320,000
Total	758,346	[r]843,963	801,863	873,550	835,090

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 6, 1986.
[2]In addition to the countries listed, several other nations produce bromine, but output data are not reported, and available general information is inadequate for formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Sold or used by producers.

TECHNOLOGY

Great Lakes continued research on polycrystalline silicon manufacture using bromine. Polycrystalline silicon of ultrahigh-purity semiconductor grades (99.97% pure) is obtained by reduction of purified tetrachlorosilane or trichlorosilane with purified hydrogen. Bromosilanes could also be used in making polycrystalline silicon. J. C. Schumacher Co. announced plans to start a 75-ton-per-year pilot plant to produce bromosilanes using a bromine process.[27]

The stoichiometry and relative rate of bromochloramine oxidation of a substance in the presence of monochloramine were described. The results were important not only because the methods have been used to measure oxidants in the environment under conditions where bromochloramine may be present, but also because they were believed to be the first describing the reaction of bromochloramine with any substance.[28]

The U.S. Department of Energy (DOE) contracted with Exxon Research and Engineering Co. to produce a zinc-bromine battery that powered Ford's ETX electric test vehicle. This was the first advanced secondary battery to power an electric vehicle successfully. DOE also contracted with Energy Research Corp. to produce a 50-kilowatt-per-hour battery module that would be joined to supply a 500-kilowatt-per-hour stationary energy storage battery. After testing, a 100-megawatt-per-hour zinc-bromine battery could be used by utility companies to level their demand loads.[29]

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[1]Physical scientist, Division of Industrial Minerals.

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[7]Federal Register. Environmental Protection Agency. Identification and Listing of Hazardous Waste Management System. V. 50, No. 80, Apr. 25, 1985, pp. 16432-16436.

[8]———. U.S. Occupational Safety and Health Administration (Dep. Labor). Ethylene Dibromide. V. 50, No. 82, Apr. 29, 1985, p. 17455.

[9]Pesticide & Toxic Chemical News. Arkansas, New Mexico Granted Final RCRA Authorization by EPA. V. 14, No. 10, 1985, p. 18.

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[11]Chemical Marketing Reporter. Chemical Profile. V. 227, No. 7, 1985, p. 54.

[12]Verbanic, C. J. Is 1986 Bromine's Turnabout Year? Chem. Bus., v. 8, No. 3, 1986, pp. 20-23.

[13]Work cited in footnote 12.

[14]Manufacturing Chemist. Water Chemical Growth "Moderate." V. 57, No. 1. 1986, p. 21.

[15]Toxic Materials News. One-Time, Four-Month Extension of EDB on Exported Citrus Granted by EPA. V. 12, No. 14, 1985, p. 110.

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[17]ICF Inc. An Analysis of the Economic Role in the U.S. Market of Bromine Compounds Imported From Israel. Submitted to U.S. Trade Representative, Nov. 20, 1984, 23 pp.

[18]Federal Register. Presidential Documents. V. 50, No. 116, June 17, 1985, pp. 25037-25062.

[19]European Chemical News. ECN Market Report. V. 44, No. 1166, 1985, p. 8.

[20]Chemical Week. Pushing To Tighten Pesticide Exports. V. 136, No. 24, 1985, pp. 17-18.

[21]International Lead and Zinc Study Group (London). Lead in Gasoline, 1985. Feb. 1985, 14 pp.

[22]Work cited in footnote 21.

[23]Work cited in footnote 21.

[24]Work cited in footnote 21.

[25]Sarkisyan, K. Ashkhabad Turkmenskaya Iskra (in Russian), July 19, 1982, p. 4.

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[27]Chemical Week. A Bromine Route to High-Purity Silicon. V. 136, No. 23, 1985, pp. 11-12.

[28]Valentine, R. L. Bromochloramine Oxidation of N,N-Diethyl-p-phenylenediamine in the Presence of Monochloramine. Environ. Sci. Technol., v. 20, No. 2, 1986, pp. 166-170.

[29]Chemical Marketing Reporter. Sodium/Sulfur, Zinc/Bromine Studied for New Batteries. V. 228, No. 22, 1985, pp. 7, 26.

Cadmium

By Patricia A. Plunkert[1]

Domestic production of cadmium metal decreased only slightly in 1985, despite the closure of a domestic zinc refinery and its cadmium plant in April. A reduction in the total inventories of cadmium metal and cadmium compounds together with an increase in imported metal led to an increase in apparent consumption of cadmium. Canada continued as the principal source of imported cadmium. The price of cadmium metal declined, continuing a trend that began in mid-1984.

Domestic Data Coverage.—Domestic production data for cadmium metal and compounds are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the five metal-producing plants to which a survey request was sent, all responded, representing 100% of the total cadmium metal production shown in tables 1 and 5. Of the 11 operations that produced cadmium compounds to which a survey request was sent, all responded, representing 100% of the cadmium content of production of cadmium compounds shown in tables 3 and 4.

Table 1.—Salient cadmium statistics

	1981	1982	1983	1984	1985
United States:					
Production[1] ---metric tons--	1,603	1,007	1,052	1,686	1,603
Shipments by producers[2] ---do---	1,382	1,832	1,495	1,811	1,791
Value ---thousands--	$3,838	$2,628	$1,786	$2,581	$2,436
Exports ---metric tons--	239	11	170	106	86
Imports for consumption, metal ---do---	3,090	2,305	2,196	1,889	1,988
Apparent consumption ---do---	4,378	3,728	3,763	[r]3,300	3,720
Price: Average per pound[3] ---	$1.93	$1.11	$1.13	$1.69	$1.21
World: Production ---metric tons--	[r]17,380	[r]16,422	17,527	[p]19,171	[e]18,662

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.
[2]Includes metal consumed at producer plants.
[3]Average quoted price for cadmium sticks and balls in lots of 1 to 5 tons.

Legislation and Government Programs.—On July 29, the Environmental Protection Agency (EPA) announced the availability of nine ambient water quality criteria documents that updated and revised previously published criteria. Cadmium is one of the nine substances for which revised criteria were published. The document detailed acceptable cadmium concentration levels for both freshwater and saltwater systems.[2]

On October 16, the EPA issued a notice of intent to list cadmium as a hazardous air pollutant and to establish emission standards under the Clean Air Act.[3]

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Public Law 96-510), commonly known as the Superfund, expired on September 30, 1985. Various reauthorization bills, such as S-51 passed by the Senate on September 26 and HR-2817 passed by the House of Representatives on December 10, were under consideration by the Congress.

On July 8, the White House announced that the President had approved the National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the National Defense Stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of materials already possessed by the Government. The status of cadmium was deferred until further detailed studies could be made. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, stated that no action may be taken before October 1, 1986, to implement or administer any change in a stockpile goal in effect on October 1, 1984, that results in a reduction in the quality or quantity of any strategic and critical material to be acquired for the National Defense Stockpile. Therefore, as of December 31, 1985, the National Defense Stockpile goal for cadmium metal remained at 5,307 metric tons, and the stockpile inventory was 2,871 tons of cadmium metal.

DOMESTIC PRODUCTION

Domestic production of cadmium metal decreased slightly compared with that of 1984, despite the announced indefinite closure by ASARCO Incorporated in April 1985 of its zinc refinery and cadmium plant in Corpus Christi, TX. Prior to its closing, this facility was operating at approximately 50% of capacity. The production of cadmium compounds decreased significantly in 1985 with production levels at approximately two-thirds those of 1984.

Table 2.—Primary cadmium producers in the United States in 1985

Company	Plant location
AMAX Inc	Sauget, IL.
ASARCO Incorporated	Corpus Christi, TX, and Denver, CO.
Jersey Minière Zinc Co	Clarksville, TN.
St. Joe Resources Co	Bartlesville, OK.

Table 3.—U.S. production of cadmium compounds other than cadmium sulfide[1]

(Metric tons)

Year	Quantity (cadmium content)
1981	885
1982	971
1983	1,024
1984	1,510
1985	1,021

[1]Includes plating salts and oxide.

Table 4.—U.S. production of cadmium sulfide[1]

(Metric tons)

Year	Quantity (cadmium content)
1981	527
1982	374
1983	670
1984	771
1985	477

[1]Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Apparent consumption of cadmium increased compared with that of 1984. Although the Bureau of Mines does not collect actual consumption data, apparent consumption by use categories was estimated as follows: coating and plating, 34%; batteries, 27%; pigments, 16%; plastic stabilizers, 15%; alloys and other uses, 8%.

Ferro Corp.'s Color Div. introduced a line of cadmium pigments, consisting of 16 pure pigments and 16 lithopones with color ranges from yellow to maroon. SCM Pigments, a division of SCM Corp., announced the development of a new line of cadmium pigments that the company reported were 10% to 25% stronger in tinting strength than conventional cadmium pigments.[4]

Varta Batteries Inc. announced the introduction of a rechargeable 1.2-volt button cell that it believed to be the thinnest nickel-cadmium battery ever developed and that it reported could be used to miniaturize a wide range of products.[5]

Table 5.—Supply and apparent consumption of cadmium

(Metric tons)

	1983	1984	1985
Stocks, Jan. 1	1,417	732	901
Production	1,052	1,686	1,603
Imports, metal	2,196	1,889	1,988
Total supply	4,665	4,307	4,492
Exports	170	106	86
Stocks, Dec. 31	732	r901	686
Apparent consumption[1]	3,763	r3,300	3,720

rRevised.
[1]Total supply minus exports and yearend stocks.

STOCKS

Total inventories of cadmium in all forms decreased approximately 24% compared with those of 1984 and reached their lowest level in over 30 years. Stocks held by metal producers showed the sharpest decline owing in part to the closure of Asarco's Corpus Christi refinery.

Table 6.—Industry stocks, December 31

(Metric tons)

	1984		1985	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	208	W	136	W
Compound manufacturers	r91	r548	111	377
Distributors	52	2	59	3
Total	r351	r550	306	380

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Compound manufacturers."

PRICES

At the beginning of 1985, AMAX Inc. published a domestic producer price of $1.55 per pound for cadmium metal whereas St. Joe Resources Co. National Zinc Div.'s published price was $1.25 per pound. Both price quotes remained at these levels through June. On July 2, AMAX lowered its price to $1.00 per pound, and on July 25, National Zinc also reduced its price to $1.00 per pound. Both published domestic producer prices for cadmium metal remained at $1.00 per pound through yearend.

Dealer prices in January were listed at $1.11 to $1.15 per pound for cadmium metal. These prices fluctuated during 1985 but trended downward to close the year at $0.77 to $0.83 per pound.

FOREIGN TRADE

Exports of cadmium metal and cadmium in alloys, dross, flue dusts, residues, and scrap decreased compared with those of 1984. The four largest recipients in 1985, in descending order of receipts, France, Sweden, Netherlands, and Canada, received approximately 80% of U.S. cadmium exports.

Cadmium metal imports for consumption increased compared with those of 1984 but remained well below the average 2,400 tons of material imported during the previous 5-year period. The principal supplying country continued to be Canada, which provided over 50% of the total imports in 1985.

Imports of metal and flue dust from most favored nations (MFN) continued to be duty free. A statutory duty of $0.15 per pound continued to be imposed on cadmium metal imported from non-MFN.

Table 7.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

Year	Quantity (metric tons)	Value (thousands)
1983	170	$351
1984	106	208
1985	86	342

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption[1] of cadmium metal, by country

Country	1984		1985	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	363	$792	458	$1,043
Belgium-Luxembourg	(2)	3	12	96
Canada	[3]862	2,817	1,044	2,159
Finland	47	126	30	61
France	[3]27	119	20	55
Germany, Federal Republic of	155	343	203	356
Japan	(2)	2	--	--
Korea, Republic of	84	191	--	--
Mexico	174	344	162	238
Norway	35	94	--	--
Peru	103	227	27	48
Sweden	10	25	6	15
United Kingdom	19	13	--	--
Yugoslavia	10	37	24	49
Total[4]	[3]1,889	5,133	1,988	4,122

[1]General imports were as follows, in metric tons: 1984—1,898 and 1985—1,988.
[2]Less than 1/2 unit.
[3]Includes waste and scrap (gross weight).
[4]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

Greece.—Metra S.A., a subsidiary of the Government-owned Hellenic Industrial Development Bank, announced that it was granted the rights to develop a 2.6-million-ton sulfide ore deposit in the Molai District of Laconia. The ore contained lead and zinc with some cadmium, copper, and silver. The company reportedly planned to mine the deposit at the rate of 300,000 tons of ore per year for about 10 years.[6]

Hong Kong.—Sylva Industries Ltd., a wholly owned subsidiary of Gold Peak Industries, announced that it was the country's first manufacturer of button-type rechargeable nickel-cadmium batteries.[7]

Switzerland.—An evaluation of proposals restricting the use of cadmium in Switzerland was begun. Included in the proposals were a restriction on cadmium electroplating and the importation of most products containing cadmium-coated components, the enactment of regulations for the recovery of nickel-cadmium batteries, and the progressive reduction of the cadmium content in zinc used for galvanizing from 0.1% to 0.025% over the next 5 years. These proposals require Government approval before enactment.[8]

Discussions between the Swiss Government and the Swiss Plastics Industries Federation resulted in an agreement to restrict the annual consumption of cadmium in pigments and stabilizers to a maximum of 5 tons by 1988.[9]

Table 9.—Cadmium: World production,[1] by country

(Metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	65	65	50	50	50
Argentina	--	21	[e]19	[e]20	20
Australia (refined)	1,031	1,010	1,104	1,049	1,000
Austria	55	48	46	49	50
Belgium	1,176	996	1,260	1,476	1,200
Brazil	45	73	189	225	225
Bulgaria[e]	210	200	200	200	200
Canada (refined)	1,298	[r]854	1,456	1,602	1,400
China[e]	270	300	300	300	300
Finland	621	566	616	614	610
France	663	[2]793	513	563	510
German Democratic Republic[e]	16	16	[r]15	[r]15	15
Germany, Federal Republic of	1,192	1,030	1,094	1,111	1,075
India	113	131	131	148	[3]194
Italy	[2]489	[2]475	450	520	450
Japan	1,977	2,034	2,214	2,423	2,640
Korea, North[e]	140	100	100	100	100
Korea, Republic of	300	320	320	320	300
Mexico (refined)	590	607	642	571	600
Namibia	--	110	51	40	30
Netherlands	518	497	513	636	600
Norway	117	104	117	150	150
Peru	307	421	451	390	420
Poland	580	570	[e]570	[e]570	600
Romania[e]	85	80	80	[r]75	75
Spain	303	286	278	290	300
U.S.S.R.[e]	2,900	2,900	3,000	3,000	3,000
United Kingdom	278	354	340	390	375
United States[2]	1,603	1,007	1,052	1,686	[3]1,603
Yugoslavia	208	174	48	270	250
Zaire	[2]230	[r]280	308	318	320
Zambia	([4])	--	--	--	--
Total	[r]17,380	[r]16,422	17,527	19,171	18,662

[e]Estimated. [p]Preliminary. [r]Revised.

[1]This table gives unwrought production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not; where known, this has been indicated by footnote. Data derived in part from World Metal Statistics (published by World Bureau of Metal Statistics, London) and from Metal Statistics (published by Metallgesellschaft Aktiengesellschaft, Frankfurt am Main). Cadmium is found in ores, concentrates, and/or flue dusts in several other countries, but these materials are exported for treatment elsewhere to recover cadmium metal; therefore, such output is not reported in this table to avoid double counting. Table includes data available through Apr. 8, 1986.

[2]Includes secondary.

[3]Reported figure.

[4]Revised to zero.

TECHNOLOGY

Researchers at the Corning Glass Works, Corning, NY, reported the discovery of a new cadmium-bearing fluoride glass system that was 10 times more resistant to water corrosion than zirconium-based fluoride glasses. The new glass, a mixture of cadmium, lithium, aluminum, and lead fluorides, was developed under an Air Force Office of Scientific Research contract aimed at seeking improved glass systems. The main practical advantage of the new glass was its higher resistance to water corrosion, which could lead to applications in infrared optics and optical windows.[10]

Boeing Aerospace Co. reported the development of thin film polycrystalline solar cells with energy conversion levels of nearly 12%, eclipsing a previous efficiency level of 9%. The cells were made of copper-indium diselenide/zinc-cadmium sulfide and were part of an effort to produce solar cells for large-scale terrestrial solar power applications and for potential uses in space.[11]

Researchers at Los Alamos National Laboratory in New Mexico reported the discovery of a peptide that protected plants from being poisoned by toxic metals. The unnamed compound, a chain of seven amino acids, reportedly bound cadmium and allowed plant cells to tolerate otherwise toxic concentrations of the metal. This discovery could lead to new methods of growing more nutritious crops and to the development of biochemical filters that remove toxic metals. The scientists speculated that the peptide might be used to scavenge metals from contaminated soil, sewage sludge, and waste effluent.[12]

Developments in cadmium technology during the year were abstracted in Cadmium Abstracts, a quarterly publication available through the Cadmium Association, 34 Berkeley Square, London W1X 6AJ, England.

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Federal Register. Water Quality Criteria; Availability of Documents. V. 50, No. 145, July 29, 1985, pp. 30784-30796.

[3]———. Assessment of Cadmium Under Section 122 of the Clean Air Act. V. 50, No. 200, Oct. 16, 1985, pp. 42000-42004.

[4]Gross, S. Tailor-Made Technology, Pin-Point Marketing and High-Yield Resins Spark Vigorous Growth. Chem. Week, v. 137, No. 24, Dec. 11, 1985, pp. SAS 3-SAS 46.

[5]Advanced Battery Technology. V. 21, No. 4, Apr. 1985, p. 6.

[6]Mining Journal (London). Greek Lead-Zinc Project. V. 304, No. 7816, June 7, 1985, p. 406.

[7]Advanced Battery Technology. V. 21, No. 12, Dec. 1985, p. 1.

[8]Metal Bulletin (London). Cutting Down on Cadmium. No. 7004, July 19, 1985, p. 10.

[9]Page 10 of work cited in footnote 8.

[10]Lasers & Applications. Corning Discovers New Fluoride Glass System. V. 4, No. 10, Oct. 1985, pp. 30, 32.

[11]Photonics Spectra. Boeing, Sovonics Boost Efficiency of Solar Cells. V. 19, Issue 12, Dec. 1985, p. 8.

[12]Chemical & Engineering News. Peptide Protects Plants From Cadmium. V. 63, No. 26, July 1, 1985, p. 22.

Calcium and Calcium Compounds

By Lawrence Pelham[1]

Calcium, the fifth most abundant element in the Earth's crust, is very active, and occurs in nature in combination with other elements. The Bureau of Mines publishes individual reports for several of these calcium minerals and compounds. The commercial name for calcium fluoride is fluorspar; calcium carbonate is known as limestone; and calcium oxide and hydroxide are called lime. Information on these materials can be obtained in the "Fluorspar," "Crushed Stone," and "Lime" chapters of the "Minerals Yearbook." Other calcium compounds are covered in the chapter concerning the element with which it is combined; for example, calcium bromide is discussed in the"Bromine"chapter. This chapter covers calcium metal, calcium chloride, and various other calcium compounds not covered elsewhere.

Calcium metal was manufactured by one company in Connecticut. Natural calcium chloride was produced by three companies in California, two companies in Michigan, and one company in Washington. Synthetic calcium chloride was manufactured by one company in Louisiana, two companies in New York, and two companies in Washington.

Domestic Data Coverage.—Domestic production data for calcium chloride are developed by the Bureau of Mines from a voluntary survey of U.S. operations entitled "Calcium Chloride and Calcium-Magnesium Chloride." Of the 11 operations to which a survey request was sent, all responded, representing 100% of the total production shown in table 1.

DOMESTIC PRODUCTION

Pfizer Inc. produced calcium metal at Canaan, CT, by the Pidgeon process—an aluminothermic process in which high-purity calcium oxide, produced by calcining limestone, and aluminum powder are briquetted and heated in vacuum retorts. The vaporized calcium metal product is collected as a "crown" in a water-cooled condenser. Pfizer accounted for an estimated 50% of total calcium metal production in market economy countries.

Pfizer produced commercial-grade calcium containing 98.5% calcium in seven shapes, high-purity redistilled metal containing 99.2% calcium in four shapes, and an 80% calcium-20% magnesium alloy. Pfizer also produced an alloy consisting of 25% calcium and 75% aluminum for use in maintenance free batteries and a pure calcium wire used in the steel industry to modify inclusions. Elkem Metal Co., a Norwegian-owned company with headquarters at Pittsburgh, PA, produced calcium alloys at its plant in Alloy, WV, including a calcium-silicon alloy containing about 30% calcium, 65% silicon, and 5% iron, and two proprietary alloys that contain barium, and barium and aluminum. The Foote Mineral Co. at Exton, PA, and ASARCO Incorporated at New York, NY, also produced calcium alloys. The Pesses Co. produced calcium alloys for use in the production of iron, steel, and nickel alloys.

National Chloride Co. of America, Cargill Inc.'s Leslie Salt Co., and Hill Bros. Chemical Co. produced calcium chloride from dry-lake brine wells in San Bernardino County, CA. Hill Bros. Chemical also produced from a second operation near Cadiz Lake. Total output in California was slightly less than that of 1984. Natural calcium chloride production in California was much less than in Michigan. The Dow Chemical Co. and Wilkinson Chemical Corp. recovered calcium chloride from brines in Lapeer, Mason, and Midland Counties, MI. Dow continued to phase out all brine operations at its 80-year-old plant in Midland, MI, and relocate its calcium chloride operations to Ludington, MI. The phaseout was planned to be completed by mid-1986. Tahoma Chemical Co. Inc., a new company, began producing calcium chloride in Washington in November.

Allied Chemical Corp. recovered synthetic calcium chloride as a byproduct of soda ash production at its Solvay plant near Syracuse, NY, and as a byproduct at its Baton Rouge, LA, plant using hydrochloric acid and limestone; Texas United Chemical Corp. produced calcium chloride from purchased hydrochloric acid and limestone at its plant near Lake Charles, LA; and Occidental Chemical Corp. manufactured calcium chloride at Tacoma, WA, using limestone and hydrochloric acid. Reichold Chemicals Inc. produced a small amount of synthetic calcium chloride as a byproduct of pentachlorophenol manufacture at Tacoma, WA, before closing the operation permanently in February.

At yearend Allied was in the process of closing its Solvay complex in Syracuse, NY. Allied was expanding its plant in Amherstbury, Ontario, Canada, in order to continue serving calcium chloride customers in the Northeastern United States. Texas United Chemical announced plans to build a new granular calcium chloride plant in Lake Charles, LA, with an annual capacity of at least 20,000 short tons of a dry form of 94% to 97% calcium chloride. Construction had begun and completion was expected in May 1986.[2]

Calcium hypochlorite was produced by two U.S. companies: Olin Corp. and PPG Industries Inc. Total U.S. capacity for producing calcium hypochlorite was 116,500 tons per year.

Table 1.—U.S. production of calcium chloride (75% $CaCl_2$ equivalent)

Year	Natural		Synthetic		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1981	704,691	$61,692	212,299	$27,086	916,990	$88,778
1982	616,513	61,483	236,894	31,279	853,407	92,762
1983	663,949	71,330	192,688	29,727	856,637	101,057
1984[e]	838,000	93,000	198,000	31,500	1,036,000	124,500
1985	W	W	W	W	801,000	92,200

[e]Estimated. W Withheld to avoid disclosing company proprietary data.

CONSUMPTION AND USES

Calcium metal was used in the manufacture of batteries, as an aid in removing bismuth in lead refining, as a desulfurizer and deoxidizer in steel refining, and as a reducing agent to recover refractory metals such as chromium, thorium, and rare earths from their oxides. Some minor uses were in the preparation of vitamin B and chelated calcium supplements, and as a cathode coating in some types of photoelectric tubes. The nuclear applications of calcium metal give it strategic significance; foreign sales must be approved by the U.S. Department of State. State Department approval had been denied to countries that were not a signatory of the United Nations Nuclear Nonproliferation Treaty.

Calcium chloride was used for road and pavement deicing, dust control and road base stabilization, coal and other bulk material thawing, oil and gas drilling, concrete-set acceleration, tire ballasting, and miscellaneous uses.

The principal use of calcium chloride was to melt snow and ice from roads, streets, bridges, and pavements. Calcium chloride is more effective at lower temperatures than rock salt and has been used mainly in the Northern and Eastern States. Because of its considerably higher price, it was used in conjunction with rock salt for maximum effectiveness and economy.

Calcium hypochlorite was used to disinfect swimming pools, which accounted for

85% of domestic demand, and in other municipal and industrial bleaching and sanitation processes. It was used as an algicide, bactericide, deodorant, water purifier, disinfectant, fungicide, and bleaching agent.

Calcium nitrate was used as a concrete additive to inhibit corrosion of steel reinforcement bars, accelerate setting time, and enhance strength.

Calcium carbide and calcium-silicon alloy were used to remove sulfur from molten pig iron as it was carried in transfer ladles from the blast furnace to the steelmaking furnace.

PRICES AND SPECIFICATIONS

The published price of calcium metal crowns in quantities greater than 20,000 pounds increased on January 1 to $3.76 per ton and again on November 1 to $3.92. The price of calcium-silicon alloy remained unchanged. Yearend published prices and specifications were as follows:

	Value per pound	
	1984	1985
Calcium metal, 1-ton lots, 50-pound full crowns, 10 by 18 inches, Ca+Mg 99.5%, Mg 0.7%	$3.25	$3.92
Calcium-silicon alloy, 32% calcium, carload lots, f.o.b. shipping point	.72	.72

Source: Metals Week. V. 55, No. 53, 1984, p. 5; Metals Week. V. 56, No. 52, 1985, p. 5.

Calcium metal was usually sold in the form of crowns, broken crown pieces or nodules, or billets, which are produced by melting crowns in an argon atmosphere. The metal purity in these forms was at least 98%. Higher purity metal was obtained by redistillation.

Calcium metal was usually shipped in polyethylene bags under argon in an airtight 55-gallon steel drum.

Calcium chloride was sold as flake or pellet averaging about 75% $CaCl_2$, or as a liquid concentrate averaging 40% $CaCl_2$. Prices remained unchanged from those of 1984. Yearend 1985 published prices and specifications were as follows:

	Value per ton
Calcium chloride concentrate, regular grade, 77% to 80%, flake, bulk, carload, works	$153.00
100-pound bags, carload, same basis	196.00
Anhydrous, 94% to 97%, flake or pellet, bulk, carload, same basis	217.00
80-pound bags, carload, same basis	279.00
Brining grade, 80-pound bags	285.00
Calcium chloride liquid, 100% basis, tank car, tank truck, barge	90.69
45%, same basis	108.00
Calcium chloride, United States Pharmacopoeia, granular, 225-pound drums, truckload, freight equalized	1,800.00

Source: Chemical Marketing Reporter. V. 228, No. 27, 1985, p. 25.

FOREIGN TRADE

Calcium chloride was exported to 37 countries. A significant decrease in calcium chloride exports occurred primarily because of the phasing out of Allied's Syracuse, NY, plant and Dow's Midland, MI, plant. Exports of calcium phosphates were 58,600 tons valued at $43 million compared with 40,000 tons valued at about $33 million in 1984. The leading destinations, in descending order, were Venezuela, Colombia, Canada, and Mexico, with material sent to a total of 52 countries.

Exports of other calcium compounds, including precipitated calcium carbonate, totaled 49,000 tons valued at $25 million compared with 37,000 tons valued at $17 million in 1984. Material in this category was sent to 57 countries. The leading destinations, in descending order, were the United Kingdom, the Netherlands, Mexico, Belgium, and Canada.

Calcium chloride imports increased significantly with large gains by Canada and Sweden. The increase by Canada was a direct result of planned expansion by Allied at its Amherstburg plant in conjunction with decreasing U.S. capacity. Crude calcium chloride imports increased 246% to 75,381 tons valued at $9.1 million, mainly from Canada. Other calcium chloride imports, which increased 747% to 2,355 tons valued at $1.9 million, were supplied almost equally by Brazil, Canada, the Federal Republic of Germany, and Sweden.

Imports of other calcium compounds included 15,800 tons of calcium carbide valued at $5.0 million from Canada; 3,700 tons of calcium hypochlorite valued at $5.1 million from Japan; 274,000 tons of crude calcium carbonate chalk valued at $1.7 million from the Bahamas; 7,300 tons of calcium carbonate chalk whiting valued at $1.6 million, mainly from France; 12,000 tons of precipitated calcium carbonate valued at $4.9 million, primarily from, in descending order, the United Kingdom, Japan, and France; and 139,000 tons of calcium nitrate valued at $14.6 million, mainly from Norway.

The U.S. International Trade Commission determined on March 28, under section 735(b) of the Tariff Act of 1930, that the domestic industry had been materially injured by reason of imports of calcium hypochlorite from Japan being sold at less than fair value. An antidumping order was issued by the U.S. Department of Commerce.

Calcium metal was imported from four countries. China supplied 249,913 pounds; France, 113,885 pounds; the U.S.S.R., 101,575 pounds; and Canada, 26,871 pounds. U.S. import duties in effect during the year for calcium metal were 3.6% ad valorem for countries having most-favored-nation status, 3.0% ad valorem for less developed and developing countries, and 25% ad valorem for non-most-favored nations.

Table 2.—U.S. exports of calcium chloride, by country

Country	1984		1985	
	Short tons	Value	Short tons	Value
Brazil	209	$67,916	70	$22,483
Cameroon	885	277,159	1,333	179,239
Canada	20,976	2,658,345	14,755	2,494,945
Egypt	816	7,086,176	1,872	522,866
Mexico	295	113,470	786	216,595
Netherlands	2,340	7,634,897	874	138,583
Norway	1,453	344,531	--	--
Saudi Arabia	27	29,098	2	2,244
Sweden	1,541	752,141	968	1,136,964
Trinidad and Tobago	895	323,492	214	48,565
United Arab Emirates	2,364	377,780	2,713	636,939
United Kingdom	606	203,065	288	87,003
Venezuela	474	221,441	73	58,690
Other	1,181	478,150	2,195	797,840
Total	34,062	20,567,661	26,143	6,342,956

Source: Bureau of the Census.

Table 3.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium		Calcium chloride	
	Pounds	Value[1]	Short tons	Value[1]
1981	235,436	$751,456	86,865	$4,088,361
1982	333,054	966,665	60,623	3,010,212
1983	332,834	866,409	13,784	1,317,016
1984	248,973	669,586	22,078	1,816,915
1985	492,244	1,395,198	77,736	10,967,328

[1]U.S. Customs, insurance, freight.

Source: Bureau of the Census.

Table 4.—U.S. imports for consumption of calcium chloride, by country

Country	1984		1985	
	Short tons	Value[1]	Short tons	Value[1]
Canada	18,320	$1,188,591	65,458	$7,272,298
Germany, Federal Republic of	87	246,331	621	327,445
Mexico	2,424	69,753	1,572	54,489
Sweden	1,214	261,761	9,279	2,411,923
Other	33	50,479	806	901,173
Total	22,078	1,816,915	77,736	10,967,328

[1]U.S. Customs, insurance, freight.

Source: Bureau of the Census.

WORLD REVIEW

Calcium metal was produced in Canada, China, France, Japan, and the U.S.S.R., in addition to the United States. The market economy country production of calcium metal was estimated to be about 1,500 tons. Total world production was an estimated 2,000 tons.

[1]Physical scientist, Division of Industrial Minerals.
[2]Chemical Marketing Reporter. V. 228, No. 22, 1985, p. 31.

Cement

By Wilton Johnson[1]

U.S. cement demand increased for the third consecutive year, reflecting continued growth in the construction industry. U.S. cement production remained essentially unchanged. According to the U.S. Department of Commerce, the value of new construction put in place increased 10% to $343 billion. Housing starts remained essentially unchanged at 1.74 million units. Public buildings, highways and streets, and other public construction accounted for the bulk of construction activity.

Imports increased 64% to 14.5 million short tons, the highest level in recorded U.S. history. Clinker imports were 32% of the total.

Shipments of portland and masonry cement from U.S. plants, excluding Puerto Rico, increased 4% to 83 million tons. All consuming regions except the South experienced gains in cement shipments. The Northeast region experienced the largest gain with 12%, followed by the West, 7%, and the North Central, 3%.

Acquisition of U.S. cement plants by foreign firms continued. By yearend, approximately 32% of clinker and 35% of finish grinding capacity had been acquired by foreign interests.

Domestic Data Coverage.—Domestic production and consumption data for cement are developed by means of the portland and masonry cement voluntary survey. Of the 144 cement manufacturing plants to which an annual survey collection request was made, 100% responded, representing 100% of the cement production and consumption data shown in table 1.

Table 1.—Salient cement statistics

(Thousand short tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:[1]					
Production[2]	71,710	63,355	70,420	77,700	77,895
Shipments from mills[2 3]	71,748	64,066	70,933	80,166	83,032
Value[2 3 4] thousands	$3,723,096	$3,263,585	$3,534,324	$4,152,258	$4,286,399
Average value per ton[2 3 4]	$51.89	$50.94	$49.95	$51.80	$51.61
Stocks at mills,[2] Dec. 31	7,372	6,753	6,711	6,866	7,232
Exports	300	201	118	80	98
Imports for consumption	3,963	2,911	4,221	8,689	14,120
Consumption, apparent[5 6]	73,321	65,623	73,435	84,313	87,456
World: Production	[r]977,384	[r]978,362	1,010,116	[p]1,045,468	[e]1,071,225

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes Puerto Rico and the Virgin Islands.
[2]Portland and masonry cement only.
[3]Includes imported cement shipped by domestic producers.
[4]Value received, f.o.b. mill, excluding cost of containers.
[5]Quantity shipped, plus imports, minus exports.
[6]Adjusted to eliminate duplication of imported clinker and cement shipped by domestic cement manufacturers.

DOMESTIC PRODUCTION

One State agency and 48 companies operated 144 plants in 40 States. In addition, two companies operated two plants in Puerto Rico manufacturing hydraulic cement.

Some of the data are arranged by State or by groups of States that form cement districts. A cement district may represent a group of States or a portion of a State. The States of California, Illinois, New York, Pennsylvania, and Texas are divided to provide more definitive marketing information. Divisions for these States are as follows:

California, Northern.—Points north and west of the northern borders of Kern and San Luis Obispo Counties and the western borders of Inyo and Mono Counties.

California, Southern.—All other counties in California.

Chicago, Metropolitan.—The seven Illinois counties of Cook, Du Page, Kane, Kendall, Lake, McHenry, and Will.

Illinois.—All other counties in Illinois.

New York, Western.—All counties west of a dividing line following the eastern boundaries of Broome, Chenango, Lewis, Madison, Oneida, and St. Lawrence Counties.

New York, Eastern.—All counties east of the above dividing line, except Metropolitan New York.

New York, Metropolitan.—The five counties of New York City (Bronx, Kings, New York, Queens, and Richmond) plus Nassau, Rockland, Suffolk, and Westchester Counties.

Pennsylvania, Eastern.—All counties east of the eastern boundaries of Centre, Clinton, Franklin, Huntingdon, and Potter Counties.

Pennsylvania, Western.—All other counties in Pennsylvania.

Texas, Northern.—All counties north of a dividing line following the northern borders of Brazos, Burnet, Crockett, Jasper, Jeff Davis, Llano, Madison, Mason, Menard, Milam, Newton, Pecos, Polk, Robertson, San Jacinto, Schleicher, Tyler, Walker, and Williamson Counties.

Texas, Southern.—All counties south of the above dividing line.

PORTLAND CEMENT

Clinker production in the United States, excluding Puerto Rico, decreased 4% to 66.3 million tons, and clinker imports received by U.S. cement producers increased 105% to 3.9 million tons. A total of 74.6 million tons of portland cement was ground in the United States. Stocks at mills increased by 380,000 tons to 6.8 million tons at yearend.

Production Capacity.—By yearend, multiplant operations were being run by 25 companies. The size of individual companies, as a percentage of total U.S. clinker production capacity, ranged from 0.3% to 10.6%. The 5 largest producers provided 34% of total clinker production; the 10 largest producers provided a combined total of 55%. The 10 largest companies, in terms of clinker production, were Lone Star Industries Inc., General Portland Inc., Lehigh Portland Cement Co., Gifford-Hill & Co. Inc., Southwestern Portland Cement Co., Dundee Cement Co., Blue Circle Inc., Ideal Basic Industries Inc., Kaiser Cement Corp., and Moore McCormack Resources Inc.

At yearend, 266 kilns at 124 plants were being operated by 45 companies and 1 State agency in the United States, excluding Puerto Rico. Annual clinker production capacity at yearend was 86.3 million tons. An average of 46 days downtime was reported for kiln maintenance and repair. The industry operated at an average 77% of its apparent capacity. Average annual clinker capacity of U.S. kilns was 325,000 tons, average plant capacity was 696,000 tons, and average company capacity was about 1.9 million tons. Three plants produced white cement. In addition, 11 plants operated grinding mills using only imported or purchased clinker, or interplant transfers of clinker. Of these, seven produced portland cement only, and four ground clinker for both masonry and portland cement. Based on the fineness to which Types I and II cements must be ground and allowing for downtime for maintenance, the U.S. cement industry's estimated annual grinding capacity was 102 million tons.

Clinker was produced by wet-process kilns at 53 plants (includes Puerto Rico) and by dry-process kilns at 68 plants; 5 additional plants operated both wet and dry kilns. The initiation of major plant modernization and expansion projects, including the installation of dry-process kilns and preheater-precalciner systems, continued to decline. At yearend, there were 59 suspension and 18 grate preheaters in operation.

Capacity Additions Planned.—Box-Crow Cement Co., formerly Dal-Tex Cement Corp., continued construction of a 1-million-ton-per-year cement plant near Midlothian, TX. The plant, which will be equipped with a coal-fired preheater-precalciner system, was expected to go on-stream in December 1986.

Florida Crushed Stone Co. began construction of its 600,000-ton-per-year cement plant in Brooksville, FL. The plant also will feature a 125-megawatt power generation facility and the capacity to produce 350,000 tons per year of lime. The cement portion of the plant was expected to go into production in November 1986. The power generation and lime facilities were expected to begin operation the first part of 1987.

Plant Closings.—General Portland closed the final kiln at its Tampa, FL, cement plant and signed a clinker supply contract with Mexico's Cementos Apasco S.A. to replace clinker production at the plant. The plant will be used exclusively for grinding Mexican clinker into finished portland cement.

Genstar Cement and Lime Co.'s San Andreas, CA, plant remained closed throughout the year.

Centex Corp.'s Corpus Christi, TX, plant closed and was used as a cement distribution terminal.

Corporate Changes.—Allentown Cement Co. Inc., headquartered in King of Prussia, PA, acquired National Gypsum Co.'s Evansville, PA, cement plant and distribution terminals at Bowie, MD, and Jersey City, NJ.

Ash Grove Cement Co. of Overland Park, KS, purchased Arkansas Cement Corp.'s Foreman, AR, cement plant and distribution terminals at Little Rock and Ft. Smith, AR; Shreveport and Alexandria, LA; and Oklahoma City, OK.

Blue Circle Industries PLC, a large British cement company, acquired Atlantic Cement Co.'s 1.5-million-ton-per-year portland cement plant at Ravena, NY, its 80,000-ton-per-year slag cement plant at Sparrows Point, MD, several distribution terminals along the east coast, and a fleet of cement-carrying barges.

Columbia Northwest Corp., a subsidiary of Ashland Oil Inc., sold its Bellingham, WA, plant and distribution terminals in Anchorage, AK, Portland, OR, and Pasco and Seattle, WA, to SME Cement Inc. of Bessemer, PA.

Independent Cement Co. purchased Lone Star Industries' Hagerstown, MD, plant and Baltimore distribution terminal.

Kaiser Cement sold its Hawaiian cement plant and distribution facilities to a new partnership formed by Lone Star Industries and the Australian firm Adelaide Brighton Cement Holdings Ltd.

Table 2.—Portland cement production, capacity, and stocks in the United States, by district[1]

District	1984					1985				
	Plants active during year	Production[2] (thousand short tons)	Capacity[3] Finish grinding (thousand short tons)	Capacity[3] Percent utilized	Stocks[4] at mills, Dec. 31 (thousand short tons)	Plants active during year	Production[2] (thousand short tons)	Capacity[3] Finish grinding (thousand short tons)	Capacity[3] Percent utilized	Stocks[4] at mills, Dec. 31 (thousand short tons)
New York and Maine	6	3,198	4,199	76.2	248	6	3,655	3,915	93.3	304
Pennsylvania, eastern	9	4,476	5,102	87.7	371	9	4,327	5,121	84.5	360
Pennsylvania, western	4	1,338	2,441	54.8	131	4	1,272	2,466	51.5	169
Maryland, Virginia, West Virginia	5	3,307	3,880	85.2	255	5	3,453	3,882	88.9	329
Ohio	6	1,508	2,603	57.9	245	6	1,738	2,603	66.7	213
Michigan and Wisconsin	8	5,006	7,375	67.9	512	7	4,602	7,075	65.0	486
Indiana and Kentucky	5	2,772	3,845	72.1	291	5	2,672	3,733	71.5	308
Illinois	4	1,876	2,640	71.1	119	4	2,073	2,880	71.9	128
Georgia and Tennessee	4	2,013	2,483	81.1	144	4	2,021	2,495	81.0	227
South Carolina	3	2,313	3,400	68.0	146	3	2,276	3,447	66.0	97
Florida	6	3,268	4,258	76.7	199	5	3,403	4,186	81.3	178
Alabama	6	3,678	5,523	66.6	390	6	3,723	5,594	66.5	378
Arkansas, Louisiana, Mississippi	4	2,375	2,790	85.1	133	4	2,141	2,790	76.7	141
South Dakota	1	618	1,806	34.2	50	1	665	1,806	36.8	60
Iowa	4	1,763	3,001	58.7	347	4	1,642	3,072	53.4	348
Missouri	5	3,979	4,950	80.4	384	5	3,883	4,950	78.4	605
Kansas and Nebraska	7	2,654	4,019	66.0	319	7	2,684	4,072	65.9	408
Oklahoma	3	1,784	2,080	85.8	217	3	1,584	2,080	76.1	207
Texas, northern	9	5,044	5,489	91.9	353	9	5,096	5,474	93.0	364
Texas, southern	9	5,277	6,870	76.8	256	9	5,023	6,936	72.4	225
Idaho, Montana, Utah	6	1,754	2,365	74.2	234	6	1,744	2,315	75.3	300
Colorado and Wyoming	4	1,767	2,700	65.4	134	4	1,592	2,550	62.4	154
Alaska, Oregon, Washington	6	1,655	2,800	59.1	233	6	1,680	2,754	61.0	239
Arizona, Nevada, New Mexico	4	2,088	3,095	67.5	109	4	2,102	3,015	69.7	103
California, northern	3	2,518	3,937	64.0	235	3	2,518	3,165	79.5	119
California, southern	8	6,204	9,396	66.0	307	8	6,860	9,346	73.4	301
Hawaii	2	181	560	32.3	34	2	209	560	37.2	25
Total or average	141	74,414	103,607	71.8	6,396	139	[5]74,637	102,282	73.0	6,776
Puerto Rico	2	999	2,210	45.2	33	2	964	2,210	43.6	35

[1]Includes Puerto Rico. Includes data for three white cement facilities as follows: California (1), Pennsylvania (1), and Texas (1). Includes data for grinding plants (11 in 1984 and 1985) as follows: Alaska (1); Florida (1 in 1984 and 2 in 1985), Michigan (2 in 1984 and 1 in 1985), New York (1), Pennsylvania (2 in 1984 and 1 in 1985), Texas (2 in 1984 and 3 in 1985), and Wisconsin (2).

[2]Includes cement produced from imported clinker (1984—1,938,000 tons; 1985—1,914,000 tons).

[3]Grinding capacity based on fineness necessary to grind Types I and II cement, making allowance for downtime required for maintenance.

[4]Includes imported cement. Source of imports withheld to avoid disclosing company proprietary data.

[5]Data do not add to total shown because of independent rounding.

Table 3.—Clinker capacity and production in the United States,[1] by district, as of December 31, 1985

District	Active plants: Process used: Wet	Active plants: Process used: Dry	Active plants: Process used: Both	Active plants: Total	Number of kilns	Daily capacity (thousand short tons)	Average number of days for maintenance	Apparent annual capacity[2] (thousand short tons)	Production[3] (thousand short tons)	Percent utilized
New York and Maine	4	2	--	6	6	12.0	29	4,380	3,669	83.7
Pennsylvania, eastern	2	5	--	7	16	15.0	41	3,894	3,461	88.8
Pennsylvania, western	3	1	--	4	8	12.0	29	2,020	1,406	69.6
Maryland, Virginia, West Virginia	2	2	--	4	15	6.0	48	3,812	3,426	89.8
Ohio	2	3	1	6	11	12.0	32	1,998	1,776	88.8
Michigan and Wisconsin	2	3	--	5	13	17.0	41	5,522	3,703	67.0
Indiana and Kentucky	2	3	--	5	10	12.0	47	3,824	2,644	69.1
Illinois	--	4	--	4	8	8.0	23	2,740	1,798	65.6
Georgia and Tennessee	1	2	1	4	7	7.0	38	2,291	2,010	87.7
South Carolina	1	1	--	2	7	5.0	11	1,771	1,696	95.7
Florida	4	1	--	5	7	9.0	48	2,857	2,344	82.0
Alabama	1	5	--	6	8	14.0	29	4,705	2,685	57.0
Arkansas, Louisiana, Mississippi	3	--	--	3	8	8.0	40	2,603	2,055	78.9
South Dakota	--	--	1	1	4	3.0	72	880	667	75.7
Iowa	1	3	--	4	8	9.0	51	2,826	1,643	58.1
Missouri	2	2	--	4	7	14.0	39	4,566	4,086	89.4
Kansas and Nebraska	4	3	--	7	19	10.0	38	3,273	2,631	80.3
Oklahoma	1	1	--	2	7	5.0	6	1,795	1,585	88.3
Texas, northern	5	4	--	9	24	15.0	29	5,051	4,555	90.1
Texas, southern	1	4	1	6	8	12.0	33	3,989	3,053	76.5
Idaho, Montana, Utah	4	1	--	5	10	7.0	45	2,244	1,730	77.0
Colorado and Wyoming	2	2	--	4	7	7.0	49	2,218	1,631	73.5
Alaska, Oregon, Washington	3	2	--	5	8	5.0	13	1,762	1,336	75.8
Arizona, Nevada, New Mexico	--	4	--	4	11	8.0	44	2,572	1,954	75.9
California, northern	--	3	--	3	3	9.0	31	3,008	2,426	80.6
California, southern	1	6	1	8	24	28.0	39	9,135	6,136	67.1
Hawaii	--	1	--	1	2	2.0	66	599	201	33.5
Total or average	51	68	5	124	266	271.0	46	86,335	66,307	76.8
Puerto Rico	2	--	--	2	9	7.0	16	2,449	869	35.4

[1]Includes Puerto Rico and white cement producing facilities.
[2]Calculated on individual company data; 365 days, minus average days for maintenance, times the reported 24-hour capacity.
[3]Includes production reported for plants that added or shut down kilns during the year.

Table 4.—Daily clinker capacity in the United States,[1] December 31

Short tons per 24-hour period	Number: Plants	Number: Kilns[2]	Total capacity (short tons)	Percent of total capacity
1984:				
Less than 1,150	25	44	21,334	7.5
1,151 to 1,700	28	47	38,708	13.7
1,701 to 2,300	29	55	55,077	19.4
2,301 to 2,800	22	47	54,797	19.3
2,801 and over	28	88	113,532	40.1
Total	132	281	283,448	100.0
1985:				
Less than 1,150	25	41	19,457	7.0
1,151 to 1,700	27	58	45,283	16.3
1,701 to 2,300	24	43	44,745	16.1
2,301 to 2,800	22	49	52,596	19.0
2,801 and over	28	84	116,239	41.6
Total	126	275	278,320	100.0

[1]Includes Puerto Rico and white cement producing facilities.
[2]Total number in operation at plants.

Table 5.—Raw materials used in producing portland cement in the United States[1]

(Thousand short tons)

Raw materials	1983	1984	1985
Calcareous:			
Limestone (includes aragonite, marble, chalk)	73,075	78,484	77,627
Cement rock (includes marl)	21,644	27,010	24,255
Coral	2,030	1,103	1,277
Other			243
Argillaceous:			
Clay	5,736	6,045	5,635
Shale	3,011	3,087	3,182
Other (includes staurolite, bauxite, aluminum dross, alumina, volcanic material, other)	118	47	123
Siliceous:			
Sand and calcium silicate	1,669	1,958	1,930
Sandstone, quartzite, other	691	696	608
Ferrous: Iron ore, pyrites, millscale, other iron-bearing material	1,058	1,232	1,307
Other:			
Gypsum and anhydrite	3,474	3,967	3,959
Blast furnace slag	49	27	97
Fly ash	870	841	796
Other, n.e.c	103	296	311
Total	113,528	124,793	121,350

[1]Includes Puerto Rico.

MASONRY CEMENT

Production of masonry cement remained at 3.3 million tons. At yearend, 96 plants were manufacturing masonry cement in the United States. Two plants producing masonry cement exclusively were Cheney Lime & Cement Co., Allgood, AL, and Riverton Corp., Riverton, VA.

Table 6.—Masonry cement production and stocks in the United States, by district

District	1984			1985		
	Plants active during year	Production (thousand short tons)	Stocks[1] at mills, Dec. 31 (thousand short tons)	Plants active during year	Production (thousand short tons)	Stocks[1] at mills, Dec. 31 (thousand short tons)
New York and Maine	4	77	14	4	71	13
Pennsylvania, eastern	6	240	31	6	233	37
Pennsylvania, western	3	68	12	3	73	14
Maryland, Virginia, West Virginia	5	276	27	5	294	21
Ohio	4	103	23	4	113	26
Michigan and Wisconsin	5	206	55	6	203	47
Indiana and Kentucky	5	393	69	5	395	68
Illinois	2	W	W	1	W	W
Georgia and Tennessee	4	171	24	4	188	23
South Carolina	2	W	W	2	W	W
Florida	5	390	20	4	395	22
Alabama	7	236	29	7	256	37
Arkansas, Louisiana, Mississippi	3	97	8	3	79	10
South Dakota	1	6	2	1	4	2
Iowa	3	40	8	3	42	11
Missouri	3	143	23	4	139	26
Kansas and Nebraska	6	71	32	6	56	30
Oklahoma	3	52	9	3	46	11
Texas, northern	7	219	18	7	199	18
Texas, southern	5	73	9	5	64	8
Idaho, Montana, Utah	4	7	6	2	3	4
Colorado and Wyoming	2	W	W	2	W	W
Alaska, Oregon, Washington	1	W	W	3	9	6
Arizona, Nevada, New Mexico	3	95	7	3	98	5
California, northern	--	--	--	1	W	W
California, southern	1	W	W	1	W	W
Hawaii	2	5	2	1	6	1
Other	--	318	42	--	292	15
Total or average	96	3,286	470	96	3,258	[2]456

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes imported cement.
[2]Data do not add to total shown because of independent rounding.

ALUMINOUS CEMENT

Aluminous cement, also known as calcium aluminate cement, high-alumina cement, and Cement Fondu, is a nonportland hydraulic cement. It continued to be produced at the following three plants in the United States: Lehigh Portland Cement, Buffington, IN; Lone Star Lafarge Inc., Chesapeake, VA; and Aluminum Co. of America, Bauxite, AR.

ENERGY

Approximately 81% of the energy consumed in cement production was in the form of fuel for kiln firing to produce clinker. Average energy consumption per ton of clinker was 4.6 million British thermal units (Btu).

The average consumption of electrical energy decreased slightly to 138.2 kilowatt hours per ton. Assuming a 40% energy efficiency in conversion of fuel to electrical energy, this represents a fuel equivalent of 1.2 million Btu per ton. Thus, average fuel consumption for kiln firing plus electrical energy, primarily for finish grinding, was approximately 5.8 million Btu per ton.

Average fuel consumption for kiln firing in wet-process plants, 5.6 million Btu per ton, was 33% higher than average fuel consumption in dry-process plants, 4.2 million Btu per ton. Approximately 56% of clinker production was by the dry process.

Kilns without preheaters averaged 5.7 million Btu per ton of clinker produced; those with suspension preheaters averaged 3.9 million Btu per ton, and those with grate-type preheaters averaged 5.4 million Btu per ton.

Coal accounted for 95% of kiln fuel consumption, natural gas accounted for 4%, and oil and waste fuel accounted for the remainder.

Energy-saving additives for cement production, such as fly ash and blast furnace slags, continued to be used. The use of fly ash decreased 5% to 796,000 tons. The use of slags increased 259% to 97,000 tons, the first increase following 5 consecutive years of decline.

Table 7.—Clinker produced in the United States,[1] by fuel

Fuel	Clinker produced: Plants active during year	Clinker produced: Quantity (thousand short tons)	Clinker produced: Percent of total	Fuel consumed: Coal[2] (thousand short tons)	Fuel consumed: Oil (thousand 42-gallon barrels)	Fuel consumed: Natural gas (thousand cubic feet)
1984:						
Coal	26	12,923	18.5	2,822	--	--
Coal and oil	29	15,454	22.2	2,862	373	--
Coal and natural gas	59	30,405	43.6	5,302	--	10,461,227
Oil and natural gas	1	72	.1	--	56	95,210
Coal, oil, natural gas	17	10,879	15.6	2,066	311	3,570,680
Total	132	69,733	100.0	13,052	740	14,127,117
1985:						
Coal	25	13,435	20.0	2,631	--	--
Coal and oil	25	15,450	23.0	2,710	510	--
Coal and natural gas	53	28,886	43.0	4,831	--	8,020,775
Oil and natural gas	--	--	--	--	35	--
Coal, oil, natural gas	23	9,405	14.0	1,434	210	2,623,539
Total	126	67,176	100.0	11,606	755	10,644,314

[1]Includes Puerto Rico.
[2]Includes 0.6% anthracite, 94.7% bituminous, and 4.7% petroleum coke in 1984; 1.3% anthracite, 94.5% bituminous, and 4.2% petroleum coke in 1985.

Table 8.—Clinker produced and fuel consumed by the portland cement industry in the United States,[1] by process

Process	Clinker produced: Plants active during year	Clinker produced: Quantity (thousand short tons)	Clinker produced: Percent of total	Fuel consumed: Coal[2] (thousand short tons)	Fuel consumed: Oil (thousand 42-gallon barrels)	Fuel consumed: Natural gas (thousand cubic feet)
1984:						
Wet	58	25,950	37.2	5,672	199	5,015,128
Dry	69	40,653	58.3	6,819	526	8,241,622
Both	5	3,130	4.5	561	15	870,367
Total	132	69,733	100.0	13,052	740	14,127,117
1985:						
Wet	53	26,066	38.8	5,227	210	4,341,724
Dry	68	37,797	56.3	5,800	525	5,471,841
Both	5	3,313	4.9	579	20	830,749
Total	126	67,176	100.0	11,606	755	10,644,314

[1]Includes Puerto Rico.
[2]Includes 0.6% anthracite, 94.7% bituminous, and 4.7% petroleum coke in 1984; 1.3% anthracite, 94.5% bituminous, and 4.2% petroleum coke in 1985.

Table 9.—Electric energy used at portland cement plants in the United States,[1] by process

Process	Electric energy used: Generated at portland cement plants: Active plants	Generated at portland cement plants: Quantity (million kilowatt hours)	Purchased: Active plants	Purchased: Quantity (million kilowatt hours)	Total: Quantity (million kilowatt hours)	Total: Percent	Finished cement produced (thousand short tons)	Average electric energy used per ton of cement produced (kilowatt hours)
1984:								
Wet	--	--	58	3,634	3,634	34.4	27,942	130.1
Dry[2]	5	432	80	6,013	6,445	60.9	44.025	146.4
Both	--	--	5	500	500	4.7	3,446	145.1
Total or average	5	432	143	10,147	10,579	100.0	75,413	140.3
Percent of total electric energy used	--	4.1	--	95.9	--	--	--	--
1985:								
Wet	2	103	49	3,235	3,338	35.0	25,846	129.1
Dry[2]	5	548	66	5,118	5,666	59.4	39,585	143.1
Both	--	--	5	533	533	5.6	3,601	148.0
Total or average	7	651	120	8,886	9,537	100.0	69,032	138.2
Percent of total electric energy used	--	6.8	--	93.2	--	--	--	--

[1]Includes Puerto Rico. Includes grinding plants and white cement facilities.
[2]Includes data for grinding plants.

TRANSPORTATION

The pattern of cement transport did not differ significantly from that of recent years. U.S. shipments of portland cement to consumers were primarily in bulk (95%), by truck (93.4%), and were made directly from cement manufacturing plants (66%), rather than from distribution terminals.

With respect to shipments of cement from plants to terminals, the preferred modes of transportation were railroads, 42%, and waterways, 37%. Transportation by truck accounted for 19%. Cement used at producing plants accounted for the remaining 2%.

Table 10.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers, by type of carrier

(Thousand short tons)

Type of carrier	Shipments from plant to terminal		Shipments to ultimate consumer: From terminal to consumer		Shipments to ultimate consumer: From plant to consumer		Total shipments
	In bulk	In containers	In bulk	In containers	In bulk	In containers	
1984:							
Railroad	8,776	78	565	16	3,030	34	3,645
Truck	3,777	171	22,415	607	47,026	3,623	73,671
Barge and boat	7,922	90	145	--	305	--	450
Unspecified[2]	462	--	34	--	74	5	113
Total	20,937	339	23,159	623	50,435	3,662	[3] [4]77,881
1985:							
Railroad	9,089	89	1,079	1	3,464	75	4,619
Truck	4,073	185	22,885	554	48,536	3,474	75,449
Barge and boat	7,866	89	472	--	158	--	630
Unspecified[2]	520	--	6	--	36	4	46
Total	21,548	363	24,442	555	52,194	3,553	[3]80,744

[1]Includes Puerto Rico.
[2]Includes cement used at plant.
[3]Bulk shipments were 94.5%, and container (bag) shipments were 5.5%.
[4]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Cement consumption in the United States, excluding Puerto Rico, increased 4.0% to 87.5 million tons. Domestic producers' shipments increased 4% to 83.0 million tons, which included 5.5 million tons of imported cement. Additional imports of 4.0 million tons were shipped by other importers.

Domestic cement shipments to all regions of the United States increased except for the South. The Northeast region registered the largest increase, 12%, followed by the West, 7%, and the North Central, 3%.

The end-use distribution pattern for portland cement did not differ significantly from that of recent years. Ready-mixed concrete producers were the primary consumers, accounting for 70% of the total quantity shipped by domestic producers. Manufacturers of concrete products used 12% of the total to produce concrete blocks, pipes, and precast, prestressed, and other concrete products. The remainder was used by highway contractors; building contractors; cement dealers; Federal, State, and other government agencies; and other miscellaneous users.

According to the U.S. Department of Commerce, the value of U.S. construction put in place increased 10% to $343 billion.[2] Of this total value, 33% was in private housing; 26% was in private industrial and commercial buildings, including farms; 6% was in public buildings; 6% was in highways and streets; and the remainder was in other public construction and public utilities.

Total value of private construction put in place increased 9% to $281 billion. The value of residential units put in place increased slightly to $148 billion and that of industrial-commercial construction put in place increased 19% to $88 billion. Total value of public construction put in place increased 5% to $58 billion; of which, the value of public buildings increased 13% to $20 billion, highway construction increased 23% to $20 billion, and other public construction remained essentially unchanged at $14 billion, with military facilities and conservation and development areas accounting for the balance.

Housing starts were essentially unchanged at 1.74 million units, consisting of 1.07 million single units and 668,000 multiunits, according to the U.S. Department of Commerce. On a regional basis, housing starts decreased 15% in the South to 734,000 units, increased 15% in the Northeast to 194,000 units, increased slightly in the West to 401,000 units, and decreased 7% in the North Central region to 206,000 units.

Table 11.—Portland cement shipped by producers in the United States, by district[1]

District	1984			1985		
	Quantity (thousand short tons)	Value (thousands)	Average per ton	Quantity (thousand short tons)	Value (thousands)	Average per ton
New York and Maine	3,263	$163,527	$50.12	3,639	$175,255	$48.16
Pennsylvania, eastern	4,427	224,707	50.76	4,272	236,159	55.28
Pennsylvania, western	1,308	56,882	43.49	1,263	51,310	40.62
Maryland, Virginia, West Virginia	3,412	167,064	48.96	3,399	170,949	50.29
Ohio	1,525	69,810	45.78	1,769	84,929	48.00
Michigan and Wisconsin	4,610	208,232	45.17	4,695	207,137	44.11
Indiana and Kentucky	2,351	96,039	40.85	2,389	102,499	42.90
Illinois	1,997	82,622	41.37	2,101	86,211	41.03
Georgia and Tennessee	2,183	102,569	46.99	2,162	101,784	47.07
South Carolina	2,319	103,891	44.80	2,207	104,705	47.44
Florida	3,564	172,548	48.41	3,282	148,908	45.37
Alabama	3,656	167,191	45.73	3,721	165,972	44.60
Arkansas, Louisiana, Mississippi	2,303	119,651	51.95	2,133	111,026	52.05
South Dakota	619	30,773	49.71	655	32,774	50.03
Iowa	1,730	92,699	53.58	1,618	77,890	48.13
Missouri	3,981	178,225	44.77	3,669	159,757	43.54
Kansas and Nebraska	2,689	145,717	54.19	2,550	138,462	54.29
Oklahoma	1,732	84,701	48.90	1,589	72,583	45.67
Texas, northern	5,029	300,613	59.78	5,287	305,355	57.75
Texas, southern	5,394	256,808	47.61	4,955	227,704	45.97
Idaho, Montana, Utah	1,724	94,469	54.80	1,743	97,943	56.19
Colorado and Wyoming	1,738	109,780	63.16	1,582	100,832	63.73
Alaska, Oregon, Washington	1,711	94,916	55.47	1,700	94,159	55.38
Arizona, Nevada, New Mexico	2,209	148,704	67.32	2,192	145,476	66.36
California, northern	2,507	149,566	59.66	2,595	158,656	61.13
California, southern	6,208	370,460	59.67	6,868	442,850	64.48
Hawaii	186	18,282	98.29	215	16,050	74.65
Total[2] [3] or average	74,376	3,810,446	51.23	74,250	3,817,335	51.41
Foreign imports[4]	2,509	121,935	48.60	5,532	252,480	45.64
Puerto Rico	997	87,568	87.83	962	72,602	75.47
Grand total[3] or average	77,881	4,019,948	51.62	80,744	4,142,417	51.30

[1]Includes Puerto Rico. Includes data for three white cement facilities as follows: California (1), Pennsylvania (1), and Texas (1). Includes data for grinding plants (13 in 1984 and 11 in 1985) as follows: Alaska (1), Florida (1 in 1984 and 2 in 1985), Michigan (2 in 1984 and 1 in 1985), New York (1), Pennsylvania (2 in 1984 and 1 in 1985), Texas (4 in 1984 and 3 in 1985) and Wisconsin (2).

[2]Includes cement produced from imported clinker.

[3]Data may not add to totals shown because of independent rounding.

[4]Cement imported and distributed by domestic producers only.

Table 12.—Masonry cement shipped by producers in the United States,[1] by district

District	1984			1985		
	Quantity (thousand short tons)	Value (thousands)	Average per ton	Quantity (thousand short tons)	Value (thousands)	Average per ton
New York and Maine	78	$5,086	$65.21	76	$5,074	$66.76
Pennsylvania, eastern	226	14,779	65.39	230	15,006	65.24
Pennsylvania, western	71	6,069	85.48	74	5,964	80.59
Maryland, Virginia, West Virginia	273	16,912	61.95	285	15,424	54.11
Ohio	101	8,092	80.12	110	10,412	94.65
Michigan and Wisconsin	216	14,264	66.04	211	13,771	65.26
Indiana and Kentucky	383	21,965	57.35	396	27,994	70.69
Illinois	W	W	W	W	W	W
Georgia and Tennessee	174	12,165	69.91	192	13,152	68.50
South Carolina	W	W	W	W	W	W
Florida	383	24,624	64.29	316	17,137	54.23
Alabama	259	17,247	66.59	268	18,113	67.58
Arkansas, Louisiana, Mississippi	104	6,738	64.79	80	4,803	60.03
South Dakota	5	283	56.60	4	W	W
Iowa	42	3,260	77.62	39	3,372	86.46
Missouri	143	7,033	49.18	139	6,630	47.69
Kansas and Nebraska	70	4,244	60.63	57	3,716	65.19
Oklahoma	49	3,506	71.55	43	2,854	66.37
Texas, northern	202	16,905	83.69	187	15,965	85.37
Texas, southern	89	7,503	84.30	76	6,149	80.91
Idaho, Montana, Utah	6	416	69.33	5	361	72.20
Colorado and Wyoming	W	W	W	W	W	W
Alaska, Oregon, Washington	W	W	W	W	W	W
Arizona, Nevada, New Mexico	94	7,013	74.61	99	7,468	75.43
California, northern	--	--	--	W	W	W
California, southern	W	W	W	W	W	W
Hawaii	5	792	158.40	7	588	84.00
Other	310	20,980	67.68	293	19,143	65.33
Total[2] or average	3,281	219,877	67.02	3,187	213,096	66.86
Foreign imports[3]	([4])	1	75.62	62	3,488	56.25
Grand total[2] or average	3,281	219,878	67.02	3,250	216,584	66.64

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Does not include quantities produced on the job by masons.
[2]Data may not add to totals shown because of independent rounding.
[3]Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing company proprietary data.
[4]Less than 1/2 unit.

Table 13.—Cement shipments, by destination and origin[1]

(Thousand short tons)

Destination and origin	Portland cement[2]			Masonry cement		
	1983	1984	1985	1983	1984	1985
Destination:						
Alabama	1,088	1,204	1,306	85	94	100
Alaska[3]	180	197	156	W	W	W
Arizona	1,645	2,001	2,318	W	W	W
Arkansas	655	717	773	41	44	45
California, northern	2,608	3,166	3,439	--	W	W
California, southern	4,427	6,150	6,691	W	W	W
Colorado	1,478	1,674	1,574	26	30	23
Connecticut[3]	626	759	870	15	16	17
Delaware[3]	145	164	194	9	11	10
District of Columbia[3]	116	105	116	1	1	1
Florida	4,866	6,253	6,140	396	480	468
Georgia	2,256	2,775	2,875	189	209	228
Hawaii	216	186	214	6	5	7
Idaho	268	276	236	1	1	1
Illinois	1,053	1,236	1,391	28	31	28
Chicago, metropolitan[3]	1,188	1,378	1,333	36	41	45
Indiana	1,148	1,248	1,353	68	76	76
Iowa	1,147	1,204	1,078	12	14	11
Kansas	983	1,243	1,293	21	23	20
Kentucky	813	973	1,014	76	81	78
Louisiana	2,490	2,650	2,420	74	80	65
Maine	223	265	283	8	10	10
Maryland	1,266	1,351	1,503	113	129	139
Massachusetts[3]	1,077	1,292	1,395	34	44	45
Michigan	1,457	1,903	2,103	70	90	104
Minnesota[3]	1,124	1,173	1,419	38	40	40

See footnotes at end of table.

Table 13.—Cement shipments, by destination and origin[1] —Continued

(Thousand short tons)

Destination and origin	Portland cement[2]			Masonry cement		
	1983	1984	1985	1983	1984	1985
Destination —Continued						
Mississippi	716	790	758	51	60	57
Missouri	1,383	1,650	1,735	37	48	39
Montana	264	252	190	2	2	1
Nebraska	715	823	783	11	12	11
Nevada	459	503	637	--	--	(4)
New Hampshire[3]	260	314	374	8	15	15
New Jersey[3]	1,337	1,672	1,743	56	68	78
New Mexico	598	618	620	12	10	10
New York, eastern	366	488	621	22	31	36
New York, western	746	773	812	36	40	43
New York, metropolitan[3]	1,312	1,403	1,722	51	50	50
North Carolina	1,472	1,724	1,796	196	224	238
North Dakota[3]	317	346	286	6	6	5
Ohio	2,311	2,607	2,646	116	129	135
Oklahoma	1,758	1,751	1,329	66	60	40
Oregon	553	609	709	1	(4)	(4)
Pennsylvania, eastern	1,481	1,649	1,774	54	57	63
Pennsylvania, western	828	920	1,118	54	60	70
Rhode Island[3]	147	197	165	3	5	4
South Carolina	858	984	1,019	106	116	119
South Dakota	274	224	292	4	4	4
Tennessee	1,207	1,371	1,480	127	142	154
Texas, northern	4,936	5,466	5,474	171	182	171
Texas, southern	5,138	5,584	5,433	114	123	101
Utah	792	973	1,059	1	1	2
Vermont[3]	133	145	212	4	4	4
Virginia	1,646	1,946	2,116	147	166	177
Washington	1,077	1,156	1,208	6	7	6
West Virginia	444	445	387	29	29	29
Wisconsin	1,247	1,418	1,240	36	40	39
Wyoming	380	394	413	2	2	2
U.S. total	69,698	80,738	83,638	2,876	3,243	3,264
Foreign countries[5]	231	190	177	91	103	108
Puerto Rico	920	1,000	962	--	--	--
Total shipments[6]	70,849	81,928	84,778	2,967	3,346	3,373
Origin:						
United States[7]	67,183	74,376	74,250	2,921	3,281	3,187
Puerto Rico	931	997	962	--	--	--
Foreign:[8]						
Domestic producers	827	2,509	5,532	2	(4)	62
Others	1,908	4,046	4,034	44	65	124
Total shipments[6]	70,849	81,928	84,778	2,967	3,346	3,373

W Withheld to avoid disclosing company proprietary data; included with "Foreign countries."

[1]Includes cement produced from imported clinker and imported cement shipped by domestic producers, Canadian cement manufacturers, and other importers. Includes Puerto Rico.

[2]Excludes cement (1983—211,000 tons; 1984—225,000 tons; and 1985—253,000 tons) used in the manufacture of prepared masonry cement.

[3]Has no cement producing plants.

[4]Less than 1/2 unit.

[5]Direct shipments by producers to foreign countries and U.S. possessions and territories; includes States indicated by symbol W.

[6]Data may not add totals shown because of independent rounding.

[7]Includes cement produced from imported clinker by domestic producers.

[8]Imported cement distributed by domestic producers, Canadian cement manufacturers, and other importers. Origin of imports withheld to avoid disclosing company proprietary data.

Table 14.—Cement shipments,[1] by region and subregion

Region and subregion[2]	Portland cement: Thousand short tons 1984	Portland cement: Thousand short tons 1985	Portland cement: Percent of grand total 1984	Portland cement: Percent of grand total 1985	Masonry cement: Thousand short tons 1984	Masonry cement: Thousand short tons 1985	Masonry cement: Percent of grand total 1984	Masonry cement: Percent of grand total 1985
Northeast:								
New England	2,972	3,299	3.7	4.0	94	96	2.9	2.9
Middle Atlantic	6,905	7,790	8.5	9.3	306	340	9.4	10.4
Total	9,877	11,089	12.2	13.3	400	436	12.3	13.3
South:								
Atlantic	15,747	16,148	19.5	19.3	1,365	1,409	42.1	43.2
East Central	4,338	4,558	5.4	5.5	377	389	11.6	11.9
West Central	16,168	15,429	20.0	18.4	489	423	15.1	13.0
Total	36,253	36,135	44.9	43.2	2,231	2,221	68.8	68.1
North Central:								
East	9,790	10,067	12.1	12.0	407	427	12.6	13.1
West	6,663	6,886	8.3	8.2	147	129	4.5	3.9
Total	16,453	16,953	20.4	20.2	554	556	17.1	17.0
West:								
Mountain	6,691	7,046	8.3	8.4	46	39	1.4	1.2
Pacific	11,464	12,417	14.2	14.9	12	13	.4	.4
Total[3]	18,155	19,463	22.5	23.3	58	52	1.8	1.6
Grand total[4]	80,738	83,638	100.0	100.0	3,243	3,264	100.0	100.0

[1]Includes imported cement shipped by domestic and Canadian cement manufacturers and other importers.
[2]Geographic regions as designated by the U.S. Department of Commerce, Bureau of the Census.
[3]Does not include proprietary data from table 13.
[4]Data may not add to totals shown because of independent rounding.

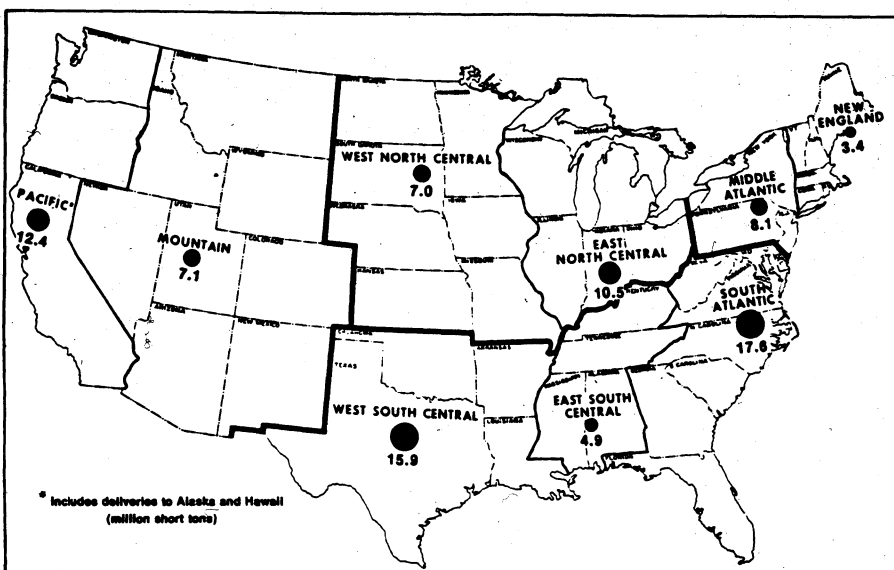

Figure 1.—Shipments of cement by geographic region of destination in 1985.

Table 15.—Portland cement shipments in 1985, by district of origin and type of customer[1]

District of origin	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State, and other government agencies		Miscellaneous including own use		Total[2] (thousand short tons)
	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	Quantity (thousand short tons)	Percent	
New York and Maine	226	6.2	559	15.4	2,517	69.2	198	5.4	120	3.3	1	--	20	.5	3,639
Pennsylvania, eastern	377	8.8	1,072	25.1	2,692	63.0	38	.9	30	.7	([3])	--	63	1.5	4,272
Pennsylvania, western	227	18.0	214	16.9	703	55.6	72	5.7	48	3.8	--	--	--	--	1,263
Maryland, Virginia, West Virginia	177	5.2	599	17.6	2,395	70.5	72	2.1	78	2.3	40	1.2	30	1.1	3,399
Ohio	134	7.5	270	15.2	1,244	70.3	115	6.5	6	.3	--	--	1	.1	1,769
Michigan and Wisconsin	148	3.2	619	13.2	3,581	76.3	235	5.0	88	1.9	7	.1	16	.3	4,695
Indiana and Kentucky	129	5.4	332	13.9	1,724	72.2	123	5.2	37	1.5	--	--	44	1.8	2,389
Illinois	66	3.1	202	9.6	1,647	78.4	102	4.9	51	2.4	--	--	33	1.6	2,101
Georgia and Tennessee	166	7.7	561	25.9	1,274	59.0	31	1.4	119	5.5	2	.1	8	.4	2,162
South Carolina	57	2.6	386	17.5	1,662	75.3	23	1.0	52	2.4	3	.1	25	1.1	2,207
Florida	425	13.0	395	12.0	2,232	68.0	81	2.5	101	3.1	14	.4	32	1.0	3,282
Alabama	328	8.8	545	14.7	2,481	66.7	187	5.0	91	2.4	19	.5	70	1.9	3,721
Arkansas, Louisiana, Mississippi	134	6.3	200	9.4	1,223	57.3	115	5.4	301	14.1	14	.7	145	6.8	2,133
South Dakota	9	1.3	28	4.3	347	52.9	136	20.8	12	1.8	--	--	124	18.9	655
Iowa	53	3.3	295	18.2	963	59.5	277	17.1	8	.5	6	.4	16	1.0	1,618
Missouri	104	2.8	377	10.3	2,813	76.6	221	6.0	76	2.1	--	--	79	2.2	3,669
Kansas and Nebraska	63	2.5	136	5.3	1,756	68.9	283	11.1	271	10.6	1	--	42	1.6	2,550
Oklahoma	48	3.0	70	4.4	1,103	69.4	148	9.3	192	12.1	2	.1	25	1.6	1,589
Texas, northern	314	5.9	410	7.8	2,710	51.3	394	7.4	1,239	23.4	98	1.9	122	2.3	5,287
Texas, southern	277	5.6	468	9.4	3,245	65.5	266	5.4	619	12.5	22	.4	58	1.2	4,955
Idaho, Montana, Utah	52	3.0	130	7.5	1,085	62.2	179	10.3	268	15.4	--	--	28	1.6	1,743
Colorado and Wyoming	46	2.9	173	10.9	1,156	73.1	144	9.1	58	3.7	--	--	5	.3	1,582
Alaska, Oregon, Washington	35	2.1	113	6.6	1,320	77.7	158	9.3	32	1.9	--	--	41	2.4	1,700
Arizona, Nevada, New Mexico	79	3.6	354	16.1	1,456	66.4	45	2.1	239	10.9	2	.1	17	.8	2,192
California, northern	163	6.3	298	11.5	2,007	77.4	27	1.0	75	2.9	7	.2	18	.7	2,595
California, southern	439	6.4	883	12.9	5,060	73.6	12	.2	387	5.6	17	.2	68	1.0	6,868
Hawaii	14	6.5	30	14.0	152	70.7	2	.9	11	5.1	2	.9	4	1.9	215
Foreign imports[4]	73	2.0	52	1.5	5,402	96.3	3	.1	--	--	--	--	3	.1	5,532
Total[2] or average	4,863	5.5	9,771	12.2	55,950	70.1	3,687	4.6	4,609	5.8	257	.3	1,145	1.5	79,781
Puerto Rico	467	48.5	44	4.6	430	44.7	--	--	18	1.9	2	.2	1	.1	962

[1]Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing company proprietary data.

Table 16.—Portland cement shipped from plants in the United States,[1] by type

Type	1984 Quantity (thousand short tons)	1984 Value[2] (thousands)	1984 Average per ton	1985 Quantity (thousand short tons)	1985 Value[2] (thousands)	1985 Average per ton
General use and moderate heat (Types I and II)	70,648	$3,576,736	$50.63	73,700	$3,699,651	$50.20
High-early-strength (Type III)	2,505	136,375	54.44	2,772	151,104	54.51
Sulfate-resisting (Type V)	479	25,633	53.51	373	22,645	60.71
Oil well	2,273	133,760	58.85	1,942	113,773	58.58
White	278	46,987	169.02	311	53,756	172.85
Portland slag and portland pozzolan	808	43,960	54.41	802	44,210	55.12
Expansive	50	3,909	78.18	35	3,380	96.57
Miscellaneous[3]	839	52,588	62.68	810	53,898	66.54
Total[4] or average	77,881	4,019,948	51.62	80,744	4,142,417	51.30

[1]Includes Puerto Rico.
[2]Mill value is the actual value of sales to customers, f.o.b. plant, less all discounts and allowances, less all freight charges to customer, less all freight charges from producing plant to distribution terminal if any, less total cost of operating terminal if any, less cost of paper bags and pallets.
[3]Includes waterproof, low-heat (Type IV), and regulated fast-setting cement.
[4]Data may not add to totals shown because of independent rounding.

PRICES

The average reported unit mill value of all types of portland cement decreased slightly. The average reported unit mill value of masonry cement prepared at cement plants decreased slightly, following 4 consecutive years of increases.

According to Engineering News-Record (ENR), yearend prices of bulk portland cement for 20 U.S. cities averaged $64.98 per ton.[3] This was 25% above the average reported mill value obtained from the Bureau of Mines canvass of cement producers. The lowest ENR quotation was $55.00 per ton for New Orleans, LA, and the highest was $78.78 per ton for Boston, MA.

Table 17.—Average mill value, in bulk, of cement in the United States[1]

(Per short ton)

Year	Portland cement	Prepared masonry cement[2]	All classes of cement
1981	$52.20	$59.29	$52.46
1982	51.04	61.56	51.43
1983	49.89	63.74	50.45
1984	51.62	67.02	52.24
1985	51.30	66.64	51.87

[1]Includes Puerto Rico. Mill value is the actual value of sales to customers, f.o.b. plant, less all discounts and allowances, less all freight charges from producing plant to distribution terminal if any, less total cost of operating terminal if any, less cost of paper bags and pallets.
[2]Masonry cement made at cement plants only.

FOREIGN TRADE

According to trade data reported by the U.S. Department of Commerce, Bureau of the Census, the United States and its possessions and territories experienced the most dramatic increase in imports ever recorded. Imports of hydraulic cement and clinker increased 64% to a record-high level of 14.5 million tons. Canada and Spain supplied 23% each of the total, followed by Mexico, 17%; Venezuela, 11%; Japan, 8%; and 28 other countries, 18%. Cement imports accounted for about 16% of U.S. apparent consumption.

Imports of white nonstaining portland cement increased 9% to 274,000 tons. Four countries, Canada, Denmark, Mexico, and Spain, accounted for the major portion of cement imports.

Imports of clinker increased 109% to 4.6 million tons. In decreasing order, Spain, Canada, and Mexico collectively accounted for 64% of clinker imports.

Growing competition among foreign cement producers for a larger share of the U.S. market caused a flurry of domestic activity including (1) the construction of new or modification of existing import terminals, (2) the introduction of floating silo ships, (3) the idling of clinker production capacity in favor of imported clinker, and (4) the initiation of direct negotiations between foreign suppliers and domestic consumers. Among the more notable developments were (1) the formation of two lobbying organizations—the American Cement Trade Alliance (ACTA) and the Cement Free Trade Association (CFTA)—and (2) the initiation of the Cement Competitive Assessment study by the U.S. Department of Commerce.

ACTA was formed by 18 cement producers to seek Government action to deal with what it termed the adverse impact that unfairly priced or governmentally subsidized imported cement has on the U.S. cement industry. CFTA, on the other hand, was composed of five independent importers with the objective of discouraging the adoption of Federal legislation or other protectionist policies that might curtail cement imports.

The U.S. Department of Commerce Cement Competitive Assessment study focused primarily on problems and issues encountered by the U.S. cement industry during the last 15 years. The study examined cement imports or other aspects of world trade only to determine their affect on domestic supplies and prices.

Other pertinent developments with regard to foreign trade include the following:

1. Apple Valley Red-e-Mix of Minneapolis, MN, imported Spanish cement into the port of New Orleans where it was off-loaded and barged up the Mississippi River to Minneapolis.

2. Eastern Cement Corp. continued work on its 48,000-ton import terminal at Port Monatee, FL.

3. Essex Cement Co., Newark, NJ, began importing cement from Greece at its 30,000-ton import terminal. The terminal is owned jointly by a local ready-mix producer and Italian interests.

4. Falcon Pacific, a subsidiary of Saudi Research and Development Corp. of Paris, France, anchored its 75,000-ton silo ship at the Port of Los Angeles. The ship was to be continually supplied by feeder vessels.

5. Gulf Portland Cement opened a new import terminal at Port Sutton in Tampa, FL. The terminal consists of three storage silos with a capacity of 13,000 tons.

6. Lone Star Industries acquired 50% interest in the Falcon Cement Co. import terminal constructed in 1984 by the Saudi Arabian firm, Redec International, to import cement from Spain into the Houston area. The new partnership was called Lone Star-Falcon.

7. Norval Inc. of Long Island, NY, opened a new 30,000-ton import terminal at the Port of Philadelphia.

8. Tampa Cement Inc. opened an import terminal at Port Sutton in Tampa, FL. The four storage silo, 30,000-ton capacity terminal is owned by UMAR International, a Delaware corporation that is in turn owned by Spanish shareholers.

Exports of hydraulic cement and clinker increased 22% to 98,000 tons, the first increase following 3 consecutive years of decline. Canada continued to be the principal recipient of U.S. cement exports receiving 91% of the total, followed by Mexico with 4%. The remaining 5% was shipped to 41 other countries.

Table 18.—U.S. exports of hydraulic cement and cement clinker, by country

Country	1983		1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Bahamas	220	$43	118	$31	479	$46
Canada	106,011	12,183	72,409	10,704	88,626	18,735
Egypt	(1)	(1)	1	1	1,314	121
Korea, Republic of	18	20	13	12	151	67
Malagasy Republic	18	16	--	--	2,010	281
Mexico	6,121	2,921	3,464	1,525	3,903	1,477
Norway	95	55	132	77	151	90
Panama	80	61	6	11	479	46
Trinidad	1,489	230	2,002	247	520	61
Venezuela	912	167	33	93	114	128
Other[2]	r3,429	r1,664	r1,829	r795	150	426
Total	118,393	17,360	80,007	13,496	97,897	21,478

rRevised.
[1]Less than 1/2 unit.
[2]Includes 40 countries in 1983, 52 in 1984, and 33 in 1985.

Source: Bureau of the Census, U.S. Department of Commerce.

Table 19.—U.S. imports for consumption of hydraulic cement and clinker, by country

(Thousand short tons and thousand dollars)

Country	1983			1984			1985		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Canada	2,201	86,198	92,851	2,945	116,815	128,920	3,393	131,117	145,005
Colombia	68	3,345	4,169	227	5,133	6,927	662	16,430	20,244
France	153	6,435	7,507	225	7,044	9,180	552	13,866	18,319
Greece	--	--	--	--	--	--	511	9,760	12,202
Japan	(2)	100	118	183	5,237	7,595	1,134	28,786	37,105
Korea, Republic of	69	3,228	4,144	332	10,046	12,129	484	26,194	29,738
Mexico	826	30,844	33,539	2,003	64,574	74,877	2,502	75,755	87,339
Spain	737	23,833	29,303	1,760	49,584	61,218	3,383	80,448	103,353
Venezuela	60	1,705	2,138	1,022	25,281	32,224	1,569	38,282	50,320
Other	154	5,751	7,756	149	10,493	10,412	298	16,791	20,148
Total	4,268	161,439	181,525	8,846	294,207	343,482	[3]14,487	437,429	523,773

[1]Cost, insurance, and freight.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census, U.S. Department of Commerce.

Table 20.—U.S. imports for consumption of clinker, by country

(Thousand short tons and thousand dollars)

Country	1983			1984			1985		
	Quantity	Value		Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Canada	446	14,786	16,534	485	16,947	19,406	746	22,156	25,763
France	152	6,389	7,439	225	7,491	9,180	414	9,434	11,789
Greece	--	--	--	--	--	--	407	7,900	9,390
Japan	--	--	--	69	2,927	2,693	291	6,397	7,840
Mexico	192	6,899	7,373	477	11,608	13,077	581	14,671	16,387
Spain	214	5,559	6,437	523	11,885	14,860	1,656	31,877	39,917
Venezuela	--	--	--	294	5,623	7,484	290	5,570	7,022
Other	--	--	--	r141	r3,319	r3,935	248	5,062	6,305
Total[2]	1,005	33,633	37,784	2,215	59,801	70,635	4,633	103,067	124,413

rRevised.
[1]Cost, insurance, and freight.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census, U.S. Department of Commerce.

Table 21.—U.S. imports for consumption of hydraulic cement and clinker, by customs district and country

(Thousand short tons and thousand dollars)

Customs district and country	1984			1985		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Anchorage:						
Canada	82	4,839	5,607	40	2,441	3,212
Japan	--	--	--	46	957	1,374
Korea, Republic of	--	--	--	49	1,984	2,766
Singapore	--	--	--	4	277	433
Total	82	4,839	5,607	139	5,659	7,785
Baltimore:						
Denmark	6	444	831	--	--	--
Japan	(2)	17	23	(2)	16	23
Mexico	--	--	--	6	179	219
Netherlands	(2)	2	2	(2)	26	28

See footnotes at end of table.

Table 21.—U.S. imports for consumption of hydraulic cement and clinker, by customs district and country —Continued

(Thousand short tons and thousand dollars)

Customs district and country	1984			1985		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Baltimore —Continued						
Spain	--	--	--	105	2,836	3,824
Venezuela	--	--	--	84	1,055	1,377
Total[3]	6	463	856	196	4,112	5,471
Boston:						
Belgium-Luxembourg	--	--	--	(2)	12	15
Canada	10	320	335	60	1,819	1,855
Spain	--	--	--	89	2,152	2,236
Venezuela	--	--	--	6	170	225
Total	10	320	335	155	4,153	4,331
Bridgeport: Canada	1	22	22	--	--	--
Buffalo: Canada	713	27,643	30,438	911	31,909	34,299
Charleston:						
France	--	--	--	(2)	17	20
Germany, Federal Republic of	--	--	--	(2)	6	7
Spain	--	--	--	130	2,449	3,240
Venezuela	--	--	--	29	499	532
Total[3]	--	--	--	160	2,971	3,799
Chicago:						
Belgium-Luxembourg	(2)	10	11	--	--	--
Canada	--	--	--	(2)	1	1
German Democratic Republic	--	--	--	(2)	2	3
Germany, Federal Republic of	(2)	15	20	(2)	43	57
Japan	(2)	1	1	(2)	6	9
Yugoslavia	(2)	5	7	(2)	9	16
Total	(2)	31	39	(2)	61	86
Cleveland: Yugoslavia	(2)	4	8	--	--	--
Detroit:						
Belgium-Luxembourg	(2)	6	7	--	--	--
Canada	293	18,588	19,243	477	20,901	22,268
Netherlands	(2)	7	9	--	--	--
Total	293	18,601	19,259	477	20,901	22,268
Duluth: Canada	156	5,077	6,312	184	5,936	7,429
El Paso:						
Canada	--	--	--	(2)	16	16
Mexico	318	11,683	11,683	541	18,653	18,653
Total	318	11,683	11,683	541	18,669	18,669
Great Falls:						
Canada	2	130	130	(2)	61	61
Germany, Federal Republic of	--	--	--	(2)	35	49
Total	2	130	130	(2)	96	110
Honolulu:						
Japan	6	341	511	--	--	--
Korea, Republic of	18	1,604	1,714	52	4,600	5,035
Total	24	1,945	2,225	52	4,600	5,035
Houston:						
Canada	--	--	--	9	320	459
Colombia	42	830	1,316	112	1,961	2,493
Germany, Federal Republic of	(2)	62	76	(2)	135	169
Greece	--	--	--	29	711	1,108
Italy	29	964	985	--	--	--
Mexico	124	2,654	3,250	--	--	--
Netherlands	--	--	--	(2)	10	13
Spain	230	5,987	6,767	518	11,887	13,937
Venezuela	--	--	--	22	668	775
Yugoslavia	(2)	80	126	1	43	59
Total[3]	425	10,577	12,520	692	15,735	19,013

See footnotes at end of table.

Table 21.—U.S. imports for consumption of hydraulic cement and clinker, by customs district and country —Continued

(Thousand short tons and thousand dollars)

Customs district and country	1984			1985		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Laredo:						
Canada	(2)	1	1	--	--	--
Mexico	88	3,210	3,210	68	2,368	2,328
Venezuela	1	5	5	--	--	--
Yugoslavia	(2)	51	90	--	--	--
Total	89	3,267	3,306	68	2,368	2,328
Los Angeles:						
Denmark	--	--	--	9	662	1,032
France	--	--	--	3	16	19
Germany, Federal Republic of	(2)	10	15	--	--	--
Japan	24	631	775	344	9,002	10,543
Korea, Republic of	243	6,550	8,027	294	17,346	19,216
Mexico	--	--	--	(2)	3	3
Spain	107	2,823	3,764	256	6,288	8,973
Taiwan	--	--	--	(2)	17	31
Yugoslavia	1	81	198	2	199	384
Total[3]	375	10,095	12,779	909	33,533	40,201
Miami:						
Bahamas	2	68	90	8	219	246
Bahrain	--	--	--	4	115	129
Barbados	--	--	--	4	129	143
Belgium-Luxembourg	3	220	1,671	2	101	186
Colombia	--	--	--	23	616	778
Costa Rica	--	--	--	(2)	10	11
Mexico	279	8,460	10,876	333	9,841	12,513
Spain	284	7,257	9,583	272	7,295	9,455
Venezuela	230	5,984	7,362	579	14,338	18,814
Total	798	21,989	29,582	1,225	32,664	42,275
Milwaukee: Canada	93	2,844	3,159	--	--	--
Mobile:						
Canada	(2)	3	3	--	--	--
Greece	--	--	--	228	3,956	5,329
Spain	78	1,725	2,464	681	11,811	16,141
Venezuela	104	1,778	2,672	59	1,011	1,359
Total	182	3,506	5,139	968	16,778	22,829
New Orleans:						
Belgium-Luxembourg	--	--	--	(2)	16	19
Canada	182	8,151	11,084	214	9,682	13,251
Colombia	16	301	506	--	--	--
France	76	1,727	2,383	394	9,572	13,172
Guatemala	--	--	--	(2)	3	6
Mexico	216	4,780	6,033	9	228	342
Spain	65	2,029	2,620	151	3,636	5,767
Venezuela	81	2,001	2,780	197	4,243	6,079
Total	636	18,989	25,406	965	27,380	38,636
New York City:						
Canada	44	1,406	1,587	139	2,366	3,371
Colombia	--	--	--	6	126	243
France	27	447	572	--	--	--
Greece	--	--	--	64	962	1,499
Guatemala	--	--	--	35	750	900
Italy	(2)	4	6	26	530	541
Norway	--	--	--	46	1,753	3,981
Spain	413	12,010	14,994	576	16,625	20,877
Venezuela	131	2,449	2,914	66	1,120	1,549
Total	615	16,316	20,073	958	24,232	32,961
Nogales: Mexico	157	7,097	7,361	314	12,149	12,149
Norfolk:						
Canada	(2)	3	3	--	--	--
France	28	3,001	3,475	20	1,723	1,781
Germany, Federal Republic of	--	--	--	(2)	9	12

See footnotes at end of table.

Table 21.—U.S. imports for consumption of hydraulic cement and clinker, by customs district and country —Continued

(Thousand short tons and thousand dollars)

Customs district and country	1984 Quantity	1984 Value Customs	1984 Value C.i.f.[1]	1985 Quantity	1985 Value Customs	1985 Value C.i.f.[1]
Norfolk —Continued						
Namibia	--	--	--	8	218	281
Spain	--	--	--	55	1,573	1,833
Venezuela	28	732	979	78	1,879	2,419
Total	56	3,736	4,457	161	5,402	6,326
Ogdensburg: Canada	415	13,168	13,178	343	12,456	12,492
Pembina: Canada	65	3,390	3,390	48	2,242	2,246
Philadelphia:						
Germany, Federal Republic of	(2)	3	7	--	--	--
Korea, Republic of	--	--	--	22	880	930
Total[3]	(2)	3	7	22	880	930
Port Arthur:						
Colombia	20	345	462	--	--	--
Greece	--	--	--	179	3,945	4,061
Spain	--	--	--	6	409	586
Venezuela	--	--	--	20	476	590
Total[3]	20	345	462	205	4,830	5,238
Portland, ME: Canada	21	763	763	6	278	278
Portland, OR:						
Canada	42	1,695	1,857	11	607	659
Japan	(2)	40	42	51	1,178	2,011
Korea, Republic of	--	--	--	19	489	625
Total[3]	42	1,735	1,899	81	2,274	3,296
Providence:						
Bahamas	--	--	--	4	109	165
Canada	4	107	358	--	--	--
Venezuela	10	413	687	55	1,383	2,115
Total[3]	14	520	1,045	59	1,492	2,281
St. Albans: Canada	571	18,101	18,139	548	18,007	18,007
San Diego:						
Colombia	40	652	462	--	--	--
Japan	94	2,241	3,648	308	8,333	11,254
Mexico	451	15,581	19,121	368	14,008	15,720
Venezuela	7	139	259	10	413	467
Total	592	18,613	23,490	686	22,754	27,441
San Francisco:						
Belgium-Luxembourg	--	--	--	(2)	51	86
Canada	--	--	--	34	1,295	1,447
Germany, Federal Republic of	(2)	7	9	--	--	--
Italy	--	--	--	(2)	18	23
Japan	60	2,298	2,559	157	3,597	4,446
Korea, Republic of	71	1,892	2,389	41	895	1,164
Sweden	(2)	8	10	--	--	--
Yugoslavia	--	--	--	(2)	3	6
Total[3]	131	4,205	4,967	238	5,859	7,173
San Juan, PR:						
Barbados	5	240	294	30	1,094	1,430
Belgium-Luxembourg	9	884	1,297	10	841	1,292
Brazil	1	39	45	1	70	89
Canada	1	1	1	--	--	--
Colombia	48	1,170	1,331	74	1,747	2,126
Costa Rica	19	1,039	1,261	1	15	35
Denmark	1	146	175	2	125	228
Dominican Republic	6	206	262	19	350	485
Germany, Federal Republic of	--	--	--	2	126	191
Honduras	--	--	--	3	102	157
Panama	24	231	272	6	280	305
Spain	12	598	833	98	2,780	3,184
Venezuela	8	293	447	84	2,812	3,541
Total[3]	135	4,847	6,218	329	10,342	13,063

See footnotes at end of table.

Table 21.—U.S. imports for consumption of hydraulic cement and clinker, by customs district and country —Continued

(Thousand short tons and thousand dollars)

Customs district and country	1984 Quantity	1984 Value Customs	1984 Value C.i.f.[1]	1985 Quantity	1985 Value Customs	1985 Value C.i.f.[1]
Savannah:						
Germany, Federal Republic of	(2)	5	6	--	--	--
Spain	--	--	--	37	339	390
Venezuela	10	279	347	37	1,242	1,508
Total	10	284	353	74	1,581	1,898
Seattle:						
Canada	251	10,563	11,761	368	14,839	16,239
Italy	--	--	--	(2)	1	2
Japan	(2)	22	37	227	5,696	7,446
Yugoslavia	--	--	--	(2)	8	19
Total	251	10,585	11,798	595	20,544	23,706
Tampa:						
Colombia	10	233	338	286	7,078	8,849
Costa Rica	(2)	3	3	--	--	--
Denmark	25	W	W	61	W	W
France	94	W	W	136	W	W
Germany, Federal Republic of	(2)	16	20	--	--	--
Greece	--	--	--	11	186	206
Mexico	362	10,645	12,803	862	20,328	25,340
Spain	565	17,143	19,990	401	10,176	12,701
Venezuela	414	11,884	13,620	230	6,536	8,448
Total[3]	1,469	45,691	53,345	1,987	58,631	72,760
Virgin Islands of the United States:						
Barbados	--	--	--	(2)	17	22
Colombia	2	128	129	18	814	865
Dominican Republic	4	120	142	6	229	263
Leeward and Windward Islands	7	285	441	(2)	6	9
Mexico	8	464	513	--	--	--
Panama	2	73	91	4	177	179
United Kingdom	--	--	--	(2)	7	10
Venezuela	--	--	--	10	276	320
Total	23	1,070	1,316	38	1,526	1,668
Wilmington:						
Brazil	2	72	84	--	--	--
Colombia	49	1,474	2,130	142	4,094	4,889
Spain	6	167	202	6	169	205
Venezuela	--	--	--	4	162	202
Total	57	1,713	2,416	152	4,425	5,296
Grand total[3]	8,846	294,207	343,482	14,487	437,429	523,773

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Cost, insurance, and freight.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census, U.S. Department of Commerce.

Table 22.—U.S. imports for consumption of cement and clinker

(Thousand short tons and thousand dollars)

Year	Roman, portland, other hydraulic cement		Hydraulic cement clinker		White nonstaining portland cement		Total[1]	
	Quantity	Value (customs)	Quantity	Value (customs)	Quantity	Value (customs)	Quantity	Value (customs)
1981	2,654	94,653	1,226	46,447	117	10,140	3,997	151,240
1982	2,369	81,710	470	18,385	90	10,791	2,929	110,886
1983	3,104	109,791	1,005	33,633	160	18,014	4,268	161,439
1984	6,379	204,899	2,215	59,801	252	29,507	8,846	294,207
1985	9,581	306,472	4,633	103,067	274	27,890	14,487	437,429

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census, U.S. Department of Commerce.

WORLD REVIEW

World cement production increased slightly to 1.07 billion tons. The United States accounted for 7% of world production. In order of production, China, the U.S.S.R., and Japan were the three principal producing countries and accounted for 36% of world production. The 10 largest cement producing countries accounted for 60% of the world's total. Exporting countries continued to view the United States as a primary market for their excess cement. Thirty-three countries exported cement to the United States in 1985 compared with 23 in 1984.

Rock Products' magazine report on the world cement industry described the following significant activities in cement plant construction, modernization, and expansion:[4]

Australia.—Adelaide Brighton Cement commissioned its 550,000-ton-per-year grinding plant. The new plant will serve markets in Brisbane, southern Queensland, and northern New South Wales.

Belgium.—S.A. des Cimenteries CBR completed work on its 2,870-ton-per-day clinker production line at its Antoing plant. The line included a five-stage preheater kiln with precalciner and is designed to burn low-volatile fuels.

Egypt.—Egypt continued to vigorously expand its cement production capacity by putting into operation five new kilns: a 3,600-ton-per-day kiln at Tourah Portland Cement Co., Tourah plant; one 4,900-ton-per-day and one 5,500-ton-per-day kiln at Helwan Portland Cement Co.'s Helwan and Assiut plants, respectively; a 4,900-ton-per-day kiln at National Cement Co.'s, Helwan plant; and a 4,900-ton-per-day kiln at Suez Cement Co.'s Quattamia plant.

France.—Ciments Français finished modernizing its facilities at Beaucaire by adding a five-stage preheater kiln with a precalcining system, which increased production by 3,000 tons per day. The company also added a precalciner and traveling grate cooler to the Dopol kiln system at its Bussac plant, which increased production by nearly 900 tons per day.

India.—The Indian cement industry continued its program of plant construction, modernization, and expansion. Kesoram Industry and Cotton Mills, Hyderabad, put its new 1,980-ton-per-day preheater-precalciner kiln and 150-ton-per-day raw material roller mill into operation; Cement Corp. of India added a new 3,300-ton-per-day dry-process kiln and coal grinding system to its Neemuch plant; Mysore Cements Ltd. put a new 1,650-ton-per-day dry-process plant with a five-stage preheater kiln into operation at Damoh; the Indian Rayon Corp. commissioned its 1,650-ton-per-day dry-process plant with preheater kiln at Rayon; Raymond Cement Works put into operation its expanded 4,200-ton-per-day dry-process five-stage preheater-precalciner plant; Shree Cement Ltd. commissioned its 2,000-ton-per-day Beawar plant and started up its Sikka plant, a 2,800-ton-per-day operation.

Korea, Republic of.—Halla Cement Manufacturing Co. completed work on its 1.3-million-ton-per-year dry-process preheater-precalciner plant; Hyundai Cement Co. Ltd. expanded capacity of its Danyang plant from 1.5 to 3.3 million tons per year; and Sung Shin Cement Industrial Co. Ltd. expanded the capacity of its Danyang plant from 2.8 million to 3.5 million tons per year.

South Africa, Republic of.—Pretoria Portland Cement Ltd. began operating its 660,000-ton-per-year plant at Dwaalboom, Northern Transvaal, and Blue Circle Industries upgraded its No. 6 kiln at its Lichtenburg plant in Western Transvaal, increasing its clinker capacity by 550,000 tons per year.

United Kingdom.—Blue Circle Industries 5-year program to modernize its cement manufacturing and distribution facilities was virtually complete with the conversion of its Cauldon plant at Staffordshire and the Dunbar operation in Lothian to single precalciner kiln operations.

Table 23.—Hydraulic cement: World production, by country[1]

(Thousand short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Afghanistan[2]	85	96	[r] [e]100	[r] [e]90	[3]85
Albania[e]	[r]870	[r]915	[r]925	[r]925	935
Algeria[e]	[3]4,916	[r]4,850	[r]5,300	[r]6,100	6,100
Angola[e]	276	276	243	386	386
Argentina	7,331	6,199	6,198	[r] [e]5,644	5,500
Australia	[r]6,620	6,332	5,331	6,022	6,600
Austria	5,829	5,525	5,409	5,400	5,500
Bahamas	32	71	29	([4])	--
Bangladesh[5]	380	360	338	301	[3]265
Barbados	--	--	--	[e]165	220
Belgium	7,376	6,967	6,304	6,300	5,800
Benin	327	347	[e]331	[e]331	331
Bolivia	413	358	361	360	330
Brazil	28,716	28,268	23,005	[e]27,558	29,800
Bulgaria	6,000	6,188	6,221	6,302	[3]5,749
Burma	350	379	369	343	[3]526
Cameroon	[e]569	584	672	([6])	NA
Canada	11,183	9,288	8,676	9,489	[3]10,537
Chile	2,054	1,248	1,383	1,532	1,430
China	92,594	103,697	119,325	133,468	157,100
Colombia	4,915	5,546	5,204	5,816	[3]5,859
Congo	54	43	17	([6])	NA
Costa Rica	507	467	425	[e]386	386
Cuba	3,629	3,487	3,562	3,689	[3]3,483
Cyprus	1,141	1,177	1,039	940	[3]727
Czechoslovakia	11,735	11,381	11,572	11,607	11,300
Denmark	1,766	1,951	1,827	1,839	[3]1,917
Dominican Republic	1,049	1,046	1,217	1,260	1,270
Ecuador	1,365	1,747	1,593	1,636	1,540
Egypt	3,857	4,696	6,063	[r] [e]7,200	8,600
El Salvador	505	461	476	449	440
Ethiopia[e]	143	154	165	176	176
Fiji	[r]102	97	121	108	[3]103
Finland	[r]2,001	[r]2,053	2,102	1,814	1,760
France	31,117	28,825	27,011	25,049	25,400
Gabon	165	193	132	229	230
German Democratic Republic	13,453	12,920	12,987	12,737	13,000
Germany, Federal Republic of	34,721	33,155	33,583	31,867	32,000
Ghana	437	322	[e]320	[e]320	380
Greece	[r]14,264	[r]14,176	15,648	14,904	14,900
Guadeloupe[e]	[3]176	176	176	176	176
Guatemala	567	558	498	866	870
Haiti	260	234	[e]238	[e]243	243
Honduras	343	306	535	[e]551	550
Hong Kong	1,673	1,582	1,892	2,037	[3]2,023
Hungary	5,109	4,816	4,677	4,569	[3]4,054
Iceland	134	137	127	130	[3]126
India	22,884	24,800	27,950	32,000	[3]36,431
Indonesia	7,596	8,268	9,025	9,765	11,000
Iran[e]	8,818	10,472	11,023	11,574	12,100
Iraq[e]	[3]6,173	6,173	6,173	8,818	8,818
Ireland	2,136	1,742	1,638	1,518	1,540
Israel	2,271	2,413	2,269	3,377	2,400
Italy	45,804	43,793	43,229	41,648	44,000
Ivory Coast	1,323	1,213	702	591	590
Jamaica	182	233	305	288	265
Japan	93,506	88,943	89,167	86,928	[3]80,311
Jordan	1,063	876	1,401	2,192	2,340
Kenya	[e]1,433	[e]1,433	1,411	1,283	1,200
Korea, North[e]	8,818	8,818	8,818	8,818	8,818
Korea, Republic of	17,215	19,717	23,459	22,501	[3]22,514
Kuwait	1,707	1,712	1,239	1,305	1,200
Lebanon	2,636	1,874	1,653	1,378	1,100
Liberia	95	88	94	93	105
Libya[e]	3,527	4,409	5,512	6,614	7,200
Luxembourg	377	379	389	375	350
Madagascar	39	40	[e]39	[e]39	39
Malawi	86	[r]59	78	77	70

See footnotes at end of table.

Table 23.—Hydraulic cement: World production, by country[1] —Continued

(Thousand short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Malaysia	3,123	3,443	3,573	3,824	3,600
Mali	[e]22	30	[e]22	28	28
Martinique[e]	[3]198	220	220	220	220
Mauritania	66	66	[e]66	([4])	--
Mexico	19,817	21,272	18,814	20,322	[3]22,686
Mongolia	231	386	370	386	440
Morocco	3,975	[r]4,122	4,242	3,955	[3]4,075
Mozambique	256	386	463	[e]496	496
Nepal	34	[e]28	50	43	[3]35
Netherlands	3,655	3,420	3,425	3,501	3,450
New Caledonia	55	59	[e]66	[e]66	66
New Zealand	[r]979	[r]1,175	1,054	1,113	1,200
Nicaragua[e]	[3]184	110	110	110	110
Niger[e]	[3]41	42	42	42	42
Nigeria[e]	[3]2,756	3,968	3,968	3,968	3,968
Norway	2,025	1,969	1,783	1,607	[3]1,764
Pakistan	[r]3,954	[r]4,076	5,443	5,178	[3]5,212
Panama	573	386	360	335	330
Paraguay	172	122	169	120	165
Peru	3,395	2,855	2,535	[e]2,425	2,425
Philippines[7]	4,508	4,795	4,831	4,040	3,500
Poland	15,681	17,747	17,857	18,409	[3]16,535
Portugal	6,280	6,393	6,683	6,106	6,600
Qatar	284	[r]252	413	527	527
Romania	16,255	16,529	15,397	15,653	[3]13,448
Saudi Arabia	5,219	7,885	8,957	9,921	9,900
Senegal	410	401	435	424	425
Singapore	2,484	2,971	3,476	3,110	[3]2,195
South Africa, Republic of	8,923	8,830	8,705	9,025	[3]7,754
Spain (including Canary Islands)[8]	31,693	32,594	33,771	28,038	28,100
Sri Lanka	708	[e]717	558	[e]551	660
Sudan	165	202	[e]220	194	[3]213
Suriname	78	79	82	[e]55	55
Sweden	2,555	[r]2,540	2,469	2,604	2,900
Switzerland	4,793	4,513	4,564	4,609	4,630
Syria	[r]2,553	[r]2,864	3,996	4,720	3,900
Taiwan	15,809	14,806	16,325	15,690	[3]15,893
Tanzania	[5]433	[e]441	[e]463	408	440
Thailand	6,904	7,285	8,006	9,083	9,040
Togo	314	308	256	268	310
Trinidad and Tobago	154	209	430	447	450
Tunisia	2,227	1,965	3,142	3,649	3,900
Turkey	16,582	17,392	14,986	17,348	17,600
Uganda	7	19	[r e]22	[r e]22	22
U.S.S.R	140,180	136,335	141,268	143,453	144,000
United Arab Emirates	[r]1,896	[r]2,447	2,280	4,415	4,400
United Kingdom	14,031	14,288	14,767	14,860	[3]14,709
United States (including Puerto Rico)	72,932	64,341	71,347	78,699	[3]78,859
Uruguay	818	726	442	368	330
Venezuela	5,375	5,988	4,899	[r e]5,270	5,400
Vietnam	601	[e]882	1,023	[e]1,213	1,430
Yemen (Sanaa)	90	261	661	937	940
Yugoslavia	10,781	10,712	10,573	10,268	9,950
Zaire	[r]545	596	565	583	530
Zambia	159	170	171	266	270
Zimbabwe	648	635	([4])	([4])	--
Total	[r]977,384	[r]978,362	1,010,116	1,045,468	1,071,225

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through July 8, 1986.
[2]Data are for the year beginning Mar. 21 of that stated.
[3]Reported figure.
[4]Revised to zero.
[5]Data are for the year ending June 30 of that stated.
[6]Revised to "Not available."
[7]Converted from officially reported data provided in terms of 94-pound cement bags.
[8]Excludes natural cement.

TECHNOLOGY

Cement.—Martin Engineering Co. developed a new solution to an old problem, the use of compressed-air cannons to remove material buildup in cement kiln preheaters. The technology has been used successfully for many years on silos, bunkers, and hoppers. When a quick release valve is opened, an explosive charge of compressed air is expelled into the structure. The sudden powerful release of energy into the material causes it to break away from the walls and flow freely to the kiln. Benefits of the new technology were reduced work force, increased productivity, and decreased energy consumption through improved heat transfer and air-material flow.[5]

A new high-efficiency air separator, called the Sepax, was developed by F. L. Smidth and Co. A/S. The separator was successfully tested at the Sociedad Financiera y Minera S.A. cement plant in Malaga, Spain. Test results showed a 30% increase in output and a 20% reduction in energy consumption. The excellent performance was due primarily to effective dispersion of material fed from the mill to the riser duct. The separator was designed for easy integration with different plant configurations, not only for cement grinding but also for processing other materials.[6]

Concrete.—The Bureau of Mines summarized its research on sulfur construction materials as well as related research conducted by other Government organizations and the private sector. The research activity covers three areas, sulfur concretes, sulfur spray coatings, and sulfur-extended asphalt as a paving material.[7]

Fuller International Inc., Bethlehem, PA, a cement industry equipment supplier, announced the results of its worldwide search for ideas on new ways to use cement. A total of 540 entries were received from 24 countries. The first place award for the most original idea involved the use of portland cement for reducing sulfur emissions from fossil-fuel-burning powerplants. The second place, granted for the idea closest to implementation, involved the use of portland cement as an antistripping agent in asphalt mixes.[8]

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[1]Mineral specialist, Division of Industrial Minerals.

[2]U.S. Department of Commerce, International Trade Administration. Construction Review. V. 32, No. 1, Jan.-Feb. 1986, pp. 12-21.

[3]Engineering News-Record. ENR Materials Prices. V. 216, No. 2, Jan. 9, 1986, p. 40.

[4]Rock Products. Cement International. V. 89, No. 4, Apr. 1986, pp. 39-75.

[5]Brown, B. E., and L. J. Goldbeck. Using Air Cannons on Cement Kiln Preheaters. Pit & Quarry, v. 78, No. 2, Aug. 1985, pp. 95-106.

[6]Joergensen, W. S. Develop High Efficiency Air Separator for Grinding Systems. Pit & Quarry, v. 78, No. 1, 1985, pp. CR36-CR40.

[7]McBee, W. C., T. A. Sullivan, and H. L. Fike. Sulfur Construction Materials. BuMines B. 678, 1985, p. 31.

[8]Fuller International Inc. Quest: The Worldwide Search for New Uses of Cement. Nov. 1985, p. 30.

Chromium

By John F. Papp[1]

In 1985, reported chromium consumption was 292,766 short tons, a 7% decrease from that of 1984. The reported consumption of chromium by the metallurgical and refractory industries decreased, whereas that of the chemical industry increased. Metallurgical industry production includes ferrochromium produced as part of the National Defense Stockpile (NDS) conversion program. Imports of chromite increased, those of ferrochromium decreased.

Domestic Data Coverage.—Domestic consumption of chromite by the primary consuming industries—metallurgical, refractory, and chemical—are developed by the Bureau of Mines by means of the voluntary monthly "Chromite Ores and Chromium Products" survey. The companies listed in table 3 by industry accounted for 100% of the chromite consumption data by industry in table 5. In 1985, 83% of the metallurgical companies, 100% of the refractory companies, and 67% of the chemical companies reported chromite consumption. Consumption was estimated for the remaining 17% of the metallurgical industry and 33% of the chemical industry.

Domestic production data for chromium ferroalloys and metal are developed by the Bureau of Mines by means of two separate voluntary surveys. These two surveys are the monthly "Chromite Ores and Chromium Products" and the annual "Ferroalloys." Production by the six metallurgical industry companies listed in table 3 represented 100% of domestic production shown in table 4. Eighty-three percent of those companies responded to both surveys. Production for the remaining 17% was estimated.

Table 1.—Salient chromium statistics

(Thousand short tons, gross weight)

	1981	1982	1983	1984	1985
CHROMITE					
United States:					
Exports	71	8	11	55	101
Reexports	67	57	5	4	4
Imports for consumption	898	507	190	305	414
Consumption	889	558	320	512	560
Stocks, Dec. 31: Consumer	728	r546	r456	327	300
World: Production	r10,018	r9,026	8,829	p10,312	e10,951
CHROMIUM FERROALLOYS[1]					
United States:					
Production[2]	226	119	36	95	110
Exports	14	5	4	15	10
Reexports	1	(3)	2	1	1
Imports for consumption	440	148	282	434	335
Consumption	423	262	388	395	369
Stocks, Dec. 31: Consumer	54	26	26	25	31
World: Production	r3,060	r2,612	2,774	p3,244	e3,247

eEstimated. pPreliminary. rRevised.
[1]High- and low-carbon ferrochromium plus ferrochromium-silicon.
[2]Includes chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.
[3]Less than 1/2 unit.

Legislation and Government Programs.—In accordance with the President's November 1982 directive, the General Services Administration (GSA) continued to upgrade NDS chromium ore to high-carbon ferrochromium. The GSA reported conversion of 125,628 tons of chromium ore to 50,254 tons of ferrochromium at a cost of $22.7 million in calendar year 1984 and 137,015 tons of chromium ore to 49,463 tons of ferrochromium at a cost of $22.5 million in calendar year 1985. The GSA exercised its contractual option to extend NDS upgrading into its third year.

The U.S. Congress, Office of Technology Assessment (OTA), completed a study on technologies to reduce U.S. vulnerability to chromium supply disruption. Based on criticality and extent of use, and vulnerability of supply, OTA found chromium to be a first-tier strategic material. Within the technological categories—mineral production and metal processing, conservation, and substitution—OTA identified and discussed potential benefits of and barriers to vulnerability reduction.[2] The OTA also examined the use of and potential substitution for chromium in superalloys used in defense applications.[3]

The Bureau of Mines published a directory of 45 domestic and 84 foreign chromium properties and deposits.[4] Nonconfidential data on location, reserves and resources, geology, mine and beneficiation systems, and operations were included. The Bureau analyzed the chromium industry of the U.S.S.R., a major world producer and exporter of chromite ore. The report found the U.S.S.R.'s reserves to be adequate to meet its long-term needs. It also found that both production growth and exports have declined in recent years. Salient characteristics of the Soviet chromium raw material base, mining and processing facilities, foreign trade, policies and programs, and future outlook were described.[5] The Bureau reviewed technological alternatives for the conservation of chromium. The review found that present U.S. chromium consumption could be reduced by about one-third by using available technology. Such technology could be used to substitute alternative materials and processes, to recover and recycle waste chromium, and to design for greater chromium efficiency.[6]

The Environmental Protection Agency (EPA) issued final water pollution rules requiring the petroleum refining industry to more stringently control total chromium and hexavalent chromium contained in waste water and storm water runoff from refinery property.[7] The EPA estimated that the new final rule would reduce allowable total chromium discharge by 286,000 pounds per year, and hexavalent chromium by 19,300 pounds per year. In another report, the EPA found chromium trichloride to be an acutely toxic chemical.[8]

The U.S. Department of Commerce and the Federal Emergency Management Agency published new NDS Specifications for chemical industry chromite ore and for chromium metal and new NDS Special Instructions for chromium metal.

The U.S. Department of Energy (DOE), as part of the National Uranium Resources Evaluation (NURE) program, geochemically assayed for chromium in streamwater and stream-sediment samples from throughout the continental United States and Alaska. The DOE's NURE assay data were put into a computer data base. Researchers located an outcrop of chromium-bearing rock by analyzing the NURE data base.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. Based on a study of the 42 most significant of 62 stockpiled materials, 6 of the 42 materials were allocated to tier I. Chromium was included in tier I. The current NDS chromium goal is 1.353 million tons contained chromium in the form of chemical- and metallurgical-grade ore, low- and high-carbon ferrochromium, ferrochromium-silicon, and chromium metal. Current NDS inventory is 1.276 million tons contained chromium. The proposed restructuring allocates 199,000 tons contained chromium to tier I and 594,000 tons contained chromium to tier II without specifying distribution among the numerous chromium material categories. These proposed allocations eliminate 77,000 tons contained chromium of unmet goals and 483,000 tons contained chromium of current inventory. At yearend, this proposal was under consideration by the Congress. The

Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

Table 2.—U.S. Government stockpile goals and yearend inventories for chromium in 1985

(Thousand short tons, gross weight)

Material	Stockpile goals	Physical inventory		
		Stockpile-grade	Nonstockpile-grade	Total
Chromite, metallurgical	3,200	1,943	313	2,256
Chromite, chemical	675	242	--	242
Chromite, refractory	850	391	--	391
High-carbon ferrochromium	185	452	1	453
Low-carbon ferrochromium	75	300	19	319
Ferrochromium-silicon	90	57	1	58
Chromium metal	20	4	--	4

Source: Federal Emergency Management Agency.

DOMESTIC PRODUCTION

The major marketplace products of chromium are chromium ore, alloys, chemicals, and metal. In 1985, the United States produced chromium alloys, chemicals, and metal from imported chromium ore. No chromium ore was mined domestically.

Domestic chromium resources are being developed by California Nickel Corp. and Interstrat Resources Inc. California Nickel awaited Forest Service, U.S. Department of Agriculture, approval of an environmental impact statement submitted in 1984. Chromium would be a byproduct of nickel and cobalt production at the Gasquet Mountain property. Interstrat financed a feasibility study for the Pine Flat Mountain claim, which it co-owns with Coastal Mining Co., a subsidiary of M. A. Hanna Co. Chromium ore would be a byproduct of nickel at the Pine Flat Mountain Claim.

The Minnesota Department of Natural Resources (DNR) announced the discovery of chromium mineralization in the Duluth Gabbro Complex in northeastern Minnesota. DNR identified a 7-foot layer of rock at a depth of 2,400 feet to have a 3.9% chromium content. This material, although not of commercial grade, encourages DNR to investigate further.

Allied Corp. closed its chromium chemicals plant at Baltimore, MD. The Baltimore plant started production in 1845 as a producer of potassium bichromate. At closure, the plant had a production capacity of 65,000 tons per year of hydrous sodium bichromate.

Foote Mineral Co. closed its Graham, WV, plant. Elkem Metals Co. experienced a 1-month strike at its Marietta, OH, plant. Satra Concentrates bought slags and equipment from Satralloy Inc. in Beverly, OH. Satralloy has not operated the ferrochromium plant since 1982. Satra Concentrates expects to produce about 175,000 tons of high-carbon and 1,000,000 tons of low-carbon chromium concentrates from slags during the time period 1985-89.

Chem-Lig International started construction of a plant at Port Allen, LA. The plant was to produce chromium and iron-chromium lignosulfonates for drilling fluids and other applications.

Table 3.—Principal producers of chromium products in 1985, by industry

Industry and company	Plant
Metallurgical:	
Elkem AS, Elkem Metals Co	Marietta, OH, and Alloy, WV.
Foote Mineral Co	Graham, WV.
Macalloy Inc	Charleston, SC.
Metallurg Inc., Shieldalloy Corp	Newfield, NJ.
Moore McCormack Resources Inc., Globe Metallurgical Inc	Beverly, OH.
SKW Alloys Inc	Calvert City, KY, and Niagara Falls, NY.
Refractory:	
Basic Inc	Maple Grove, OH.
Corhart Refractories Co. Inc	Pascagoula, MS.
Davis Refractories Inc	Jackson, OH.
General Refractories Co	Lehi, UT.
Harbison-Walker Refractories, a division of Dresser Industries Inc	Hammond, IN, and Baltimore, MD.
Kaiser Aluminum & Chemical Corp	Plymouth Meeting, PA.
National Refractories & Minerals Corp	Moss Landing, CA, and Columbiana, OH.
North American Refractories Co. Ltd	Womelsdorf, PA.
Chemical:	
Allied Chemical Corp	Baltimore, MD.
American Chrome & Chemicals Inc	Corpus Christi, TX.
Diamond Shamrock Corp., Diamond Shamrock Chemicals Co	Castle Hayne, NC.

Table 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in the United States

(Short tons)

Material	Net production		Net shipments	Producer stocks, Dec. 31
	Gross weight	Chromium content		
1984:				
Low-carbon ferrochromium; High-carbon ferrochromium; Chromium concentrate	79,515	50,919	110,389	16,256
Ferrochromium-silicon; Chromium metal; Other[1]	15,885	8,324	10,383	8,282
Total	95,400	59,243	120,772	24,538
1985:				
Low-carbon ferrochromium; High-carbon ferrochromium; Chromium concentrate	99,027	62,556	94,470	18,775
Ferrochromium-silicon; Chromium metal; Other[1]	10,536	5,637	14,002	4,786
Total	109,563	68,193	108,472	23,561

[1]Includes exothermic chromium additives and other miscellaneous chromium alloys.

CONSUMPTION AND USES

Domestic consumption of chromite ore and concentrate was 560,421 tons in 1985. Of the total chromite consumed, the metallurgical industry used 48.7%; the chemical industry, 39.7%; and the refractory industry, 11.6%. Most of the chromite consumed and ferrochromium produced by the metallurgical industry was part of the NDS conversion program. (See "Legislation and Government Programs" section of this chapter).

Chromium has a wide range of uses in the three primary consumer groups. In the metallurgical industry, its principal use in 1985 was in stainless steel. Of the 376,452 tons of chromium ferroalloys, metal, and other chromium-containing materials reported consumed, stainless steel accounted for 78%; full-alloy steel, 9%; superalloys, 3%; and other end uses, 10%. Chromium ferroalloys, metal, and other chromium material consumption decreased 6% compared with that of 1984.

The primary use of chromium in the refractory industry was in the form of chromite to make refractory bricks to line metallurgical furnaces. Chromite consumption by the refractory industry decreased 33% compared with that of 1984.

The chemical industry consumed chromite for manufacturing chromates, chromic acid, and pigments. Sodium and potassium chromate and bichromate are the materials from which a wide range of chromium chemicals are made. Chromite consumption by the chemical industry in 1985 increased 18% compared with that of 1984.

Table 5.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

Year	Metallurgical industry		Refractory industry		Chemical industry		Total	
	Gross weight (short tons)	Average Cr_2O_3 (percent)	Gross weight (short tons)	Average Cr_2O_3 (percent)	Gross weight (short tons)	Average Cr_2O_3 (percent)	Gross weight (short tons)	Average Cr_2O_3 (percent)
1981	503,051	35.7	147,853	37.3	238,465	42.6	889,369	37.9
1982	283,481	35.2	79,760	36.4	194,935	44.9	558,176	38.9
1983	64,310	39.3	72,050	36.9	183,611	44.9	319,971	42.0
1984	225,727	43.5	97,469	37.4	188,960	44.8	512,156	42.8
1985	272,885	38.5	65,245	38.1	222,291	45.3	560,421	41.2

Table 6.—U.S. consumption of chromium ferroalloys and metal in 1985, by end use

(Short tons, gross weight)

End use	Ferrochromium		Ferrochromium silicon	Other	Total
	Low-carbon ferrochromium	High-carbon ferrochromium			
Steel:					
Carbon	3,156	3,867	W	W	7,023
Stainless and heat-resisting	9,797	275,951	6,271	583	292,602
Full-alloy	6,091	26,570	1,685	83	34,429
High-strength, low-alloy and electric	2,221	2,075	W	W	4,296
Tool	939	3,032	250	--	4,221
Cast irons	536	5,708	W	W	6,244
Superalloys	4,236	3,587	65	3,236	11,124
Welding materials[1]	428	646	--	74	1,148
Other alloys[2]	416	166	W	2,012	2,594
Miscellaneous and unspecified	102	24	11,462	1,183	12,771
Total	27,922	321,626	19,733	[3]7,171	376,452
Chromium content	19,108	174,999	7,135	5,619	206,861
Stocks, Dec. 31	5,482	24,115	1,289	[4]1,280	32,166

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Includes structural and hard-facing welding material.
[2]Includes magnetic and nonferrous alloys.
[3]Includes 4,341 tons of chromium metal.
[4]Includes 535 tons of chromium metal.

STOCKS

Reported consumer stocks of chromite declined from 327,321 tons in 1984 to 300,187 tons in 1985. Metallurgical industry stocks increased, whereas chemical and refractory industry stocks declined. Producer stocks of chromium ferroalloys, metal, and other materials declined from 24,538 tons in 1984 to 23,561 tons in 1985. Consumer stocks increased from 26,302 tons in 1984 to 32,166 tons in 1985. At the 1985 annual rate of chromium ferroalloy and metal consumption, producer plus consumer stocks represented a 1.4-month supply.

Table 7.—U.S. consumer stocks of chromite, December 31, by industry

(Short tons, gross weight)

Industry	1981	1982	1983	1984	1985
Metallurgical	229,800	119,540	140,324	24,442	44,361
Refractory	128,210	113,233	75,832	69,619	48,635
Chemical	370,463	312,808	239,420	233,260	207,191
Total	728,473	545,581	455,576	327,321	300,187

Table 8.—U.S. consumer stocks of chromium ferroalloys and metal, December 31, by product

(Short tons, gross weight)

Product	1981	1982	1983	1984	1985
Low-carbon ferrochromium	5,198	3,459	3,474	3,375	5,482
High-carbon ferrochromium	46,601	21,793	20,948	19,946	24,115
Ferrochromium-silicon	1,801	1,237	1,294	1,422	1,289
Other[1]	2,468	2,593	954	1,559	1,280
Total	56,068	29,082	26,670	26,302	32,166

[1]Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

PRICES

The price of South African chromite ore decreased, whereas that of Turkish chromite increased. The published price of South African Transvaal chromite, 44% Cr_2O_3, no specific chromium-to-iron ratio, decreased from a range of $48 to $52 per metric ton to a range of $40 to $42 per metric ton, f.o.b. South African ports. The published price of Turkish chromite increased from $110 per metric ton to $125 per metric ton, f.o.b. Turkish ports.

The price of domestic chromium ferroalloys and metal remained unchanged. The published price of imported high-carbon ferrochromium containing 50% to 55% chromium decreased from a range of 43 to 45 cents per pound to a range of 43 to 44.5 cents per pound in January. It then increased to a range of 43 to 45 cents per pound in September and declined to a range of 42.5 to 44 cents per pound in October. The published price of imported high-carbon ferrochromium containing 60% to 65% chromium declined from a range of 45 to 46 cents per pound to a range of 44.5 to 46 cents per pound in January. It then increased to a range of 45.5 to 46.5 cents per pound in February, increased again to a range of 46.5 to 48 cents per pound in June, and then decreased to a range of 46 to 47 cents per pound in October. The published price of imported low-carbon ferrochromium increased from a range of 87 to 89 cents per pound to a range of 88 to 89.5 cents per pound in June. It then decreased to a range of 86 to 87 cents per pound in October.

Table 9.—Price quotations for chromium materials at beginning and end of 1985

Material	January	December
	Cents per pound of chromium	
U.S. charge chromium (50% to 55% chromium)	(1)	(1)
Imported charge chromium (50% to 55% chromium)	43-45	42.5-44
Imported charge chromium (60% to 65% chromium)	45-46	46-47
U.S. charge chromium (66% to 70% chromium)	54	54
U.S. low-carbon ferrochromium (0.025% carbon)	100	100
U.S. low-carbon ferrochromium (0.05% carbon)	95	95
Imported low-carbon ferrochromium (0.05% carbon)	89-95	86-87
Simplex (low-carbon ferrochromium)	100	100
	Cents per pound of product	
Electrolytic chromium metal	375	375
Ferrochromium-silicon	r38.6	38.6

rRevised.
[1]Price listing suspended.

Source: Metals Week.

FOREIGN TRADE

Exports of chromium materials from the United States included chromite ore, chromium metal, ferroalloys, chemicals, and pigments. Exports of chromite ore and concentrate increased 84% in 1985. Exports of all other chromium materials decreased.

Imports of chromium materials included chromium metal, ferrochromium-silicon, chemicals, and pigments. Imports of chromium metal and ferrochromium-silicon decreased 16% and 50%, respectively, in 1985. Of the chromium chemicals, imports of chromic acid, potassium chromate and dichromate, and sodium chromate and dichromate increased 100%, 15%, and 135%, respectively. Chromium carbide imports decreased 32%.

Table 10.—U.S. exports and reexports of chromite ores and concentrates

Year	Exports		Reexports	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1981	70,672	$5,893	66,566	$9,575
1982	8,165	1,574	56,830	9,172
1983	11,032	1,874	4,561	1,350
1984	54,928	2,957	3,855	864
1985	100,810	4,600	3,676	670

Source: Bureau of the Census.

Table 11.—U.S. exports of chromium materials, by type

Type	1983 Quantity (short tons)	1984 Quantity (short tons)	1985 Quantity (short tons)	1985 Value (thousands)	Principal destinations, 1985
Chromite ore and concentrate	11,032	54,928	100,810	$4,600	Sweden (67%); Republic of Germany (30%).
Metal and alloys:					
Chromium metal[1]	238	259	222	2,964	Japan (21%); United Kingdom (32%); Canada (16%).
Chromium ferroalloys	[2]4,247	[3]15,388	[4]10,262	7,688	Federal Republic of Germany (51%); Canada (32%).
Chemicals:					
Chromic acid	3,927	5,672	3,881	5,582	Japan (24%); Canada (23%); Republic of Korea (16%).
Potassium chromate and dichromate	11	72	71	94	Canada (58%); Australia (10%).
Sodium chromate and dichromate	14,174	18,321	9,726	5,679	Republic of Korea (23%); Canada (18%); China (17%); Colombia (14%).
Pigments	2,555	2,062	1,928	6,438	Canada (29%); Federal Republic of Germany (17%); Japan (11%).

[1]Wrought and unwrought and waste and scrap.
[2]Contained 2,589 tons of chromium.
[3]Contained 9,996 tons of chromium.
[4]Contained 6,277 tons of chromium.

Source: Bureau of the Census.

Table 12.—U.S. imports of selected chromium materials, by type

Type	1983 Quantity (short tons)	1984 Quantity (short tons)	1985 Quantity (short tons)	1985 Value (thousands)	Principal sources, 1985
Metal and alloys:					
Chromium metal[1]	3,359	4,677	3,954	$19,615	United Kingdom (44%); Japan (32%); China (11%); France (10%).
Ferrochromium-silicon	[2]1,438	[3]7,942	[4]3,940	2,085	Zimbabwe (98%); Italy (2%).
Chemicals:					
Chromic acid	3,267	2,456	4,905	6,965	Italy (28%); Federal Republic of Germany (28%); Netherlands (16%); United Kingdom (14%).
Chromium carbide	237	181	123	897	Federal Republic of Germany (54%); United Kingdom (33%); Japan (12%).
Potassium chromate and dichromate	347	554	639	676	Federal Republic of Germany (35%); United Kingdom (33%); U.S.S.R. (18%).
Sodium chromate and dichromate	8,933	4,617	10,836	6,380	United Kingdom (36%); Italy (21%); Turkey (13%); Republic of South Africa (12%).
Pigments:					
Chrome green	21	53	202	126	Mexico (73%); Canada (15%).
Chrome yellow	1,933	2,560	3,187	4,480	Canada (59%); Federal Republic of Germany (17%); United Kingdom (13%).
Chrome oxide green	1,997	1,999	1,616	3,168	Federal Republic of Germany (51%); Japan (29%); Romania (9%).
Hydrated chromium oxide green	2	18	13	79	Belgium (85%); Italy (15%).
Molybdenum orange	738	1,013	1,077	2,278	Canada (70%); Federal Republic of Germany (13%).
Strontium chromate	165	197	431	892	Federal Republic of Germany (30%); France (24%), Spain (22%); Belgium (18%).
Zinc yellow	1,381	1,186	1,731	2,121	Norway (44%); Federal Republic of Germany (18%); Canada (16%); Hungary (16%).

[1]Wrought and unwrought and waste and scrap.
[2]Contained 579 tons of chromium.
[3]Contained 3,032 tons of chromium.
[4]Contained 1,493 tons of chromium.

Source: Bureau of the Census.

Table 13.—U.S. import duties for chromium-containing materials

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1985	Jan. 1, 1987	Jan. 1, 1985
Ore: Chrome ore and concentrate	601.15	Free	No target duty	Free.
Metal and alloys:				
Low-carbon ferrochromium	606.22	3.4% ad valorem	3.1% ad valorem	30% ad valorem.
High-carbon ferrochromium	606.24	1.9% ad valorem	No target duty	7.5% ad valorem.
Ferrosilicon chromium	606.42	10% ad valorem	10% ad valorem	25% ad valorem.
Chrome metal[1]	632.18	4% ad valorem	3.7% ad valorem	30% ad valorem.
Chemicals:				
Potassium chromate and dichromate	420.08	1.6% ad valorem	1.5% ad valorem	3.5% ad valorem.
Sodium chromate and dichromate	420.98	2.5% ad valorem	2.4% ad valorem	8.5% ad valorem.
Chromium carbide	422.92	4.7% ad valorem	4.2% ad valorem	25% ad valorem.
Chromic acid	423.0092	4% ad valorem	3.7% ad valorem	Do.
Pigments:				
Chrome green	473.10	4% ad valorem	No target duty	Do.
Chrome yellow	473.12	do	do	Do.
Chromium oxide green	473.14	do	3.7% ad valorem	Do.
Hydrated chromium oxide green	473.16	do	do	Do.
Molybdenum orange	473.18	do	No target duty	Do.
Strontium chromate	473.19	do	3.7% ad valorem	Do.
Zinc yellow	473.20	do	No target duty	Do.

[1]Includes wrought, unwrought, waste and scrap chromium metal.

Table 14.—U.S. imports for consumption of chromite, by country

Country	Not more than 40% Cr_2O_3			More than 40% but less than 46% Cr_2O_3			46% or more Cr_2O_3			Total[1]		
	Gross weight (short tons)	Cr_2O_3 content (short tons)	Value (thousands)	Gross weight (short tons)	Cr_2O_3 content (short tons)	Value (thousands)	Gross weight (short tons)	Cr_2O_3 content (short tons)	Value (thousands)	Gross weight (short tons)	Cr_2O_3 content (short tons)	Value (thousands)
1984:												
Canada	5,929	2,243	$320	30	12	$2	2	1	(2)	5,961	2,256	$322
Finland	--	--	--	11,228	4,940	535	--	--	--	11,228	4,940	535
New Caledonia	--	--	--	--	--	--	3,472	1,944	$357	3,472	1,944	357
Philippines	45,293	15,033	4,154	--	--	--	3,196	1,901	350	48,489	16,934	4,504
South Africa, Republic of	5,441	2,104	372	109,705	48,459	4,121	120,284	57,689	5,265	235,430	108,252	9,758
Total[1]	56,663	19,380	4,846	120,963	53,412	4,659	126,955	61,535	5,972	304,580	134,327	15,477
1985:												
Albania	15,673	5,396	485	2,315	972	132	--	--	--	17,988	6,368	617
Canada	--	--	--	4	2	1	--	--	--	4	2	1
Finland	--	--	--	22,838	10,330	1,140	--	--	--	22,838	10,330	1,140
Japan	--	--	--	48	19	4	--	--	--	48	19	4
Philippines	41,399	12,917	3,179	--	--	--	--	--	--	41,399	12,917	3,179
South Africa, Republic of	32,533	12,951	1,266	142,474	63,228	6,135	126,182	59,094	5,854	301,189	135,273	13,255
Turkey	30,905	11,282	1,974	--	--	--	--	--	--	30,905	11,282	1,974
Total[1]	120,510	42,545	6,904	167,679	74,554	7,412	126,182	59,094	5,854	414,371	176,191	20,170

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

Table 15.—U.S. imports for consumption of ferrochromium, by country

Country	Low-carbon ferrochromium (less than 3% carbon)			High-carbon ferrochromium (3% or more carbon)		
	Gross weight (short tons)	Chromium content (short tons)	Value (thousands)	Gross weight (short tons)	Chromium content (short tons)	Value (thousands)
1984:						
Brazil	--	--	--	13,062	7,055	$4,616
Canada	--	--	--	23	15	10
France	19	14	$25	21	13	4
Germany, Federal Republic of	5,023	3,603	5,072	39	26	52
India	--	--	--	3,420	2,356	1,649
Italy	710	531	868	4,956	3,023	1,968
Japan	60	39	65	36	25	31
Norway	51	33	74	--	--	--
Philippines	--	--	--	5,423	3,428	2,434
South Africa, Republic of	4,997	3,066	4,018	257,919	136,199	97,010
Spain	--	--	--	925	632	429
Sweden	4,325	3,163	4,778	1,101	689	480
Turkey	1,873	1,256	1,613	47,907	29,234	19,648
Yugoslavia	--	--	--	27,675	17,925	13,420
Zimbabwe	8,074	5,531	6,885	38,170	24,868	18,302
Total[1]	25,132	17,236	23,397	400,677	225,487	160,054
1985:						
Brazil	--	--	--	10,362	5,589	3,860
Canada	--	--	--	145	99	58
Finland	--	--	--	8,851	4,658	3,534
Germany, Federal Republic of	4,445	3,178	4,803	1,240	778	632
Greece	--	--	--	4,082	2,489	2,238
Italy	169	123	206	--	--	--
Japan	513	337	541	602	398	589
Netherlands	78	56	86	772	344	24
Philippines	--	--	--	6,483	3,896	2,844
South Africa, Republic of	5,151	3,062	3,889	198,320	105,178	78,427
Sweden	7,004	4,730	7,063	--	--	--
Turkey	4,094	2,795	4,135	26,932	17,340	13,152
Yugoslavia	--	--	--	13,998	9,065	7,155
Zimbabwe	4,781	3,244	4,253	33,043	21,752	19,058
Total[1]	26,236	17,525	24,976	304,829	171,587	131,570

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World chromite production increased to 11 million tons, from 10 million tons in 1984. Ferrochromium production increased to 3,160,000 tons from 3,155,000 tons in 1984.

Chromite resource investigations were reported in Australia, Brazil, Pakistan, and Turkey. Ferrochromium production facilities started production in Finland and India. Ferrochromium production capacity was being developed in India, the Republic of South Africa, Sweden, and Turkey.

France and the United Kingdom were disposing of their stockpiles. Japan was building its stockpile. The Republic of Korea announced its decision to build a stockpile.

Finland and the Republic of South Africa are the two major world chromium producers integrated from chromite ore production through stainless steel marketing.

Australia.—Australia Mining N.L. made an agreement with Ascot Holdings Pty. Ltd. to explore the Omega Prospect in Western Australia, about 350 kilometers north-northeast of Geraldton. Previous exploration preliminarily identified a 1,600-meter strike length. Two 0.5-meter drill holes yielded material grading 7% and 8.8% chromium content.

Brazil.—The Brazilian Mines and Energy Ministry located a chromite deposit about 1.5 kilometers from the Mineração Vale do Jacurici S.A. operation in Bahia State. A second chromite deposit was located by Docegeo, the Brazilian state mineral exploration company, in Pará State, about 15 kilometers from the famous Serra Pelada gold mine. Brazil produces chromite for domestic consumption, ferrochromium for domestic use and export, and stainless steel for domestic use.

European Economic Community (EEC).—The EEC doubled its 1985 duty-free ferrochromium quota from 228,000 tons to 456,000 tons, including ferrochromium containing not less than 4% carbon, from 8,000 to 15,000 tons, and that containing not less than 6% carbon, from 200,000 to 400,000 tons.

The EEC set its 1986 duty-free quota at 19,000 tons for ferrochromium containing not less than 4% carbon, and 200,000 tons for ferrochromium containing not less than 6% carbon.

Finland.—In 1985, Outokumpu Oy started production, at its Tornio Works, with a 75-megavolt-ampere furnace having a high-carbon ferrochromium production capacity of from 100,000 to 120,000 tons per year. The new furnace was constructed in about 15 months between 1983 and 1985 at a cost of about $35 million. The new furnace is part of a process that uses hot gases resulting from smelting to preheat the furnace feed. Outokumpu started production of high-carbon ferrochromium in 1968 with a 35-megavolt-ampere furnace of 60,000-ton-per-year production capacity. Finland produced chromite, ferrochromium, and stainless steel for world markets.

Greece.—Hellenic Ferroalloy S.A. announced its intention to increase production capacity from the present 45,000 tons per year to 100,000 tons per year. The capacity expansion was planned to be achieved by adding a 36-megavolt-ampere furnace to its present 20-megavolt-ampere furnace.

India.—Orissa Mining Corp. Ltd. started operation of its ferrochromium plant in Bamnipal, Orissa. The plant had one 35-megavolt-ampere furnace with about 50,000 tons per year of production capacity.

Indian Charge Chrome Ltd., a subsidiary of Indian Metals and Ferro Alloys Ltd., contracted for the construction of a coal-fired powerplant to serve its presently operating ferrochromium plant at Therubali and its plant under construction at Choudhar.

The Minister for Steel and Mines reported India's detailed mineral land mapping to be over one-half completed. Chromite mineral reserves were set at 148 million tons. The Geological Survey of India reported chromite resources of Orissa to be 144 million tons.

Japan.—Japan announced the decision to reduce its import duty on chromium ferroalloys. The reduced duties were to become effective in 1986. The duty on ferrochromium was to be reduced from 8% ad valorem to 7.2% ad valorem. The duty on ferrochromium-silicon was to be reduced from 3.7% ad valorem to 3% ad valorem.

Japan offered its ferrochromium industry financial support in exchange for the reduction of ferrochromium production capacity. The offer was made under Japan's industrial restructuring law. The ferrochromium industry was to reduce its capacity by about 10% of its 632,000 tons of installed capacity, to be achieved by March 31, 1987. Financial support was to be made through personal-property-tax-payment exemption.

Japan added 7,910 tons of high-carbon ferrochromium to its stockpile, of which 3,296 tons was added to the national stockpile, 3,296 tons to the joint Government-private stockpile, and 1,318 tons to the private stockpile. The material added represented about 4.8 days worth of consumption by the Japanese industry, making Japan's stockpile equivalent to about 16.8 days of consumption. Japan planned to add a 4.8-day supply in the 1985 fiscal year (April 1985 to March 1986).

Korea, Republic of.—The Republic of Korea announced its decision to stockpile 1,300 tons of ferrochromium by the end of 1985.

Oman.—Oman Mining Co. (OMC) reported confirmation of reserves of 2 million tons of chromite. OMC had a chromite production capacity of about 20,000 tons per year and produced about 7,000 tons in 1984. OMC considered the construction of a crusher and smelter to process its ore into ferrochromium. A decision to construct a plant would be based primarily on adequacy of chromite ore reserves and availability of investment capital.

Pakistan.—The Geological Survey of Pakistan was conducting exploratory studies of chromite deposits in the Lasbele District and in Malakand. The Pakistan Development Corp. and Al-Ghurair Enterprises, of United Arab Emirates, agreed to jointly develop a chrome-magnesite refractory brick factory.

South Africa, Republic of.—Union Carbide Corp. negotiated the sale of its interest in Tubatse Ferrochrome (Pty.) Ltd., Jagdlust Chrome Co. (Pty.) Ltd., Chrometco

Minerals Pty. Ltd., and Chrome Corp. (South Africa) Pty. Ltd. to General Mining Union Corp. Ltd. (Gencor). The sale was to take place in January 1986. Gencor owns South African Manganese Amcor Ltd. (Samancor).

Samancor started construction of a new refining facility, called IC3, at its Ferrometals (Pty.) Ltd. plant, at Witbank. IC3 was scheduled for completion in 1986. Upon completion, IC3 was to produce medium- and low-carbon ferrochromium (2% to 6% carbon) from high-carbon ferrochromium (6% to 8%). The high-carbon ferrochromium was to be fed as hot metal. IC3 was to have a refining capacity of about 50,000 tons per year. Samancor planned construction of a ferrochromium plant at its Ruighoek Mine. Plant construction was to start in 1986. Samancor erected a beneficiation plant at its Mooinooi Mine at a cost of about $75,000. The plant was designed to produce chemical- and metallurgical-grade concentrates from a stockpile of fines. Until 1985, Mooinooi produced only lump ore for sale, resulting in a 340,000-ton stockpile of fines. Samancor was to install a new ferrochromium production process at its Ferrometals Ltd. plant at Witbank. The new process involves kiln reduction of chromite with coal, followed by submerged-arc furnace reduction to complete the smelting process. Construction was to start in 1986, and the new process was to be operational in 1987 at an annual production capacity of about 60,000 tons per year. This process was to replace about 45,000 tons per year of conventional submerged-arc production capacity.

Middleburg Steel & Alloys Holdings (Pty.) Ltd. (MSA) continued development of its direct current transferred-arc plasma furnace at its Krugersdorp plant. MSA was also studying the feasibility of using a kiln roasting prereduction process.

Table 16.—Chromite: World production, by country[1]

(Thousand short tons, gross weight)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Albania[e]	[r]783	[r]744	[r]755	[r]794	909
Brazil[3]	261	304	171	282	303
Cuba[4]	23	30	37	41	44
Cyprus	11	3	--	--	--
Finland[4]	454	380	271	492	500
Greece[5]	[r]27	[r]32	30	68	68
India	369	374	465	466	[6]610
Iran[e]	35	45	55	55	55
Japan	12	12	9	8	[6]13
Madagascar	110	49	50	66	66
New Caledonia	5	55	101	93	[6]87
Pakistan	2	[r]4	7	3	4
Philippines	484	355	294	286	[6]284
South Africa, Republic of[4 7]	3,164	2,385	2,460	3,314	[6]3,682
Sudan	[6]28	[e]21	[e]22	[r e]22	22
Turkey	[r]442	[r]499	381	537	496
U.S.S.R.[e 8]	3,200	3,240	3,240	[r]3,240	3,240
Vietnam[e]	17	18	18	20	17
Yugoslavia	([9])	--	--	--	--
Zimbabwe	591	476	463	525	551
Total	[r]10,018	[r]9,026	8,829	10,312	10,951

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 1, 1986.
[2]In addition to the countries listed, Bulgaria, China, and North Korea may also produce chromite, but output is not reported quantitatively and available general information is inadequate for formulation of reliable estimates of output levels. Figures for all countries represent marketable output unless otherwise noted.
[3]Figures are sum of (1) crude ore sold directly for use and (2) concentrate output, both as reported in Brazilian sources. Total run-of-mine crude ore production (not comparable to data for other countries) was as follows, in thousand short tons: 1981—1,021; 1982—736; 1983—517; 1984—782; and 1985—800 (estimated).
[4]Production of marketable product (direct-shipping lump ore plus concentrates and foundry sand).
[5]Exports of direct-shipping ore plus production of concentrates.
[6]Reported figure.
[7]Excludes production by Bophuthatswana, which was as follows, in thousand short tons: 1982—295 and 1983—302.
[8]Estimates for 1981 and 1985 are based in part on crude output reported in Soviet sources as follows, in thousand short tons: 1981—3,600 and 1985—3,700.
[9]Less than 1/2 unit.

Sweden.—Construction of SwedeChrome AB's high-carbon ferrochromium plant started in Malmö. SwedeChrome was to use SKF Steel Engineering AB's plasma process technology. The plant was to have a total annual ferrochromium production capacity of 85,000 to 90,000 tons per year divided equally between two furnaces. The plant was also to supply excess thermal energy to Malmö's local district heating system. SKF's plasma process was to use plasma heaters in a shaft furnace. Advantages of this plasma process include higher chromium recovery, increased capability of excess process energy recovery, use of less costly fine-sized raw materials (agglomeration not required), and lack of constraints on furnace burden composition because of electrical resistivity requirements. Site preparation was completed and plant construction begun. Equipment installation and production startup was planned for 1986.

Turkey.—Etibank continued development of a chromite ore concentrator and ferrochromium production plant. With completion targeted for 1987, the concentrator was to have a production capacity of about 250,000 tons per year of concentrate and the ferrochromium plant was to increase capacity from 50,000 to 150,000 tons per year of high-carbon ferrochromium. The concentrator was at Kefdag, and the ferrochromium plant at Elazig.

Bomar Resources Inc., United States, entered a joint venture with Etibank and Egemetal Madencilik AS to study chromite resources in the Orhaneli region near Bursa in northwest Turkey.

Bilfer Madencilik AS reactivated 13 chromite mines in 6 Provinces because of improved market conditions.

United Kingdom.—The United Kingdom announced its decision to dispose of its strategic stockpile. March 1986 was the date by which 25% of the stockpile was to have been sold.

WORLD RESERVES

Geological aspects of the Bushveld Complex, the Republic of South Africa, the largest resource of chromium, were reviewed. The geologic implications derived from studies of chromite resources in the Potgietersrus, Nietverdiend, and Zwartkop Mine areas were discussed. Geologic aspects of the UG-2 chromitite layer were also discussed.[9]

The Manitoba Department of Energy and Mines, Canada, reevaluated the Bird River sill chromite resources. The Page, Chrome, Bird Lake, and Euclid properties were calculated to have a geologic reserve (measured plus indicated) of about 2.7 million tons of contained Cr_2O_3.[10]

Australia, previously a chromite producer, evaluated its chromite resources. Over 50 deposits were analyzed. Demonstrated paramarginal resources were set at about 2.3 million tons and inferred subeconomic resources at about 20 million tons.[11]

TECHNOLOGY

The Bureau of Mines conducted resource identification and beneficiation studies as part of its domestic mineral assessment program. Chromite deposits along the Border Ranges Fault, southern Alaska, were investigated and described, and the minerals were characterized and beneficiated.[12] The 94 subeconomic deposits were found to range in size from less than 1,000 to greater than 1,000,000 tons of contained chromic oxide. Samples from the deposits were peridotites and chromites that consisted primarily of chromite, olivine, and serpentine. Beneficiation by grinding, sizing, and gravity concentration yielded chromium recoveries ranging from 37% to 95%. The Bureau studied the bulk mineralogy and geochemistry of Alaskan chromite spinels.[13] Systematic differences in chemical content were found between samples from the Chugach mountain range and the Alaskan interior. Considerable mineralogical variability was found between and within these groups. Alaskan chromium deposits studied by the Bureau from 1979 to 1984 were found to contain 3 to 4 million tons of chromic oxide in 132 podiform deposits and 1 placer deposit.[14]

The Bureau researched chromite mineral extraction to increase extraction efficiency and economy, and devised a process to recover chromium as chemicals from domestic chromites that contain silicon and aluminum impurity levels that are too high to permit processing by present industrial processes.[15] The Bureau process consists of reacting chromite with molten sodium hydroxide under oxidizing conditions to form sodium chromate. Domestic chromites from Alaska, California, and Oregon were successfully treated by this procedure. The Bureau devised a column flotation technique and compared it with conventional flotation of Montana chromite.[16] Column flotation produced higher concentrate grades and recoveries than conventional chromite flotation for both deslimed and undeslimed chromite ore. The Bureau upgraded high-iron domestic chromite concentrates by a carbonyl process.[17] The high-iron chromites were reduced to convert iron oxides to the metal, then were treated with carbon monoxide to convert part of the iron to iron pentacarbonyl. The iron pentacarbonyl was then extracted from the concentrate. Chromic oxide content was improved by as much as 10% and chromium-to-iron ratio increased by up to threefold compared with that of the starting concentrates. The Bureau researched environmental issues associated with chromite extraction from the Stillwater Complex, MT.[18] Specific land, water, air, and other environmental factors were identified and analyzed as to how they would relate to mining of chromite deposits. Shrinkage stoping mining methods and gravity concentration milling were assumed as part of the environmental issues study. With the exception of technology for ferrochromium smelter sludge reclamation, all technology necessary for development was found to be available and sound.

The Bureau researched the potential for reducing the chromium content of stainless and alloy steels to improve chromium use technology. Chromium-nickel stainless steels with molybdenum, copper, and vanadium for corrosion-resistant applications, and with silicon and aluminum for heat-resistant applications, were studied.[19] For several reduced chromium stainless steels, tensile properties were evaluated, corrosion rates were measured, welding performance was evaluated, stress rupture properties were measured, and oxidation tests were performed. Additions such as molybdenum, silicon, and aluminum were found to be potential substitutes for about one-half the chromium in stainless steels for many applications. The Bureau performed oxidation studies, obtained mechanical properties, determined stress rupture strength data, and investigated melting, casting, and working characteristics for iron-manganese-aluminum alloys as a potential substitute for stainless steels.[20] The alloys studied did not exhibit good oxidation resistance during mild thermal cycling and were problematic to melt, cast, and cut. The alloys were easily hot worked and had good mechanical properties unless aged. Iron-chromium-nickel-aluminum alloys were studied as potential substitutes for stainless steels used in sulfur-containing environments.[21] With minor additions of titanium, manganese, and silicon to improve workability, sulfidation resistance was found to exceed that of stainless steel types 304 and 316; oxidation resistance was equivalent to that of type 310; and mechanical properties approached those of type 310. The Bureau investigated a cast-on hard-surfacing technique that improves wear resistance.[22] The cast-on surface was found to be a potential substitute for weld-rod hard facing.

The Bureau studied in-plant recycling of speciality steelmaking particulate wastes.[23] Particulate waste such as flue dust, mill scale, and grinding swarf was pelletized and reduced in an electric-arc furnace. Consistent recoveries of about 90% of the chromium were achieved. The Bureau cosponsored a workshop on conservation and substitution technology for chromium in bearings.[24] Strategies such as substitution of alternate materials, including metals and nonmetals, and use of extended life bearings, were identified.

The U.S. Department of Defense developed a microprocessor-controlled chromium plating process and studied the effect of plating conditions on the structure of electrodeposited chromium.[25]

The National Materials Advisory Board studied the potential industrial application of plasma processing technology.[26] The report identified plasma technology as potentially applicable to ferrochromium production and to the recovery of chromium from dusts. Current industrial applications of plasma technology to ferrochromium production, low-grade chromium ore processing, and chromium recovery from steel mill baghouse dust were identified.

The National Institute for Metallurgy, Republic of South Africa, developed an accurate and precise method for the determination of iron and chromium in chromite.[27]

The economic recovery of chromite from the UG-2 seam of the Bushveld Complex was studied by the Council for Mineral Technology (Mintek), Republic of South Africa.[28] A beneficiation process to produce chromite concentrate was developed and tested at pilot plant and production scales. A low-grade chromite concentrate was found to have been economically recoverable from UG-2 seam material currently mined by Western Platinum Ltd. for its platinum content.

Mintek also studied chromite reduction and energy transfer in a submerged-arc furnace. Chromite combined with graphite and reduced in an argon atmosphere at 1,300° C was found to react sequentially. First ferric iron in chromite ore was reduced to the ferrous state, followed by reduction of ferrous to metallic iron. Chromium was then reduced.[29] Heat flows were measured in the submerged-arc furnace and a time-dependent, two-dimensional mathematical model developed.[30]

Ferrochromium production is energy intensive, and new smelting techniques are being developed by industry to lower energy costs. Traditional smelting methods use electric submerged-arc furnaces. As alternatives to the traditional smelting practice, kiln roast prereduction and plasma furnace smelting are being studied. The Ministry of International Trade and Industry, Japan, began construction of a pilot plant at Nippon Steel Corp.'s Kimitsu Works to study ferrochromium production with stainless steel production.[31] Samancor was to restructure its Ferrometals plant to produce ferrochromium from chromite prereduced with coal in a kiln roasting process. Mintek, Republic of South Africa, studied the reduction of chromite in a transferred-arc plasma furnace.[32] The transferred-arc plasma technology was found to be a potential alternative to traditional submerged-arc technology. The plasma technology was found capable of processing low-grade fine chromite ore that is precluded from direct electric submerged-arc processing. The plasma furnace was also studied for the purpose of recycling ferrochromium metal fines.[33] Mintek found that these fines could be remelted and consolidated in a plasma furnace with metal recoveries of over 90%.

Finland reported the production of ferrochromium from low-grade ores.[34] The process of producing charge-grade ferrochromium by smelting pelletized and hardened concentrates from chromium ore in an enclosed electric furnace was described.

Commercial chromium-recovery membranes are being developed. A coupled-transport liquid-membrane chromium extraction process that was demonstrated effective on plating solution waste was to have been applied to a commercial process.

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Clays

By Sarkis G. Ampian[1]

Total quantity of clays sold or used by domestic producers increased 3% in tonnage but decreased slightly in value. Clays in one or more of six classification categories, ball clay, bentonite, common clay and shale, fire clay, fuller's earth, or kaolin, were produced in 44 States and Puerto Rico during 1985. Clay production, as in 1984, was not reported in Alaska, Delaware, the District of Columbia, Hawaii, Rhode Island, Vermont, or Wisconsin. The leading seven States, in descending order, were Georgia, Texas, North Carolina, Wyoming, California, Ohio, and Alabama. Unpredictable shortages of natural gas and the cost of fuels were major concerns to clay producers and manufacturers until yearend, when an oil glut caused by world overproduction started softening energy prices. Industry-wide efforts to economize by reducing capital and/or energy costs, although persistent during the year, intensified at yearend. Environmental restrictions and associated costs, combined with persistent high capital costs, continued to hinder production.

Production of common clay and shale increased because of an upturn in construction, due in part to the softening of interest rates and improving business climate, that increased demand for clay building materials—brick, portland cement, floor and wall tile, and vitrified sewer pipe. An exception to the Nation's buoyant construction rates were those noted in the oil producing States of Louisiana, Oklahoma, and Texas, because declining oil revenues depressed residential, business, and governmental construction activity. Increases in production of the specialty clays, ball clay and fuller's earth, were caused largely by an improvement in the overall economy. Production of bentonite, fire clay, and kaolin declined because their major consumers, the steel, oil and gas exploration, and foundry industries, were in a period of readjustment with lower production levels.

Kaolin accounted for 17% of the clay production but 59% of clay value. Kaolin production of 7.8 million short tons decreased from that of 1984.

Domestic Data Coverage.—Domestic production data for clays are developed by the Bureau of Mines from one voluntary survey of U.S. operations. Of the 1,084 operations covered by the survey, 1,004 responded, representing 93% of the total clay and shale production sold or used shown in table 1.

Table 1.—Salient U.S. clays and clay products statistics[1]

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
Domestic clays sold or used by producers:					
Quantity	44,379	35,345	40,858	r43,702	44,974
Value	$988,845	$825,064	$931,092	r$1,032,127	$1,011,377
Exports:					
Quantity	3,151	2,619	2,484	2,699	2,780
Value	$292,914	$267,700	$254,237	$295,733	$309,871
Imports for consumption:					
Quantity	33	24	21	32	41
Value	$7,895	$4,514	$3,488	$4,868	$5,981
Clay refractories shipments: Value	$609,949	$559,655	$595,299	$782,308	$629,738
Clay construction products shipments: Value	$971,824	$923,459	$1,160,543	$1,342,196	$1,427,851

rRevised.
[1]Excludes Puerto Rico.

Table 2.—Clays sold or used by producers in the United States in 1985, by State[1]

(Short tons unless otherwise specified)

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total	Total value
Alabama	--	W	1,630,739	130,000	--	111,886	[2]1,872,625	[2]$13,139,143
Arizona	--	32,824	153,608	--	--	--	186,432	1,503,279
Arkansas	--	--	911,335	--	--	140,271	1,051,606	10,769,180
California	--	112,890	2,062,256	W	--	28,138	[3]2,203,284	[3]26,600,429
Colorado	--	80	282,411	20,384	--	--	302,875	1,742,690
Connecticut	--	--	106,033	--	--	--	106,033	631,873
Florida	--	--	248,680	--	387,076	36,323	672,079	33,074,154
Georgia	--	--	1,732,742	--	593,033	6,345,205	8,670,980	575,096,905
Idaho	--	W	--	W	--	1,505	[2 3]1,505	W
Illinois	--	--	265,467	--	W	--	[4]265,467	[4]876,123
Indiana	--	--	739,711	--	--	--	739,711	2,776,446
Iowa	--	--	503,298	--	--	--	503,298	2,449,931
Kansas	--	24,000	854,177	--	--	--	878,177	5,325,709
Kentucky	W	--	661,176	W	--	--	774,780	6,486,980
Louisiana	--	--	333,619	--	--	--	333,619	7,016,609
Maine	--	--	49,500	--	--	--	49,500	99,555
Maryland	W	--	336,085	--	--	--	[5]336,085	[5]1,646,991
Massachusetts	--	--	264,538	--	--	--	264,538	1,388,090
Michigan	--	--	1,477,309	--	--	--	1,477,309	5,513,822
Minnesota	--	--	W	--	--	W	W	W
Mississippi	W	197,531	850,706	--	W	--	1,558,300	34,864,168
Missouri	--	--	1,204,854	283,697	W	56,701	[4]1,545,252	[4]10,271,129
Montana	--	254,398	24,190	503	--	--	279,091	8,295,649
Nebraska	--	--	244,228	--	--	--	244,228	718,214
Nevada	--	79,861	--	--	W	W	[4 6]79,861	[4 6]3,775,947
New Hampshire	--	--	W	--	--	--	W	W
New Jersey	--	--	120,000	10,166	--	--	130,166	2,050,079
New Mexico	--	--	57,048	2,767	--	--	59,815	160,714
New York	--	--	699,764	--	--	--	699,764	3,129,207
North Carolina	--	--	2,611,455	--	--	76,864	2,688,319	10,476,986
North Dakota	--	--	W	--	--	--	W	W
Ohio	--	--	1,873,037	241,045	--	--	2,114,082	10,580,605
Oklahoma	--	--	996,522	--	--	--	996,522	2,337,657
Oregon	--	--	188,026	--	--	--	188,026	284,626
Pennsylvania	--	--	1,061,607	80,610	--	W	[6]1,142,217	[6]5,292,781
Puerto Rico	--	--	118,192	--	--	--	118,192	263,568
South Carolina	--	--	1,029,178	--	W	866,812	[4]1,895,990	[4]37,695,224
South Dakota	--	W	117,065	--	--	--	[2]117,065	[2]309,052
Tennessee	664,555	--	579,069	--	W	--	[4]1,243,624	[4]25,912,698
Texas	30,201	46,762	3,919,159	21,196	W	W	4,106,646	28,059,057
Utah	--	14,006	317,725	500	--	--	332,231	2,509,304
Virginia	--	--	786,295	--	28,000	--	814,295	6,976,908
Washington	--	--	242,914	--	--	--	242,914	1,402,107
West Virginia	--	--	233,269	98,064	--	--	331,333	3,342,451
Wyoming	--	2,116,085	185,917	--	--	--	2,302,002	64,146,205
Undistributed	206,923	316,843	95,421	85,482	1,051,172	129,617	[7]1,172,463	[7]52,647,917
Total	901,679	3,195,280	30,168,325	974,414	2,059,281	7,793,322	45,092,301	1,011,640,162

W Withheld to avoid disclosing company proprietary data; included with "Total" and/or "Undistributed."
[1]Includes Puerto Rico.
[2]Excludes bentonite.
[3]Excludes fire clay.
[4]Excludes fuller's earth.
[5]Excludes ball clay.
[6]Excludes kaolin.
[7]Incomplete total; difference included with individual State totals.

Table 3.—Number of mines[1] from which producers sold or used clays in the United States in 1985, by State

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total
Alabama	--	1	26	5	--	8	40
Arizona	--	5	6	--	--	--	11
Arkansas	--	--	18	--	--	5	23
California	--	5	53	1	--	5	64
Colorado	--	1	28	8	--	--	37
Connecticut	--	--	2	--	--	--	2
Florida	--	--	3	--	4	1	8
Georgia	--	--	18	--	8	85	111
Idaho	--	1	1	--	--	1	3
Illinois	--	--	9	--	2	--	11
Indiana	--	--	17	--	--	--	17
Iowa	--	--	11	--	--	--	11
Kansas	--	1	20	--	--	--	21
Kentucky	6	--	11	2	--	--	19
Louisiana	--	1	8	--	--	--	9
Maine	--	--	4	--	--	--	4
Maryland	1	--	7	--	--	--	8
Massachusetts	--	--	3	--	--	--	3
Michigan	--	--	8	--	--	--	8
Minnesota	--	--	1	--	--	1	2
Mississippi	1	4	21	--	2	--	28
Missouri	--	--	14	35	2	6	57
Montana	--	12	5	1	--	--	18
Nebraska	--	--	5	--	--	--	5
Nevada	--	6	--	--	--	2	8
New Hampshire	--	--	1	--	--	--	1
New Jersey	--	--	2	1	--	--	3
New Mexico	--	--	4	2	--	--	6
New York	--	--	11	--	--	--	11
North Carolina	--	--	50	--	--	2	52
North Dakota	--	--	4	--	--	--	4
Ohio	--	--	53	16	--	--	69
Oklahoma	--	--	19	--	--	--	19
Oregon	--	--	6	--	--	--	6
Pennsylvania	--	--	37	19	--	2	58
South Carolina	--	--	26	--	1	22	49
South Dakota	--	1	1	--	--	--	2
Tennessee	23	--	9	--	1	--	33
Texas	1	8	69	2	2	1	83
Utah	--	4	14	1	1	--	20
Virginia	--	--	15	--	1	--	16
Washington	--	--	9	2	--	--	11
West Virginia	--	--	3	1	--	--	4
Wyoming	--	107	2	--	--	--	109
Total	32	157	634	96	24	141	1,084

[1]Includes both active and idle operations.

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Domestic production of kaolin decreased slightly to 7.8 million tons. The average unit value of all grades of kaolin decreased 4% to $76.43 per ton. Kaolin was again produced in 13 States. Two States, Georgia and South Carolina, accounted for 93% of total production. Arkansas ranked third, and Alabama, fourth. Both Alabama and Arkansas produce refractory- and alum-grade kaolins. Kaolin producers reported major domestic end uses for their clay as follows: paper coating, 35%; paper filling, 18%; refractories, 8%; face brick, 7%; fiberglass and insulation, and rubber, 5% each; and catalysts and chemicals, 3% each.

Kaolin is defined as a white, claylike material approximating the mineral kaolinite. It has a specific gravity of 2.6 and a fusion point of 1,785° C. The other kaolin-group minerals, such as halloysite and dickite, are encompassed.

Overcapacity of water-washed and calcined kaolin grades continued to worry the major producers who are heavily tied to the presently depressed paper industry. Competition for Asian and European markets, traditionally supplied by domestic water-washed kaolin producers, intensified because of the strong U.S. dollar and foreign overcapacity. Finished paper-stock imports further compounded the problem. Kaolin sales for refractories appeared to have leveled off. The refractory industry adjusted to new lower levels of production brought about by changes in technology and imports. Production of the three paper-grade kaolins was mixed compared with that of 1984. Low-temperature calcined kaolin production increased 3%, while that of water-washed and delaminated decreased 5% and 4%, respectively.

Several major acquisitions started at yearend 1984 were finalized during the year. The Engelhard Corp. Specialty Chemicals Div. purchased Freeport Kaolin Co. from Freeport-McMoRan Inc. for $100 million. Rationalization of the present Engelhard and Freeport operations was proceeding. A letter of intent for The Morie Co. Inc., Energy and Minerals Inc., to buy Ottawa Silica Co. was terminated by the parent company, South Jersey Industries Inc., at yearend. Ottawa Silica produces filler-grade kaolin from sand kaolin deposits near Kosse, TX. Other diversified mineral-based companies were reportedly interested in acquiring Ottawa Silica. In another company move, Standard Oil Co. (Indiana) sold the shares of its minerals subsidiary, Cyprus Minerals Co., to its shareholders. The new operating company, Cyprus Minerals, includes Cyprus Industrial Minerals with kaolin and ball clay operations in Georgia, South Carolina, and Tennessee.

All Georgia and South Carolina kaolin filler-extender-pigment producers, water-washed and air-floated, continued to modernize, instead of expanding, to reduce operating costs. Emphasis continued to be placed on energy related costs. In this regard, the first superconducting magnet for use in removing iron-bearing impurities from wet kaolin processing streams was installed by the J. M. Huber Corp. in its Wrens, GA, complex. The new magnetic separator reportedly requires 80% less electric power than the currently used varieties. Georgia Kaolin Co. was planning to convert the spray-dryers in its American Industrial Clay Co. plant in Deepstep, GA, from natural gas to wood gas produced from a wood gasification facility. The facility included provisions for a cogenerating internal combustion engine, which was to provide exhaust heat to dry the wood chips prior to gasification. J. M. Huber, at its Langley, SC, air-float kaolin plant, began fueling its dryers with methane gas, instead of natural gas, drawn from decomposed waste in a local landfill. Preliminary estimates indicated savings of approximately $70,000 yearly from the conversion. Evans Clay Co., McIntyre, GA, planned to install additional bulk kaolin storage capacity and silo-to-railcar loading equipment. The emissions were to be controlled by specially installed baghouse collectors at each transfer point. Engelhard started operating its newly expanded proprietary oil-refining catalyst plant at its Attapulgus, GA, site, which also produces attapulgite-type fuller's earth products. The catalyst is prepared from kaolin-type clays.

C-E Minerals, a division of Combustion-Engineering Inc., completed a large expansion at its Andersonville, GA, complex. The complex is capable of supplying 600,000 tons per year of various alumina-silica kaolin calcines for refractory and foundry use. The expansion featured a virtual 100% conversion to coal firing from natural gas, and a new integrated instrumental quality control procedure designed to automatically monitor material along the entire flowsheet from mining to finished products. The coal was furnished from C-E's own metallurgical-grade coal mines in West Virginia.

Properties in Minnesota and Vermont were proposed for kaolin mining and processing ventures. Northwestern Portland Cement Co. and Vermont Minerals and Pigments Co. announced plans for operating in the Mocassin Springs development east of Redwood Falls, MN, and on Bald Mountain, in northwest Bennington, VT, respectively.

Table 4.—Kaolin sold or used by producers in the United States, by State

State	1984		1985	
	Short tons	Value	Short tons	Value
Alabama	238,520	$18,631,800	111,886	$1,959,747
Arkansas	85,898	5,681,092	140,271	8,877,441
California	59,705	1,838,393	28,138	760,752
Florida	33,004	2,438,372	36,323	2,843,000
Georgia	6,508,319	562,696,774	6,345,205	534,980,001
Idaho	1,464	W	1,505	W
Missouri	68,137	1,946,674	56,701	1,701,030
North Carolina	46,787	1,075,548	76,864	1,943,619
South Carolina	776,567	33,404,087	866,812	35,309,338
Other[1]	134,268	6,674,390	129,617	7,240,830
Total	7,952,669	634,387,130	7,793,322	595,615,758

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Minnesota, Nevada, Pennsylvania, Texas, and data indicated by symbol W.

Exports of kaolin, as reported by the U.S. Department of Commerce, decreased only 3% to 1.38 million tons valued at $174 million, despite a strong U.S. dollar and foreign competition. Kaolin, including calcined material, was exported to 70 countries, 2 more than in 1984. The major recipients were Japan, 32%; Canada, 20%; the Netherlands, 11%; Italy, 8%; and Mexico, 7%. Kaolin producers reported end uses for their exports as follows: paper coating, 61%; refractories, 12%; paper filling, 11%; paint, 9%; rubber, 3%; and other, including ceramics and plastics, the remainder.

Kaolin imports decreased 12% to 9,387 tons valued at $996,000. The unit price of kaolin imported from the United Kingdom, the largest importing country, increased nearly 33% to $102.93 per ton.

Kaolin prices quoted in the trade journals remained unchanged. Chemical Marketing Reporter, December 31, 1985, quoted prices as follows:

Water-washed, fully calcined, bags, carload lots, f.o.b. Georgia, per ton	$255.00
Paper-grade, uncalcined, bulk, carload lots, f.o.b. Georgia, per ton:	
No. 1 coating	94.00
No. 2 coating	75.00
No. 3 coating	73.00
No. 4 coating	70.00
Filler, general purpose, same basis per ton	58.00
Delaminated, water-washed, uncalcined, paint-grade, 1-micrometer average, same basis, per ton	182.00
Dry-ground, air-floated, soft, same basis, per ton	60.00
National Formulary, powder, colloidal, bacteria controlled, 50-pound bags, 5,000-pound lots, per pound	.24

Table 5.—Kaolin sold or used by producers in the United States, by kind

Kind	1984		1985	
	Short tons	Value	Short tons	Value
Air-float	1,153,291	$62,401,704	1,275,733	$66,136,128
Calcined[1]	1,204,117	157,909,403	1,108,098	116,319,429
Delaminated	764,566	72,529,476	735,503	72,075,882
Unprocessed	891,645	16,734,107	914,263	14,419,612
Water-washed	3,939,050	324,812,440	3,759,725	326,664,707
Total	7,952,669	634,387,130	7,793,322	595,615,758

[1]Includes both low-temperature filler and high-temperature refractory grades.

Table 6.—Calcined kaolin sold or used by producers in the United States, by State

State	High-temperature		Low-temperature	
	Short tons	Value	Short tons	Value
1984				
Georgia and Alabama	578,520	$40,976,800	[1]510,372	[1]$107,065,496
Other	[2]58,255	[2]5,020,187	[3]56,970	[3]4,846,920
Total	636,775	45,996,987	567,342	111,912,416
1985				
Georgia and Alabama	432,495	10,565,958	[1]532,275	[1]91,979,229
Other	[2]90,537	[2]8,691,212	[3]52,791	[3]5,083,030
Total	523,032	19,257,170	585,066	97,062,259

[1]Excludes Alabama.
[2]Includes Arkansas, California (1984), and Idaho.
[3]Includes Pennsylvania, South Carolina, and Texas.

Table 7.—Georgia kaolin sold or used by producers, by kind

Kind	1984		1985	
	Short tons	Value	Short tons	Value
Air-float	591,869	$27,989,083	739,563	$31,824,375
Calcined[1]	850,372	129,410,496	945,106	100,875,939
Delaminated	764,566	72,529,476	735,503	72,075,882
Unprocessed	395,094	9,799,483	196,312	5,594,126
Water-washed	3,906,418	322,968,236	3,728,721	324,609,679
Total	6,508,319	562,696,774	6,345,205	534,980,001

[1]Includes both low-temperature filler and high-temperature refractory grades.

Table 8.—Georgia kaolin sold or used by producers, by use

(Short tons)

Use	1984 Air-float	1984 Unprocessed[1]	1984 Water-washed[2]	1984 Total	1985 Air-float	1985 Unprocessed[1]	1985 Water-washed[2]	1985 Total
Domestic:								
Adhesives	9,556	--	63,276	72,832	7,413	--	73,399	80,812
Aluminum sulfate and other chemicals	--	250,000	8,819	258,819	243	109,923	351	110,517
Animal feed	17	--	142	159	88	--	1,264	1,352
Asphalt tile and linoleum	3,635	--	--	3,635	3,776	--	--	3,776
Catalysts (oil-refining)	54,839	--	115,854	170,693	60,767	253	106,717	167,737
Cement, portland	--	72,700	--	72,700	--	--	--	--
Electrical porcelain	16,393	--	--	16,393	13,086	--	--	13,086
Face brick	--	20,700	--	20,700	--	25,943	55,285	81,228
Fiberglass and mineral wool	117,520	--	51,123	168,643	109,130	--	61,373	170,503
Fine china and dinnerware; crockery and earthenware	37,813	1,399	--	39,212	15,518	1,453	--	16,971
Firebrick, blocks and shapes	2,567	4,643	--	7,210	2,901	940	--	3,841
Floor and wall tile, ceramic	20,866	--	--	20,866	8,412	--	--	8,412
Flue linings; high-alumina brick and specialties; glazes, glass, enamels	20,000	3,030	--	23,030	--	3,064	--	3,064
Foundry sand	--	--	41	41	--	--	364	364
Grogs and calcines, refractory	--	245,000	--	245,000	1,544	260,567	--	262,111
Ink	W	--	W	W	W	--	W	W
Kiln furniture, refractory and mortar cement	W	W	--	W	W	W	--	W
Medical, pharmaceutical, cosmetic	--	--	1,894	1,894	1,233	--	1,202	2,435
Paint	14,314	--	187,473	201,787	21,734	--	150,825	172,559
Paper coating	8,827	--	2,465,748	2,474,575	--	--	2,263,846	2,263,846
Paper filling	89,484	--	890,799	980,283	27,107	--	1,144,228	1,171,335
Plastics	2,400	--	44,160	46,560	5,648	--	35,414	41,062
Pottery	271	699	--	970	9,224	726	--	9,950
Roofing granules	17,944	--	--	17,944	21,878	--	--	21,878
Rubber	24,803	--	60,487	85,290	92,709	1,213	28,962	122,884
Sanitary ware	108,579	11,891	51	120,521	122,630	12,353	728	135,711
Miscellaneous, air-float:								
Common brick, fertilizers, gypsum products, pesticides and related products, roofing and structural tile, other uses not specified	11,190	--	--	11,190	66,083	--	--	66,083
Miscellaneous, unprocessed:								
Fertilizers, pesticides and related products, other uses not specified (1985)	--	--	--	--	--	4,731	--	4,731
Miscellaneous, water-washed:								
Gypsum products, pesticides and related products, waterproofing and sealing, fertilizers, other uses not specified	--	--	57,127	57,127	--	--	100,181	100,181
Undistributed	19,873	30,032	220	50,125	20,805	49,337	90	70,232
Total	580,891	640,094	3,947,214	5,168,199	611,929	470,503	4,024,229	5,106,661

Exports:								
Paint	126	--	33,480	33,606	77,883	--	30,438	108,321
Paper coating	--	--	941,417	941,417	23,297	--	766,392	789,689
Paper filling	134	--	217,242	217,376	8,206	--	137,049	145,255
Plastics	21	--	22,935	22,956	--	--	19,223	19,223
Refractories	110	95,000	823	95,933	--	138,640	281	138,921
Rubber	24	--	785	809	235	--	885	1,120
Undistributed	10,563	--	17,460	28,023	18,013	--	18,002	36,015
Total	10,978	95,000	1,234,142	1,340,120	127,634	138,640	972,270	1,238,544
Grand total	591,869	735,094	5,181,356	6,508,319	739,563	609,143	4,996,499	6,345,205

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."

[1]Includes high-temperature calcined.

[2]Includes low-temperature calcined and delaminated.

Table 9.—South Carolina kaolin sold or used by producers, by kind

Kind	1984		1985	
	Short tons	Value	Short tons	Value
Air-float[1]	530,208	$32,188,917	504,330	$31,670,613
Unprocessed	246,359	1,215,170	362,482	3,638,725
Total	776,567	33,404,087	866,812	35,309,338

[1]Includes water-washed.

Table 10.—South Carolina kaolin sold or used by producers, by kind and use

(Short tons)

Kind and use	1984	1985
Air-float:[1]		
Adhesives	16,751	14,528
Animal feed and pet waste absorbent	6,844	5,333
Ceramics[2]	5,843	13,542
Fertilizers, pesticides and related products	19,300	33,855
Fiberglass	82,149	67,095
Paint	365	364
Paper coating and filling	1,488	1,843
Plastics	12,351	13,051
Rubber	204,627	188,945
Refractories[3]	9,318	30,052
Other uses[4]	108,514	85,495
Exports[5]	62,658	50,227
Total	530,208	504,330
Unprocessed: Face brick and other uses	246,359	362,482
Grand total	776,567	866,812

[1]Includes water-washed.
[2]Includes floor and wall tile, pottery, and roofing granules.
[3]Includes refractory calcines and grogs; refractory mortar and cement; high-alumina refractories; and firebrick, blocks and shapes.
[4]Includes animal oil, catalysts (oil-refining); chemical manufacturing, ink, medical, sewer pipe, and unknown uses.
[5]Includes ceramics, adhesives, paper filling, pesticides and related products, and rubber.

Table 11.—Kaolin sold or used by producers in the United States, by use

(Short tons)

Use	1984				1985			
	Air-float	Unprocessed[1]	Water-washed[2]	Total	Air-float	Unprocessed[1]	Water-washed[2]	Total
Domestic:								
Adhesives	26,307	--	66,733	93,040	21,941	--	75,632	97,573
Aluminum sulfate and other chemicals	--	327,497	10,544	338,041	243	202,424	3,017	205,684
Animal feed	6,861	--	5,526	12,387	5,421	--	5,686	11,107
Brick, common and face	5,213	319,340	--	324,553	6,692	487,694	--	494,386
Catalysts (oil- and gas-refining)	114,799	30,000	115,854	260,653	110,864	2,100	106,970	219,934
Cement, portland	--	134,240	1,336	135,576	--	133,977	1,140	135,117
China and dinnerware	31,767	1,399	1,240	34,406	13,908	1,453	729	16,090
Crockery and other earthenware	W	--	W	W	W	--	--	W
Electrical porcelain	26,871	--	--	26,871	24,810	--	312	25,122
Fertilizers[3]	11,300	--	2,986	14,286	26,165	--	2,937	29,102
Fiberglass, mineral wool and other insulation	212,174	--	66,607	278,781	223,472	--	80,079	303,551
Firebrick, blocks and shapes	7,814	4,643	--	12,457	5,713	936	4	6,653
Floor and wall tile; ceramic glazes, glass, enamels	30,477	2,820	--	33,297	18,571	--	--	18,571
Flue linings, high-alumina brick and specialties	20,000	47,818	--	67,818	22,807	92,191	--	114,998
Foundry sand	869	--	41	910	925	--	39	964
Grogs and calcines, refractory	4,886	417,062	--	421,948	4,790	286,034	--	290,824
Gypsum products and wallboard	8,324	7,249	2,759	18,332	4,721	--	3,696	8,417
Ink	W	--	W	W	W	--	W	W
Kiln furniture, refractory and mortar cement	17,662	30,032	--	47,694	45,195	49,337	--	94,532
Linoleum and asphalt tile	14,098	--	7,000	21,098	27,183	--	6,000	33,183
Medical, pharmaceutical, cosmetic	1,244	--	1,894	3,138	2,408	--	1,396	3,804
Paint	14,679	849	214,475	230,003	14,099	3,938	181,643	199,680
Paper coating	8,827	--	2,465,748	2,474,575	--	--	2,266,846	2,266,846
Paper filling	90,972	--	893,799	984,771	120,596	--	1,052,582	1,173,178
Pesticides and related products	8,073	31,750	2,458	42,281	7,848	15,344	44,037	67,229
Plastics	14,751	--	44,160	58,911	18,699	--	35,414	54,113
Pottery	4,568	699	1,712	6,979	13,159	726	1,546	15,431
Roofing granules	19,288	--	4,152	23,440	22,779	--	1,000	23,779
Roofing and structural tile	353	--	--	353	371	--	--	371
Rubber	229,430	--	65,139	294,569	230,507	--	83,484	313,991
Sanitary ware	109,912	11,891	51	121,854	124,095	12,353	730	137,178
Waterproofing and sealing	W	--	W	W	--	--	W	W
Miscellaneous	36,361	16,131	60,713	113,205	54,210	7,653	68,528	130,391
Total	1,077,880	1,383,420	4,034,927	6,496,227	1,172,192	1,296,160	4,023,447	6,491,799

See footnotes at end of table.

Table 11.—Kaolin sold or used by producers in the United States, by use —Continued

(Short tons)

Use	1984				1985			
	Air-float	Unprocessed[1]	Water-washed[2]	Total	Air-float	Unprocessed[1]	Water-washed[2]	Total
Exports:								
Ceramics	3,551	--	--	3,551	3,387	--	2,381	5,768
Foundry sand, grogs and calcines; other refractories	--	145,000	--	145,000	11,293	141,135	281	152,709
Paint	126	--	33,480	33,606	466	--	112,007	112,473
Paper coating	--	--	941,417	941,417	23,297	--	766,392	789,689
Paper filling	371	--	217,242	217,613	8,448	--	136,871	145,319
Plastics	21	--	22,935	22,956	--	--	19,223	19,223
Rubber	47,968	--	785	48,753	38,848	--	885	39,733
Miscellaneous	23,374	--	20,172	43,546	17,802	--	18,807	36,609
Total	75,411	145,000	1,236,031	1,456,442	103,541	141,135	1,056,847	1,301,523
Grand total	1,153,291	1,528,420	5,270,958	7,952,669	1,275,733	1,437,295	5,080,294	7,798,322

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Includes high-temperature calcined.
[2]Includes low-temperature calcined and delaminated.
[3]Includes soil conditioners and mulches.

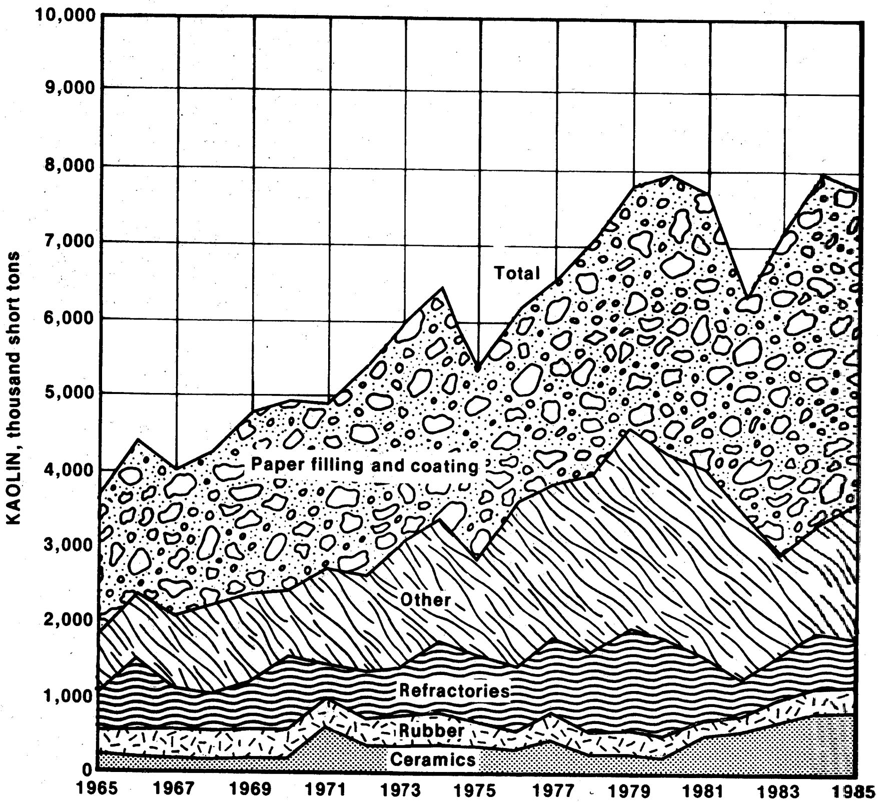

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

BALL CLAY

Reported production of domestic ball clay increased about 4% to nearly 902,000 tons valued at about $35 million. Tennessee provided 74% of the Nation's output, followed, in order of production, by Kentucky, Mississippi, Texas, and Maryland.[2] Production, as in 1984, either increased or remained relatively unchanged in all States. The principal ball clay markets were ceramics, chiefly dinnerware, pottery, sanitary ware, and wall tile. Domestic producers also enjoyed a robust export market, despite a strong U.S. dollar, usually over 20% of total production. Continued recovery of the domestic construction industry, spurred on by declining interest rates and the improved overall economy during the year, increased the demand for ball clays.

Ball clay is defined as a plastic, white-firing clay used principally for bonding in ceramic ware. The clay is of sedimentary origin and consists mainly of the clay mineral kaolinite and sericite mica.

Industrywide enlargements, modernizations, and/or mergers started to occur again. H. C. Spinks Clay Co. announced plans to open a new ball clay mine in the Paris, TN, area and began expansion of its facilities to ship water-slurried clays by tank cars. Spinks previously only produced dry-processed clay. Most of the major ball clay producers were currently either producing or planning to produce slurried clays. American Olean Tile Co., a subsidiary of National Gypsum Co., announced plans for a $13 million expansion of its Lansdale, PA, manufacturing facilities, to be completed by mid-1986. The enlargement was to include state-of-the-art ceramic tile manufacturing equipment capable of producing a more versatile product line to meet the ever changing consumer demand in sizes and shapes of glazed floor tile for residential and commercial uses.

The average unit value for ball clay reported by domestic producers increased over 7% to $38.49. Chemical Marketing Reporter, December 31, 1985, listed ball clay prices as follows:

Domestic, air-floated, bags, carload lots, Tennessee, per ton	$49.00
Domestic, crushed, moisture-repellent, bulk carload lots, Tennessee, per ton	24.00

Ball clay exports increased nearly 24% to 204,000 tons valued at $6.8 million. Unit value decreased slightly to $33.21 from $39.37 per ton in 1984. Shipments were made to 30 countries, the same as in 1984. The major recipients were Mexico, 60%; the Federal Republic of Germany, 20%; and Canada, 16%. The large Mexican ceramic market continued to be partially supplied by its domestic clay because of international financial difficulties, and its ceramic exports, predominantly to the United States, are fabricated largely with U.S. and domestic clays.

Ball clay imports, again almost entirely from the United Kingdom, decreased 36% to 1,269 tons valued at $148,000. The unit value of these imports increased 15% to $116.63 per ton.

Table 12.—Ball clay sold or used by producers in the United States, by State

State	Air-float		Unprocessed		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1984						
California	--	--	246	$2,958	246	$2,958
Tennessee[r]	479,353	$17,000,841	[1]125,560	[1]3,523,445	604,913	20,524,286
Other[r]	[2]251,090	[2]10,118,879	[3]11,175	[3]453,536	262,265	10,572,415
Total[r]	730,443	27,119,720	136,981	3,979,939	867,424	31,099,659
1985						
Tennessee	[1]502,301	[1]20,463,910	162,254	4,136,759	664,555	24,600,669
Other[2]	203,634	9,036,635	33,490	1,070,953	237,124	10,107,588
Total	705,935	29,500,545	195,744	5,207,712	901,679	34,708,257

[r]Revised.
[1]Includes water-slurried.
[2]Includes Kentucky, Maryland, Mississippi, and Texas
[3]Includes Kentucky, Maryland, Mississippi, and New York.

Table 13.—Ball clay sold or used by producers in the United States, by use

(Short tons)

Use	1984[r]			1985		
	Air-float[1]	Unprocessed	Total	Air-float[1]	Unprocessed	Total
Adhesives	W	--	W	W	--	W
Animal feed	W	W	8,535	W	W	13,943
Crockery and other earthenware	W	--	W	W	W	W
Drilling mud	W	--	W	W	--	W
Electrical porcelain	18,787	7,059	25,846	42,240	--	42,240
Fiberglass and catalysts (oil-refining)	W	--	W	W	W	W
Fine china and dinnerware	35,704	--	35,704	27,491	--	27,491
Firebrick, blocks and shapes	W	W	W	W	W	W
Floor and wall tile	92,115	35,981	128,096	97,586	31,466	129,052
Glazes, glass, enamels	2,461	273	2,734	1,606	--	1,606
Grogs and calcines, high-alumina, mortar and cement, other refractories	93,752	8,207	101,959	91,791	13,837	105,628
Kiln furniture	1,789	--	1,789	1,708	--	1,708
Paper coating and filling	11,062	--	11,062	5,532	--	5,532
Pesticides and related products	W	--	W	W	--	W
Pottery	180,759	17,022	197,781	140,375	63,118	203,493
Rubber	W	--	W	W	W	W
Sanitary ware	92,683	45,379	138,062	114,788	38,309	153,097
Miscellaneous	119,061	19,649	[2]130,175	130,540	23,479	[2]140,076
Exports	82,270	3,411	85,681	52,278	25,535	77,813
Total	730,443	136,981	867,424	705,935	195,744	901,679

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Total" and/or "Miscellaneous."
[1]Includes water-slurried.
[2]Incomplete total; difference included in totals for specific uses.

FIRE CLAY

Fire clay sold or used by domestic producers decreased 15% to about 974,000 tons valued at $18.0 million. Fire clay is defined as detrital material, either plastic or rock-like, containing low percentages of alkalies, iron oxide, lime, and magnesia to enable the material to withstand temperatures of 1,500° C or higher. It is basically kaolinite but usually contains other materials such as ball clay, bauxite clay, diaspore, and shale. Fire clay commonly occurs as underclay below coal seams and is generally used for refractories.

Industrywide expansions and modernizations were slowed during the year, while acquisitions and/or mergers were commonplace. Plants continued to be either operating intermittently or on minimal production schedules. The clay refractory industry has been in a period of low production since 1982, reflecting lower demand by major consumers—steel, nonferrous metals, ceramics, glass, and minerals processing. The fire clay industry's problems were further exacerbated by the technological changes in steelmaking processes that require more higher alumina-based refractories, either direct-fired or specialties, which contain less fire clay. These uncertainties in the fire clay industry resulted in the divestiture of refractory manufacturing operations of Kaiser Aluminum & Chemical Corp. and Allied-Signal Inc. Kaiser sold most of its North American clay and nonclay refractory manufacturing and administrative facilities in California, Indiana, Missouri, Ohio, and Ontario, Canada, to the newly formed employee-owned National Refractories and Minerals Corp., a company organized by the former management of Kaiser Refractories and Kelso and Co., an investment banker, for an undisclosed sum. The Allied-Signal's divestiture included its North American Refractories Co. (NARCO), which, subject to financing, was purchased by Kirtland Capital Corp. and members of NARCO'S management. NARCO, headquartered in Cleveland, OH, operates 10 manufacturing facilities in the United States and Canada.

An exception to the industry malaise was the $8 million expansion by Didier-Taylor Refractories Corp. of its Cincinnati, OH, plant. The expansion included a one-third increase of the existing area to boost production of continuous steel casting refractories, a clay-derived mullitic and/or zirconia-based material.

Exports of fire clay decreased about 3% to 223,000 tons valued at $17.8 million. The unit value of exported clay increased 6% to $79.86 indicating that, despite a decrease in exports, the trend of shipping a higher percentage of higher quality material continued. Fire clay was exported to 24 countries, a decrease of 7 from that of 1984. Japan received 27%, while Belgium-Luxembourg, Canada, and Mexico received 24%, 13%, and 11%, respectively. No imports were again reported for fire clay.

Unit value for fire clay, reported by producers, ranged from about $2.00 to $30.00 per ton. The average unit value remained relatively unchanged at $18.46 per ton.

Table 14.—Fire clay[1] sold or used by producers in the United States, by State

State	1984		1985	
	Short tons	Value	Short tons	Value
Alabama	144,267	$3,488,675	130,000	$3,217,200
Colorado	14,795	169,403	20,384	166,330
Missouri	427,681	8,540,260	283,697	5,072,854
Montana	--	--	503	2,641
New Jersey	12,018	211,000	10,166	250,079
New Mexico	1,813	11,080	2,767	16,547
Ohio	303,327	5,004,394	241,045	4,442,140
Pennsylvania	60,507	305,196	80,610	772,095
Texas	24,251	189,894	21,196	156,190
Utah	411	3,289	500	3,300
Washington	6,000	W	--	--
West Virginia	98,064	2,794,824	98,064	2,794,824
Other[2]	51,840	422,871	85,482	1,092,536
Total	1,144,974	21,140,886	974,414	17,986,736

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Refractory uses only.
[2]Includes California, Idaho, Indiana (1984), Kentucky, and value indicated by symbol W.

BENTONITE

Bentonite production decreased over 7% to about 3.2 million tons valued at almost $102 million. A 12% decrease in production of swelling bentonite in Wyoming, the largest producing State, accounted for most of this decrease. Domestic production for drilling mud, foundry sand, and pelletizing iron ore all declined.

Bentonite was again produced in 13 States. The high-swelling or sodium bentonites continued to be produced chiefly, in descending order, in Wyoming and Montana. The calcium or low-swelling bentonites continued to be produced in the other States. Calcium bentonite production in Mississippi is suitable for the production of both absorbent and acid-activated products.

The major western and southern bentonite producers continued to cancel or defer planned enlargements and/or modernizations. Most plants continued sporadic operation at new lower production levels. The industry depression continued to be caused by lower oil- and gas-drilling activities during the year, exacerbated by the downturn in the steel and foundry industries. These three industries traditionally consume about 90% of the total domestic output. Some drilling activity increased in the first three quarters of the year but slowed again at yearend.

Exceptions to industry retrenchments were largely confined to the calcium bentonite or southern bentonite producers. American Colloid Co., Skokie, IL, completed a $3.5 million expansion at its Aberdeen, MS, facility, to produce acid-activated clays for purifying and filtering edible and nonedible oils and juices. In a novel barge loading scheme, to increase export competitiveness by lowering transportation costs, American Colloid began using an abandoned bridge over the Tennessee-Tombigbee Waterway to load barges with granular product as a first leg in shipping clay to Asian markets. The Belen City Council, Belen, NM, approved the issue of industrial revenue bonds for the maintenance of a city-owned facility, operated by the lessee, United Desiccants Div. of United Catalysts, to manufacture and market clay desiccants used in shipping moisture-sensitive electronic and photographic components.

The Office of Surface Mining granted the State of Wyoming $30 million to reclaim about 100 sodium bentonite mines on 5,000 acres in Crook County, northern Wyoming. The funds were also to be used for reclaiming several other minesites, one of which was a shale mine.

On December 31, 1985, Chemical Marketing Reporter quoted domestic bentonite, 200 mesh, bags, carload lots, f.o.b. mines, as unchanged at $43.50 per ton. The average unit value reported by domestic producers increased 10% to $31.90 per ton. Per-ton values reported in the various producing States ranged from $14 to over $70, but the average value reported by the larger producers was near the Montana average of about $32.

Bentonite exports increased nearly 14% to 640,000 tons valued at almost $45.0 million. The unit value of exported bentonite decreased nearly 13% to $70.27 per ton; this was attributed to higher percentages of lower cost iron ore pelletizing grades shipped over the costlier drilling-mud and foundry grades exported. Domestic bentonite producers continued to face increased competition in foreign markets; in particular, the Canadian iron ore markets where Mediterranean bentonites have made inroads into an area traditionally served by domestic producers.

Bentonite was exported to 67 countries, a decrease of 4 from that of 1984. The major recipients were Canada, 49%; Japan, 15%; the Netherlands and Singapore, 4% each; and the United Kingdom, 3%. Domestic bentonite producers reported their exports were foundry sand, 39%; drilling mud, 27%; and other, 33%.

Bentonite imports, consisting mostly of both untreated clay and chemically or artificially activated material, increased over 35% to nearly 23,000 tons. The chemically activated category, slowly increasing in quantity for the past several years, increased over 35% to 14,443 tons valued at $3.7 million, primarily because of increased shipments from Mexico, which were 64% more than those of 1984. The chemically activated bentonite was imported from six countries, one less than in 1984, with Mexico supplying 74%; Canada, 22%; the United Kingdom, 3%; and the Federal Republic of Germany, Japan, and Switzerland, the remaining 1%.

Table 15.—Bentonite sold or used by producers in the United States, by State

State	Nonswelling		Swelling		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1984						
Arizona	20,466	$300,618	28	$835	20,494	$301,453
California	69,098	5,099,773	25,445	1,593,017	94,543	6,692,790
Colorado	139	1,896	11	204	150	2,100
Kansas	--	--	20,000	750,000	20,000	750,000
Mississippi[r]	227,625	6,385,218	--	--	227,625	6,385,218
Montana[r]	--	--	212,223	5,615,989	212,223	5,615,989
Nevada	--	--	20,092	1,191,011	20,092	1,191,011
Texas	35,850	W	26,495	W	62,345	925,694
Utah	--	--	3,994	139,810	3,994	139,810
Wyoming[r]	--	--	2,414,905	66,686,549	2,414,905	66,686,549
Other[r]	[1]158,171	[1]5,591,798	[2]203,398	[2]5,928,019	361,569	[3]10,594,123
Total[r]	511,349	17,379,303	2,926,591	81,905,434	3,437,940	99,284,737
1985						
Arizona	31,924	713,571	900	27,000	32,824	740,571
California	92,379	6,681,403	20,511	1,349,102	112,890	8,030,505
Colorado	74	740	6	60	80	800
Kansas	--	--	24,000	888,000	24,000	888,000
Mississippi	197,531	6,106,229	--	--	197,531	6,106,229
Montana	--	--	254,398	8,232,639	254,398	8,232,639
Nevada	--	--	79,861	3,775,947	79,861	3,775,947
Texas	30,791	637,227	15,971	212,470	46,762	849,697
Utah	--	--	14,006	420,721	14,006	420,721
Wyoming	--	--	2,116,085	63,064,643	2,116,085	63,064,643
Other	[1]145,250	[1]3,250,695	[2]171,593	[2]6,565,338	316,843	9,816,033
Total	497,949	17,389,865	2,697,331	84,535,920	3,195,280	101,925,785

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Alabama, Idaho, and Louisiana (1984).
[2]Includes Idaho and South Dakota.
[3]Incomplete total; difference included with individual State totals.

Table 16.—Bentonite sold or used by producers in the United States, by use

(Short tons)

Use	1984[r]			1985		
	Non-swelling	Swelling	Total	Non-swelling	Swelling	Total
Domestic:						
Adhesives	--	6,757	6,757	2,000	6,938	8,938
Animal feed	49,811	136,321	186,132	38,265	92,219	130,484
Catalysts (oil-refining)	8,763	--	8,763	5,748	2,470	8,218
Cement, portland	--	W	W	--	W	W
Drilling mud	14,878	1,346,191	1,361,069	17,913	1,168,728	1,186,641
Filtering, clarifying, decolorizing:						
Animal oils, mineral oils and greases, and desiccants	1,074	5,119	6,193	7,300	3,071	10,371
Vegetable oils	--	--	--	29,200	--	29,200
Foundry sand	227,886	520,177	748,063	206,388	522,199	728,587
Glazes, glass, enamels	--	W	W	--	W	W
Medical, pharmaceutical, cosmetic	--	5,081	5,081	--	3,968	3,968
Oil and grease absorbents	100,951	45	100,996	34,448	45	34,493
Paint	--	10,852	10,852	--	7,161	7,161
Pelletizing (iron ore)	--	404,493	404,493	--	290,567	290,567
Pesticides and related products	425	10,268	10,693	897	235	1,132
Waterproofing and sealing	1,597	72,795	74,392	3,432	119,876	123,308
Miscellaneous[1]	103,016	67,524	170,540	126,302	79,334	205,636
Total	508,401	2,585,623	3,094,024	471,893	2,296,811	2,768,704
Exports:						
Drilling mud	--	153,188	153,188	--	117,130	117,130
Foundry sand	1,310	161,038	162,348	24,978	142,420	167,398
Other[2]	1,638	26,742	28,380	1,078	140,970	142,048
Total	2,948	340,968	343,916	26,056	400,520	426,576
Grand total	511,349	2,926,591	3,437,940	497,949	2,697,331	3,195,280

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous."
[1]Chemical manufacturing; fiberglass; firebrick, blocks and shapes; gypsum products; mineral wool and insulation; paper coating and filling; pet waste absorbents; plastics; rubber; ink; uses not specified; and data indicated by symbol W.
[2]Includes animal feed, face brick, paint, plastics, waterproofing and sealing, and uses not specified.

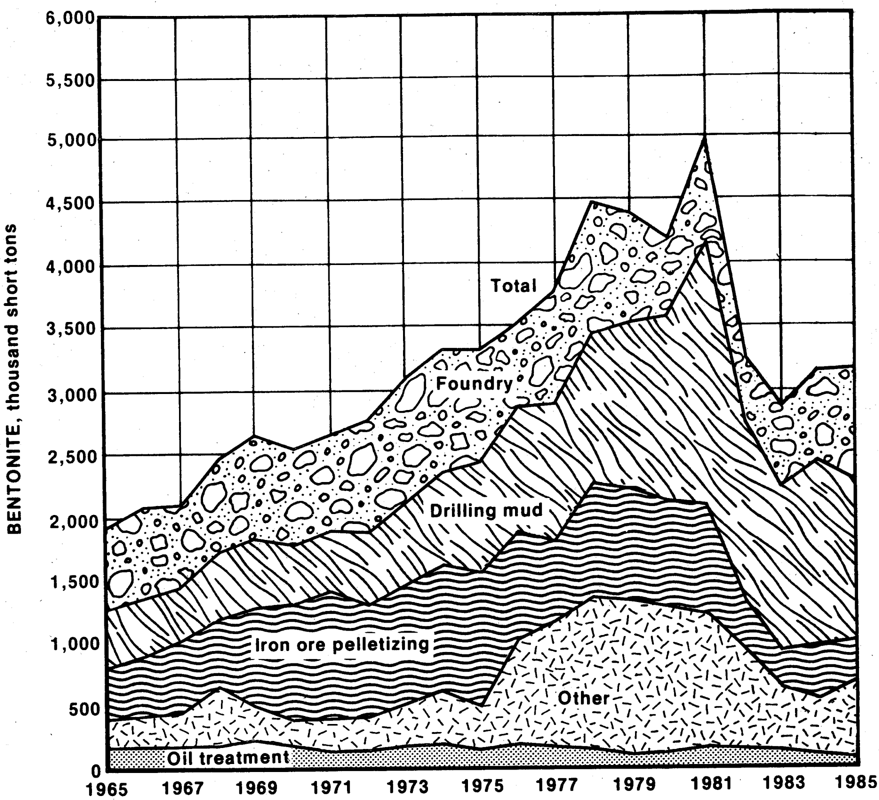

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

FULLER'S EARTH

Production of fuller's earth increased 8% to almost 2.1 million tons valued at about $129 million. This increase in production, after the first reported decline in 1984, marks a return to the upward trend in production that the industry has enjoyed for over 10 years. Generally an increase in absorbent-grade clay production was partially offset by a 16% decline in attapulgite-gelling clay production in Florida. The average unit value increased slightly to $62.87 per ton. Production was reported from operations in 10 States, or 1 less than in 1984. The two top producing States, Florida and Georgia, accounted for 48% of domestic production. All States, except Florida, Missouri, and South Carolina, showed gains in production.

Increases in consumption occurred in oil and grease absorbents while consumption of pet waste absorbents declined.

Fuller's earth is defined as a nonplastic clay or claylike material, usually high in magnesia, which has adequate absorbing, decolorizing, and purifying properties. Sepiolite-type clays are also included for statistical convenience.

Production from the region that includes Attapulgus, Decatur County, GA, and Quincy, Gadsden County, FL, is composed predominantly of the lath-shaped amphibole-like clay mineral attapulgite. Most of the fuller's earth produced in other areas of the United States contains varieties of montmorillonite.

Industrywide enlargements, modernizations, acquisitions, and/or merger plans, slowed because of the economic downturn in the past 2 years, were beginning to be activated again. Oil-Dri Corp., Chicago, IL, finalized the purchase of Anschutz Mining Corp., near Ochlocknee, GA, for $1.75 million in cash and notes. The newly acquired assets included buildings, equipment, land,

and mineral leases all situated directly adjacent to Oil-Dri's plant and mining operations. A stock offering was also announced by Oil-Dri to raise capital for expanding and improving both Ochlocknee facilities. The projected growth of the premium segment of the cat litter market and Oil-Dri's emphasis on developing agriculturally related and specialty absorbents were cited for the additional reserves and plant capacity. In another acquisition, United States Borax & Chemical Corp., Los Angeles, CA, a subsidiary of The Rio Tinto Zinc Corp. PLC of the United Kingdom, purchased the assets of Pennsylvania Glass Sand Corp. (PGS), Berkeley Springs, WV, a subsidiary of ITT Corp., for $80 million. The purchase included PGS' Floridin Co., a major Florida producer of attapulgite-type fuller's earth used primarily in absorbent, thickening, and drilling-mud markets. Floridin also completed doubling its production capacity for its specially processed finely ground attapulgite used as thickening and suspending agents in paint, wallboard, adhesives, and asphalt coating and/or sealants applications at its fully automated Quincy, FL, plant. Floridin and the Seaboard Coast Line successfully developed a double-tier stacking arrangement for shipping up to 55 tons of bagged clay in a boxcar. Previously, single pallets, weighing up to 30 tons, were permitted in a 50-foot boxcar. The novel shipping techniques should increase the competitiveness of rail shipments.

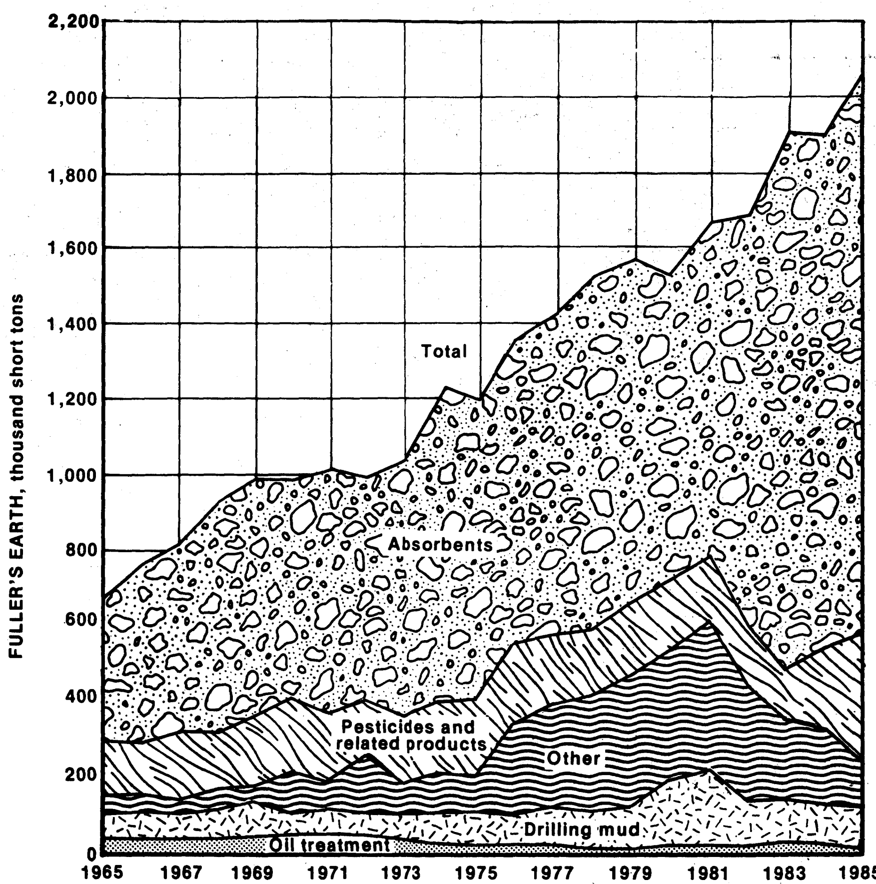

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

Table 17.—Fuller's earth sold or used by producers in the United States, by State

State	Attapulgite		Montmorillonite		Total	
	Short tons	Value	Short tons	Value	Short tons	Value
1984						
Florida	459,502	$30,785,273	--	--	459,502	$30,785,273
Georgia	363,669	23,601,595	205,414	$8,812,997	569,083	32,414,592
Virginia	--	--	24,000	2,400,000	24,000	2,400,000
Other	[1]115,190	[1]6,371,947	[2]731,370	[2]46,417,069	846,560	52,789,016
Total	938,361	60,758,815	960,784	57,630,066	1,899,145	118,388,881
1985						
Florida	387,076	29,451,978	--	--	387,076	29,451,978
Georgia	386,737	25,333,176	206,296	9,294,984	593,033	34,628,160
Virginia	--	--	28,000	2,940,000	28,000	2,940,000
Other	[1]146,819	[1]8,293,241	[2]904,353	[2]54,155,576	1,051,172	62,448,817
Total	920,632	63,078,395	1,138,649	66,390,560	2,059,281	129,468,955

[1]Includes Illinois, Nevada (1984), and Texas.
[2]Includes Illinois, Mississippi, Missouri, Nevada (1985), South Carolina, Tennessee, and Utah (1984).

Table 18.—Fuller's earth sold or used by producers in the United States, by use

(Short tons)

Use	1984			1985		
	Attapulgite	Montmorillonite	Total	Attapulgite	Montmorillonite	Total
Domestic:						
Adhesives	1,798	--	1,798	2,740	--	2,740
Animal feed	12,139	--	12,139	--	--	--
Drilling mud	105,716	--	105,716	106,980	--	106,980
Fertilizers	52,291	10,576	62,867	46,899	10,482	57,381
Filtering, clarifying, decolorizing mineral oils and greases	18,017	784	18,801	15,321	--	15,321
Medical, pharmaceutical, cosmetic	105	--	105	94	--	94
Oil and grease absorbents	209,831	220,878	430,709	291,612	309,015	600,627
Paint	6,606	--	6,606	3,244	--	3,244
Pesticides and related products	96,200	120,223	216,423	92,266	164,546	256,812
Pet waste absorbents	291,943	506,279	798,222	214,800	566,869	781,669
Other[1]	25,872	19,841	45,713	22,782	23,400	46,182
Miscellaneous[2]	28,710	30,911	59,621	17,417	27,094	44,511
Total	849,228	909,492	1,758,720	814,155	1,101,406	1,915,561
Exports:						
Drilling mud	1,246	--	1,246	156	--	156
Oil and grease absorbents	41,020	38,138	79,158	61,518	18,701	80,219
Pesticides and related products	9,135	373	9,508	8,418	971	9,389
Pet waste absorbents	27,642	12,295	39,937	27,382	11,434	38,816
Miscellaneous[3]	10,090	486	10,576	9,003	6,137	15,140
Total	89,133	51,292	140,425	106,477	37,243	143,720
Grand total	938,361	960,784	1,899,145	920,632	1,138,649	2,059,281

[1]Includes paper filling and roofing granules.
[2]Includes common brick; catalysts (oil-refining); chemical manufacturing; glazes, glass, and enamels; gypsum products; mortar and cement refractories; plastics; pottery; and sanitary ware.
[3]Includes paint and uses not specified.

Attapulgite, a fuller's earth-type clay, finds wide application in both absorbent and gelling and/or thickening areas. The thixotropic properties of attapulgite clays provide the important thickening and viscosity controls necessary for suspending solids. Mineral thickeners are used in such diverse markets as paint, joint compound cement, and saltwater drilling muds.

Prices for attapulgite reported by producers ranged from $49.50 to $68.51 per ton; montmorillonite prices ranged from about $21.00 to $105.00.

Exports of fuller's earth went to 33 countries, 2 more than in 1984, but the quantity decreased over 10% to 104,000 tons valued at about $9.1 million. The unit value of exported fuller's earth increased nearly 10% over that of 1984 to $87.84, which was attributed to a larger percentage of the high-cost gelling and drilling-mud grades exported in 1985 compared with the absorbent grades shipped. The major recipients were Canada, 73%; the Netherlands, 17%;

and the United Kingdom, 3%. Imports of fuller's earth, usually nil, were 3,814 tons valued at about $153,000. Imports consisted of over 3,600 tons of drilling-mud attapulgite received at New Orleans, LA. All attapulgite previously used by the domestic drilling-mud companies was domestically produced clay. Continued imports of attapulgite for the already depressed drilling exploration market will probably result in further production cutbacks by the domestic suppliers.

COMMON CLAY

Domestic sales or use of common clay and shale increased 6% to about 30.2 million tons valued at almost $132 million. Output rose above 5% in each of the States that produced over 1 million tons except for South Carolina. Texas, the major producing State, increased about 15%, which was largely attributed to the increased use of lightweight aggregates in road surfacing. The increase offset the decline in building construction rates because of its softening oil- and gas-based economy. Common clay and shale represented 67% of the quantity and 13% of the value of total domestic clay production. Domestic clay and shale are generally mined and used captively to fabricate or manufacture products. Less than 10% of the total output is usually sold. The average unit value for all common clay and shale produced in the United States and Puerto Rico decreased 3% to $4.37 per ton. The unit value ranged from $2 to over $20.

Table 19.—Common clay and shale sold or used by producers in the United States,[1] by State

State	1984		1985	
	Short tons	Value	Short tons	Value
Alabama	1,523,073	$8,379,481	1,630,739	$7,962,196
Arizona	117,134	517,140	153,608	762,708
Arkansas	933,420	2,157,030	911,335	1,891,739
California	1,945,840	15,334,228	2,062,256	17,809,172
Colorado	293,347	1,939,506	282,411	1,575,560
Connecticut	99,078	564,620	106,033	631,873
Florida	279,947	824,512	248,680	779,176
Georgia	1,601,268	4,917,857	1,732,742	5,488,744
Illinois	253,381	939,966	265,467	876,123
Indiana	653,135	2,085,427	739,711	2,776,446
Iowa	623,169	2,694,651	503,298	2,449,931
Kansas	897,722	4,786,598	854,177	4,437,709
Kentucky	661,644	2,532,769	661,176	2,305,585
Louisiana	539,472	10,858,373	333,619	7,016,609
Maine	43,488	96,522	49,500	99,555
Maryland	346,963	1,483,631	336,085	1,646,991
Massachusetts	239,929	1,211,614	264,538	1,388,090
Michigan	1,320,774	5,051,586	1,477,309	5,513,822
Mississippi	r1,045,938	r3,981,311	850,706	3,292,143
Missouri	1,079,094	4,178,762	1,204,854	3,497,245
Montana	16,422	25,743	24,190	60,369
Nebraska	179,946	555,818	244,228	718,214
New Jersey	50,000	400,000	120,000	1,800,000
New Mexico	64,784	132,226	57,048	144,167
New York	543,368	2,434,776	699,764	3,129,207
North Carolina	2,280,634	7,911,093	2,611,455	8,533,367
Ohio	1,656,686	5,468,566	1,873,037	6,138,465
Oklahoma	979,291	2,498,178	996,522	2,337,657
Oregon	189,167	288,443	188,026	284,626
Pennsylvania	902,448	3,745,079	1,061,607	4,520,686
Puerto Rico	127,966	266,435	118,192	263,568
South Carolina	1,057,061	3,405,359	1,029,178	2,385,886
South Dakota	119,149	343,149	117,065	309,052
Tennessee	560,278	1,165,263	579,069	1,312,029
Texas	3,406,593	15,362,396	3,919,159	18,317,566
Utah	310,439	2,079,497	317,725	2,085,283
Virginia	687,968	3,603,785	786,295	4,036,908
Washington	285,961	1,598,120	242,914	1,402,107
West Virginia	283,328	615,084	233,269	547,627
Wyoming	213,350	1,234,381	185,917	1,081,562
Other[2]	115,492	422,688	95,421	324,908
Total	r28,528,147	r128,091,663	30,168,325	131,934,671

rRevised.
[1]Includes Puerto Rico.
[2]Includes Minnesota, New Hampshire, and North Dakota.

Common clay is defined as a clay or claylike material that is sufficiently plastic to permit ready molding and that vitrifies below 1,100° C. Shale is a sedimentary rock composed chiefly of clay minerals that has been both laminated and indurated while buried under other sediments. Clay and shale are used in the manufacture of structural clay products such as brick and drain tile, portland cement clinker, and expanded lightweight aggregates.

Increased production capacities, new plants, modernizations, acquisitions and/or mergers proceeded slowly during the year. The construction industry, the biggest user of heavy clay products, such as brick, lightweight aggregate, portland cement, sewer pipe, and tiles was moving along at a brisk pace. Large inventories accumulated during the winter months were worked off by the first quarter, and at midyear, the industry was experiencing heavy production, somewhat encouraged by declining interest rates. A notable exception to boom times was the declining construction rates in the depressed oil producing States of Texas, Louisiana, and Oklahoma.

In acquisitions, Jim Walter Corp., a large Tampa, FL, building supply and home building company, purchased Cherokee Brick of North Carolina Inc. and Sanford Brick Corp., also in North Carolina, for an undisclosed sum. The purchase, Walter's first of a brick plant, signals the company's move to further diversify its building supply line by adding brick. Cherokee, based in Raleigh, has a plant in Mancure, and Sanford Brick, based in Sanford, has plants in Sanford and Norwood and a Chatham County plant making specialty bricks of various sizes and colors. North Carolina is traditionally the largest brick producing State. In another move, Old Virginia Brick Co. (OVB) was acquired by a group of three entrepreneurs experienced in the brick industry. The company, in business since 1890, produces both wood-molded and extruded bricks at its Salem, VA, complex, near Roanoke. The new owners planned substantial changes in both plant operations and marketing strategies along with automation in administration and quality control.

Increases in production capacity were announced by Robinson Brick Co., Denver, CO; and Cloud Ceramics Inc., Concordia, KS, installed a new slug cutter to replace one that cut nearly 1 billion bricks. An oxygen enrichment scheme for gas firing its tunnel kilns was successfully completed by Watsontown Brick Co. at its Watsontown, PA, brickworks. The new firing scheme not only succeeded in reducing gas costs by over 20% but unexpectedly resulted in producing a more competitive, deeper, and uniformly colored red brick.

CONSUMPTION AND USES

The manufacture of heavy clay products including (1) building brick, sewer pipe and drain, roofing, structural, terra cotta, and other tile; (2) portland cement clinker; and (3) lightweight aggregate accounted for 35%, 20%, and 10%, respectively, of total domestic consumption. In summary, 65% of all clay produced was consumed in the manufacture of these clay- and shale-based construction materials.

Heavy Clay Products.—The value reported for shipments by the Bureau of the Census of heavy clay products increased 6% to about $1.43 billion. The million standard brick count for building or common face brick increased slightly. Shipments of clay floor and wall tile increased 9%, while vitrified clay sewer pipe and fittings decreased 7%. Increases in common clay and shale used in building brick manufacturing occurred in most States with total domestic production increasing 3%. Increases were largely under 10% with an average State upturn of about 6%.

Lightweight Aggregates.—Consumption of clay and shale in the manufacture of lightweight aggregate increased nearly 8% to about 4.7 million tons. The upturn in overall construction uses, except for the largest category, concrete block (55% of total production), which declined 2%, was largely responsible. Highway surfacing increased 22%, while the second largest consuming area, structural concrete (30% of production), increased 18%. The new market areas, such as recreational and horticultural uses included in the other category, increased 24%.

Refractories.—All types of clay were used in manufacturing refractories. Bentonite, fire clay, and kaolin accounted for 28%, 32%, and 19%, respectively, of total clay used for this purpose. The remainder, ball clay, common clay and shale, and fuller's earth, were used chiefly as bonding agents. Bentonite, both swelling and nonswelling, was used as a bonding agent in proprietary foundry formulations imparting both green strength and hot strength to the sand.

Table 20.—Clays sold or used by producers in the United States[1] in 1985, by use

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Total
Absorbents:							
Oil and grease absorbents	--	34,493	W	--	600,627	--	635,120
Pet waste absorbents	--	W	W	29,200	781,669	--	810,869
Other[2]	--	61,494	135,349	--	--	--	196,843
Ceramics and glass:							
Catalysts (oil-refining)	W	8,218	--	--	W	219,934	228,152
Crockery and other earthenware	W	--	8,331	16,134	--	W	24,465
Electrical porcelain	42,240	--	54	--	--	25,122	67,416
Fine china and dinnerware	27,491	--	--	--	--	16,090	43,581
Glazes, glass, enamels	1,606	W	--	5,000	W	489	7,095
Mineral wool and insulation, fiberglass	W	W	--	--	--	303,551	303,551
Pottery	203,493	--	9,361	2,023	W	15,431	230,308
Roofing granules	--	1,029	100,600	--	--	23,779	125,408
Sanitary ware	153,097	--	--	--	W	137,178	290,275
Other[2]	108,014	2,507	--	--	6,270	--	116,791
Chemical manufacturing	--	2,986	--	--	1,772	46,461	51,219
Civil engineering and sealing	--	123,308	148,710	--	--	4,866	276,884
Drilling mud	W	1,186,641	--	--	106,980	104	1,293,725
Fillers, extenders, binders:							
Adhesives	W	8,938	--	W	2,740	97,573	109,251
Animal feed	13,943	130,484	4,000	W	--	11,107	159,534
Fertilizers	--	--	--	--	57,381	29,102	86,483
Gypsum products and wallboard	--	--	--	--	W	8,417	8,417
Ink	--	W	--	--	--	W	W
Medical, pharmaceutical, cosmetic	W	3,968	--	--	94	3,804	7,866
Paint	W	7,161	50	--	10,395	199,680	217,286
Paper coating	W	W	--	--	--	2,266,846	2,266,846
Paper filling	W	W	--	--	2,759	1,173,178	1,175,937
Pesticides and related products	W	1,132	5,144	--	256,812	67,229	330,317
Plastics	--	W	--	W	W	54,113	54,113
Rubber	W	W	7,410	W	--	313,991	321,401
Other[2]	16,699	7,533	--	1,500	3,120	942	29,794
Filtering, clarifying, decolorizing:							
Animal oils	--	1,741	--	--	--	650	2,391
Desiccants	--	29,200	--	--	--	--	29,200
Mineral oils and greases	--	8,630	--	--	15,321	--	23,951

See footnotes at end of table.

Table 20.—Clays sold or used by producers in the United States[1] in 1985, by use —Continued

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Total
Floor and wall tile:							
Ceramic	129,052	--	97,746	12,759	--	18,082	257,639
Quarry tile	--	--	189,146	--	--	--	189,146
Other	6,316	--	--	--	--	57,676	63,992
Heavy clay products:							
Brick, common	2,921	3,433	2,522,955	176	--	10,840	2,540,325
Brick, face	--	--	12,450,809	16,861	--	483,546	12,951,216
Drain tile	--	--	30,624	--	--	--	30,624
Flower pots	--	--	42,401	--	--	--	42,401
Flue linings	--	--	64,890	9,983	--	3,064	77,937
Portland and other cements	--	611	8,708,502	3,405	--	135,117	8,847,635
Roofing tile	--	--	23,574	--	--	--	23,574
Sewer pipe, vitrified	--	--	282,068	223	--	8,768	291,059
Structural tile	--	--	36,975	--	--	871	37,846
Terra cotta	--	--	887	--	--	--	887
Other	--	16,584	6,024	--	--	--	22,608
Lightweight aggregate:							
Concrete block	--	--	2,612,678	--	--	--	2,612,678
Highway surfacing	--	--	546,382	--	--	--	546,382
Structural concrete	--	--	1,412,858	--	--	502	1,413,360
Other	--	--	138,898	--	--	--	138,898
Pelletizing iron ore	--	290,567	--	--	--	--	290,567
Refractories:							
Firebrick, blocks and shapes	W	1,542	135,454	491,290	--	6,653	634,939
Foundry sand	--	728,587	--	69,477	--	964	799,028
Grogs and calcines	W	--	--	137,438	--	290,824	428,262
High alumina brick and specialties	6,627	6,714	--	66,712	--	111,934	191,987
Kiln furniture	1,708	--	--	--	--	1,747	3,455
Mortar and cement, refractory	W	--	289,376	90,532	26,198	92,785	498,891
Other[2]	110,659	--	--	--	--	--	110,659
Other[3]	--	101,203	133,552	15,647	43,423	249,289	543,114
Exports	77,813	426,576	23,517	6,054	143,720	1,301,523	1,979,203
Total	901,679	3,195,280	30,168,325	974,414	2,059,281	7,793,322	45,092,301

W Withheld to avoid disclosing company proprietary data; included with "Total" and/or "Other."
[1]Includes Puerto Rico.
[2]Includes uses indicated by symbol W.
[3]Includes tamping dummies and uses not specified.

Table 21.—Shipments of principal structural clay products in the United States

Product	1981	1982	1983	1984	1985
Unglazed common and face brick:					
Quantity ---million standard brick--	5,202	4,407	5,792	6,510	6,605
Value ---million--	$540	$504	$704	$836	$887
Unglazed structural tile:					
Quantity ---million standard brick--	92	49	30	32	55
Value ---million--	$8	$6	$5	$7	$12
Vitrified clay and sewer pipe fittings:					
Quantity ---million standard brick--	463	325	375	397	368
Value ---million--	$73	$52	$64	$79	$78
Unglazed, salt-glazed, ceramic-glazed structural facing tile including glazed brick:					
Quantity ---million standard brick--	35	11	W	W	W
Value ---million--	$10	$8	W	W	W
Clay floor and wall tile including quarry tile:					
Quantity ---million standard brick--	288	296	333	340	370
Value ---million--	$341	$354	$388	$421	$450
Total value[1] ---do---	$972	$923	$1,161	$1,342	$1,428

W Withheld to avoid disclosing company proprietary data.
[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census Report Form M32-D (84), Current Industrial Reports—Clay Construction Products.

Table 22.—Common clay and shale used in building brick production in the United States, by State

State	1984		1985	
	Short tons	Value	Short tons	Value
Alabama	721,338	$2,924,014	784,324	$3,585,969
Arizona and New Mexico	143,866	380,227	137,851	390,099
Arkansas	493,325	1,269,049	518,199	1,387,518
California	378,644	1,527,701	379,976	2,039,790
Colorado	291,547	1,937,112	280,611	1,572,065
Connecticut and New Jersey	149,078	1,314,620	226,033	2,431,873
Georgia	1,356,003	3,782,607	1,458,993	4,429,239
Illinois	106,740	402,342	116,840	462,611
Indiana and Iowa	361,865	926,670	315,833	829,789
Kansas	193,022	535,701	173,832	459,968
Kentucky	292,800	1,354,941	285,266	1,299,938
Louisiana	117,404	306,673	111,237	273,845
Maine, Massachusetts, New Hampshire	166,451	860,538	193,572	1,014,908
Maryland and West Virginia	375,013	1,515,289	376,537	1,714,440
Michigan and Minnesota	51,641	128,111	54,771	168,528
Mississippi	r919,621	r5,155,238	751,920	2,980,254
Missouri	84,373	358,183	74,025	291,796
Nebraska and North Dakota	180,927	490,011	183,586	439,974
New York	88,397	90,248	134,551	136,451
North Carolina	2,067,546	7,398,557	2,250,402	7,625,482
Ohio	919,971	3,205,889	972,163	3,423,479
Oklahoma	518,107	1,661,852	543,935	1,491,028
Oregon	18,874	41,001	17,848	37,838
Pennsylvania	765,237	2,857,355	782,491	3,020,028
South Carolina	660,974	2,540,845	688,556	1,523,674
Tennessee	394,182	685,569	416,599	788,947
Texas	1,725,337	7,331,347	1,705,625	8,450,837
Utah	217,914	1,645,138	191,430	1,402,828
Virginia	583,405	1,634,348	680,724	1,948,756
Washington	150,115	415,315	130,117	351,137
Wyoming	44,711	553,079	35,917	466,562
Total	r14,538,428	r55,229,570	14,973,764	56,439,651

rRevised.

The tonnage of clays used for refractories decreased slightly and constituted 6% of total clay produced. An increase in the use of high-alumina clay-based refractories, in particular, calcined kaolin grogs, in monoliths offset the decline in production of the more conventional refractory bricks and shapes. The major refractory consuming industries—cement, foundry, glass, ferrous and nonferrous metals—continued to undergo major changes in technology and production levels for their products. Metal imports further exacerbated the industry's problems.

Filler.—All kinds of clay have been used to some extent as fillers in one or more areas of use. Bentonite, fuller's earth, and kaolin are the principal filler clays. Kaolin, either air-floated, water-washed, low-temperature calcined, and/or delaminated, is used in the manufacture of paper, rubber, paint, and plastics. Fuller's earth is used primarily in pesticides and fertilizers. Clays are in pesticides and fertilizers as either thickeners, carriers, diluents, or prilling agents. Bentonites were used mainly in animal feeds.

Of the total clay produced, 11% was used in filler applications; of this, kaolin accounted for 89%; fuller's earth, 7%; bentonite, 3%; and ball clay, common clay and shale, and fire clay, the remaining 1%. Kaolin consumed as fillers decreased slightly to 4.2 million tons. An approximate 8% decline in paper coater-grade kaolin, which constitutes 54% of the total filler and extender category, was largely responsible. Increases occurred in most of the other filler categories for kaolin, except for paint and plastics, which decreased 13% and 8%, respectively. The paper filling and pesticides end uses increased 19% and 59%, respectively, while the other increases were more modest, generally under 6%. The total quantity of fuller's earth used in pesticides and related products, such as fungicides, increased nearly 19% over that of 1984.

Absorbent Uses.—Absorbent uses for clays accounted for over 1.6 million tons, or about 4% of total clay consumption. Demand for absorbents increased 8%. Fuller's earth was the principal clay used for absorbent purposes, and this application accounted for 84% of its entire output. Demand for clays in pet waste absorbents, representing nearly 49% of absorbent use, decreased 15%. Use in floor absorbents, chiefly to absorb hazardous oily substances, accounted for another 39% of the absorbent demand, which rose 14% above that of 1984. An upturn in the industrial sector, large consumers of floor absorbents, and the economy in general were responsible for the increased consumption.

Drilling Mud.—Demand for clays in rotary-drilling muds decreased 12% to about 1.3 million tons and accounted for nearly 3% of total clay production. This decrease reestablished the downward trend, except for the increase noted in 1984, begun in 1982 when a combination of excess oil production and economic uncertainties resulted in lower oil and gas well-drilling activities, which depressed bentonite demand. Oil and gas well-drilling activity softened further at yearend because of additional overproduction. Swelling-type bentonite remained the principal clay used in drilling-mud mixes, although fuller's earth, used mostly in saltwater drilling techniques, and nonswelling sodium-activated bentonites, were also used to a limited extent. Bentonite and fuller's earth accounted for nearly 100% of the total amount of clay used in this category. Small amounts of ball clay and kaolin were used in specialized formulations.

Floor and Wall Tile.—Common clay and shale, ball clay, kaolin, and fire clay, in order of volume, were used in manufacturing floor, wall, and quarry tile. This end-use category accounted for about 1% of the total clay production. Downsizing of homes, in part due to the need for remaining competitive in the marketplace, has largely ended with declining interest rates.

Pelletizing Iron Ore.—Bentonite continued to be used as a binder in forming indurated iron ore pellets. Demand decreased nearly 28% to about 291,000 tons. Inroads of inexpensive Mediterranean area bentonite, largely sodium-activated, into the traditional U.S. clay marketing area of the Great Lakes, coupled with lower demand due to changing technology, metal imports, and shrinking production levels, have all combined to lessen the demand for domestic bentonites in this category.

Ceramics.—Total demand for clay in the manufacture of pottery, sanitary ware, fine china and dinnerware, and related products (excluding clay flower pots) accounted for 3% of the total clay output. This demand, principally ball and kaolin clays, increased slightly to nearly 1.44 million tons. The increase in this category was also attributed to the increased demand for residential housing because of declining interest rates.

Table 23.—Common clay and shale used in lightweight aggregate production in the United States, by State

State	Short tons					Total value
	Concrete block	Structural concrete	Highway surfacing	Other	Total	
1984						
Alabama and Arkansas	521,001	146,007	19,364	4,200	690,572	$3,698,200
California	123,481	201,091	--	19,114	343,686	2,788,638
Florida, Indiana, Iowa	185,874	39,600	26,122	--	251,596	698,494
Kansas, Kentucky, Louisiana	538,537	192,028	48,707	12,347	791,619	13,830,093
Massachusetts, Mississippi, Missouri	256,722	80,096	23,715	--	360,533	1,846,549
Montana and New York	148,050	137,750	--	--	285,800	2,000,500
North Carolina and North Dakota	124,120	81,642	--	24	205,786	572,927
Ohio, Oklahoma, Pennsylvania	227,232	35,733	100	--	263,065	577,377
Utah and Virginia	144,215	32,509	--	8,036	184,760	2,276,592
Texas	401,978	247,789	329,766	20,988	1,000,521	4,997,293
Total	2,671,210	1,194,245	447,774	64,709	4,377,938	33,286,663
1985						
Alabama and Arkansas	708,200	190,857	14,683	--	913,740	4,321,766
California	131,897	237,737	--	15,049	384,683	3,364,460
Florida and Indiana	192,210	43,200	13,000	--	248,410	689,528
Kansas, Kentucky, Louisiana	412,713	124,844	25,250	8,126	570,933	9,916,737
Massachusetts, Mississippi, Missouri	221,385	75,156	36,461	--	333,002	1,779,111
Montana and New York	208,650	178,250	--	--	386,900	2,455,240
North Carolina	210,000	140,000	--	--	350,000	881,000
Ohio, Oklahoma, Pennsylvania	186,536	45,448	1,460	--	233,444	640,219
Utah and Virginia	146,772	32,249	5,707	1,040	185,768	2,395,170
Texas	194,315	345,117	449,821	114,683	1,103,936	2,355,859
Total	2,612,678	1,412,858	546,382	138,898	4,710,816	28,799,090

Table 24.—Shipments of refractories in the United States, by product

Product	Unit of quantity	1984 Quantity	1984 Value (thousands)	1985 Quantity	1985 Value (thousands)
CLAY REFRACTORIES					
Superduty fire clay brick and shapes	1,000 9-inch equivalent.	34,422	$41,887	26,509	$33,517
Other fire clay including semisilica brick and shapes, glasshouse pots, tank blocks, feeder parts, upper structure parts used only for glass tanks.	do	66,368	44,742	65,959	50,272
High-alumina (50% to 60% Al_2O_3) brick and shapes made of calcined diaspore or bauxite.[1]	do	81,957	151,578	71,271	138,314
Insulating firebrick and shapes	do	29,296	29,677	16,577	16,429
Ladle brick	do	66,763	22,622	45,261	23,778
Sleeves, nozzles, runner brick, tuyeres	do	20,665	30,475	31,935	27,996
Hot-top refractories	Short tons	W	W	W	W
Kiln furniture, radiant heater elements, potter's supplies, other miscellaneous-shaped refractory items.	do	28,769	26,526	XX	25,333
Refractory bonding mortars	do	80,317	36,589	XX	40,478
Plastic refractories and ramming mixes, containing up to 87.5% Al_2O_3.[2]	do	95,968	48,362	XX	43,346
Castable refractories	do	219,939	88,637	XX	87,434
Gunning mixes	do	85,551	31,121	XX	38,450
Other clay refractory materials sold in lump or ground form.[3] [4]	do	505,525	230,092	XX	104,391
Total clay refractories		XX	782,308	XX	629,738
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent.	7,095	15,025	5,728	13,608
Magnesite and magnesite-chrome brick and shapes.	do	25,754	112,129	24,512	113,426
Chrome and chrome-magnesite brick and shapes.	do	38,656	154,045	30,322	125,325
Shaped refractories containing natural graphite.	Short tons	17,461	33,308	12,924	30,552
Zircon and zirconia brick and shapes; other carbon refractories: Forsterite, pyrophyllite, dolomite, dolomite-magnesite molten-cast,[5] other brick and shapes.	1,000 9-inch equivalent.	5,043	36,762	1,084	37,209
Other mullite, kyanite, sillimanite, or andalusite brick and shapes.	do	3,734	16,100	3,506	18,319
Other extra-high (over 60%) alumina brick and fused bauxite, fused alumina, dense-sintered alumina shapes.[6]	do	3,677	46,611	64,425	48,113
Silicon carbide brick, shapes, kiln furniture	do	1,674	34,845	1,284	38,834
Refractory bonding mortars	Short tons	14,223	9,792	XX	11,942
Hydraulic-setting nonclay refractory castables	do	23,742	23,973	21,130	20,363
Plastic refractories and ramming mixes	do	130,966	87,041	XX	79,740
Gunning mixes	do	233,331	86,709	XX	109,180
Dead-burned magnesia or magnesite[3] [7]	do	376,029	102,160	XX	141,836
Dead-burned dolomite	do	309,291	18,002	XX	23,111
Other nonclay refractory material sold in lump or ground form.[3]	do	213,433	47,834	XX	63,169
Total nonclay refractories		XX	824,336	XX	874,727
Grand total refractories		XX	1,606,644	XX	1,504,465

W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Heat short of fusion; volatile materials are thus driven off in the presence of chemical changes, giving more stable material for refractory use.
[2]More or less plastic brick and materials that, after the addition of any water needed, are rammed into place.
[3]Materials for domestic use as finished refractories and all exported material.
[4]Includes calcined clay, ground brick, and siliceous and other gunning mixes.
[5]Molten cast refractories are made by fusing refractory oxides and pouring the molten material into molds to form finished shapes.
[6]Completely melted and cooled, then crushed and graded for use in a refractory.
[7]Includes shipments to refractory producers for reprocessing in the manufacture of other refractories.

Source: Bureau of the Census Report Form MQ32-C (84), Current Industrial Reports—Refractory.

Table 25.—U.S. exports of clays in 1985, by country

(Thousand short tons and thousand dollars)

Country	Ball clay		Bentonite		Fire clay		Fuller's earth		Kaolin		Clays, n.e.c.		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	(1)	46	--	--	(1)	11	12	2,092	1	834	13	2,983
Australia	(1)	3	21	1,179	15	1,055	(1)	4	12	2,166	2	1,110	50	5,517
Belgium-Luxembourg	(1)	9	(1)	43	53	3,956	2	373	14	1,907	1	257	70	6,545
Brazil	(1)	12	12	2,071	--	--	(1)	10	3	873	15	12,599	30	15,565
Canada	33	1,329	312	16,280	28	1,856	76	5,722	277	26,544	24	2,554	750	54,285
Chile	(1)	33	1	182	--	--	(1)	3	2	801	(1)	64	3	1,083
Colombia	--	--	14	774	(1)	19	(1)	5	8	1,183	5	4,427	27	6,408
Ecuador	3	237	1	136	(1)	10	1	232	3	177	1	163	9	955
Finland	(1)	11	--	--	--	--	--	--	10	1,747	(1)	8	10	1,766
France	(1)	17	1	111	1	154	(1)	96	13	2,650	1	539	16	3,567
Germany, Federal Republic of	41	142	16	873	(1)	59	(1)	30	41	4,166	3	1,335	101	6,605
Hong Kong	--	--	1	210	--	--	--	--	1	132	(1)	58	2	400
Italy	--	--	(1)	70	4	356	2	222	107	11,912	(1)	65	113	12,625
Japan	(1)	187	94	8,826	61	5,245	(1)	76	437	60,169	88	13,777	680	88,280
Korea, Republic of	(1)	10	4	991	--	--	--	--	47	9,278	3	495	54	10,774
Mexico	123	4,310	2	311	25	1,732	(1)	2	93	9,248	27	6,540	270	22,143
Netherlands	--	--	24	1,645	(1)	54	18	1,412	156	14,634	27	2,377	225	20,122
Peru	--	--	1	159	--	--	--	--	2	439	1	859	4	1,457
Philippines	2	171	3	439	--	--	(1)	32	2	474	2	291	9	1,407
Saudi Arabia	--	--	7	307	--	--	(1)	10	(1)	19	(1)	64	7	400
Singapore	(1)	41	26	1,683	--	--	(1)	52	2	461	(1)	203	28	2,440
South Africa, Republic of	(1)	8	(1)	65	--	--	1	186	5	1,081	(1)	168	6	1,508
Spain	--	--	(1)	135	(1)	19	--	--	13	2,138	(1)	221	13	2,513
Sweden	(1)	10	(1)	7	10	1,012	(1)	9	19	2,043	8	1,143	37	4,224
Switzerland	(1)	11	(1)	3	12	829	(1)	2	1	212	(1)	4	13	1,061
Taiwan	(1)	27	17	1,788	5	340	(1)	2	46	5,989	(1)	121	68	8,267
Thailand	(1)	4	5	550	--	--	--	--	3	584	1	187	9	1,325
United Arab Emirates	--	--	3	258	(1)	4	(1)	46	--	--	(1)	117	3	425
United Kingdom	1	33	20	1,129	7	941	3	385	6	2,295	7	3,735	44	8,518
Venezuela	(1)	40	10	886	(1)	12	(1)	22	15	2,439	4	616	29	4,015
Other	1	130	45	3,816	1	156	1	191	31	6,351	7	2,044	86	12,688
Total[2]	204	6,775	640	44,973	223	17,809	104	9,135	1,381	174,204	228	56,975	2,780	309,871

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce.

Table 26.—U.S. imports for consumption of clays in 1985, by kind

Kind	Quantity (short tons)	Value (thousands)
China clay or kaolin:		
Canada	75	$12
Germany, Federal Republic of	2	5
Netherlands	18	20
Taiwan	3	2
United Kingdom	9,288	956
Total[1]	9,387	996
Fuller's earth, not beneficiated:		
Belgium	24	4
Canada	44	2
France	7	2
Jamaica	25	2
Senegal	3,638	133
Total	3,738	143
Fuller's earth, beneficiated:		
Guinea	20	3
United Kingdom	56	7
Total	76	10
Bentonite:		
Canada	1,044	197
China	30	14
Denmark	2	4
Japan	2	5
Mexico	5,805	85
Norway	47	4
Singapore	958	143
United Kingdom	215	59
Total[1]	8,104	511
Common blue and other ball clay, not beneficiated: United Kingdom	92	11
Common blue and other ball clay, wholly or partly beneficiated:		
Netherlands	22	3
United Kingdom	1,155	134
Total	1,177	137
Other clay, not beneficiated:		
Canada	28	4
Japan	22	6
United Kingdom	1,704	19
Total	1,754	29
Clay, n.e.c., beneficiated:		
Belgium	4	5
Brazil	28	13
Canada	327	94
Denmark	1	3
France	103	27
Germany, Federal Republic of	211	40
Italy	10	1
Japan	1	2
Netherlands	1	1
United Kingdom	1,445	294
Total	2,131	480
Artificially activated clay:		
Canada	3,151	858
Germany, Federal Republic of	180	133
Japan	13	20
Mexico	10,700	2,512
Switzerland	20	39
United Kingdom	379	102
Total	14,443	3,664
Grand total	40,902	5,981

[1]Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce.

WORLD REVIEW

Estimated world production of all grades of fuller's earth increased almost 7%, kaolin increased slightly, while bentonite decreased nearly 4%. World fuller's earth production during the year was about 2.7 million tons, and U.S. output accounted for 76% of the total. Bentonite production was 6.2 million tons, with the United States accounting for 51% of the total. Kaolin production was nearly 23.4 million tons, and U.S. output was 33% of the world total.

Australia.—Kaiser, Oakland, CA, was planning to sell most of its clay and nonclay refractory assets in Australia to Morganite Australia Pty. Ltd., a subsidiary of Morgan Crucible Co. PLC, London, United Kingdom, for an undisclosed sum. Kaiser (see "Fire Clay" section) was negotiating with an employee group for a leveraged buyout of its North American refractories division as part of its intent to withdraw from the refractories business.

Barbados.—American investors purchased the assets of the country's only brick manufacturer, Building Supplies Ltd., which included a factory near its clay deposits in the St. Andrew area. The investors intended to convert the facility into a clay floor and wall tile manufacturing plant, destined largely for export to the Florida and Texas markets. The U.S. group was striving to take advantage of the duty-free provisions of the Caribbean Basin Initiative (CBI) that eliminates import duties for most Caribbean products through 1995. Clay brick tile exports from non-CBI countries pay a 23% import duty in the United States. Future plans included a high-tech ceramic line for the U.S. automotive industry.

Brazil.—Caolim da Amazonas announced a 100% expansion of its 250,000-ton-per-year paper-grade kaolin plant on the Rio Jari, with construction scheduled for mid-1986.[3]

Canada.—Oil-Dri Corp. of America, a Chicago-based absorbent clay company, purchased the remaining 50% of Favorite Products Co. of Montreal.[4] Favorite is the leading Canadian marketer of absorbent clays. Assets include a modern automated packaging plant and production facilities for manufacturing Oil-Dri's proprietary absorbents. The new management plans to expand Favorite's markets into the Maritime Provinces and Ontario and provide research and development support.

The Calgary-based Ekaton Energy Ltd. established a wholly owned subsidiary, Ancon Research and Engineering Ltd., to provide technical expertise on developing the parent company's kaolinized sand property in the Wood Mountain and Eastend acres in Saskatchewan.[5] The company's plans called for constructing a wet beneficiating plant to separate the kaolin and sand fractions in 1987 after an initial development program. The kaolin was targeted for the domestic paper filler market, and the sand, for local amber glass production. Carlson Mines Ltd. has obtained an option to buy up to a 50% interest in a kaolin sand deposit northwest of Smooth Rock Falls in Ontario.[6] Carlson planned to develop the deposits, which contain proven reserves of over 50 million tons of kaolin and silica sand.

Jannock Ltd. purchased the operations of Domtar Inc.'s brickworks in Ottawa and Mississauga in Ontario and one in La Prairie, Quebec, capable of producing 130 million bricks annually.[7]

Chile.—The Government planned to entertain bids for developing the Solar de Uyuni salt deposits.[8] The concession area, located about 250 miles from La Paz in the Department of Potosí, in addition to salt, lithium, potassium, and boron values, also contains large reserves of kaolin.

China.—A bentonite deposit, reportedly China's largest, with verified reserves near 70 million tons, was found near Changchun in Jilin.[9] The deposit, situated under a coal seam, reportedly averages 300 feet in thickness, and at the present rate of coal production, upwards of 200 tons per day of bentonite could be extracted. A deposit of over 2 billion tons of a unique illite clay was discovered in Ji County, Tianjin Municipality.[10] The county plans to become a major producer, along with Yixing Town in Jiangsu Province, for the distinctive purple sand pottery.

Finland.—A large kaolin deposit, containing about 20 million tons of ore, was found by the Geological Research Center and Lohja Oy in Paljakka, close to Puolanka in the north.[11] Feasibility studies were under way to optimize a mining and processing scheme to yield paper quality clays. Finland's paper industry imports nearly 400,000 tons of English china clay yearly.

Germany, Federal Republic of.—The manufacturing operations of Oil-Dri, a Chicago-based U.S. firm, were acquired by Laporte Industries Ltd. of the United Kingdom for about $4 million.[12] The acquisition not only included Oil-Dri's Cologne plant, which manufactures granular absorbent clay products for agricultural, industrial, and pet waste uses, but also its European marketing operations in Switzerland. The acquisition agreement provided for Oil-Dri to supply Laporte with Georgia fuller's earth clays for further processing. In addition, the two companies planned to cooperate in their European business and in technology transfer. This latest acquisition in the Federal Republic of Germany and another in the Netherlands appear to fit in with Laporte's efforts to make inroads into European bentonite and/or fuller's earth markets.

Eduard Kick GmbH, the country's second largest producer, installed and commissioned a new 84-inch high-intensity wet magnetic PEM separator at its Schnaittenbach plant.[13] Kick processes the sand kaolins of the Hirschau-Schnaittenbach Basin for the local paper, ceramics, and fiberglass industries.

Greece.—A new $1 million bentonite processing plant was under development by Silver and Baryte Ores Mining Co. to increase its processing capacity for granulating, sodium activating, and drying clays on the Island of Milos to nearly 500,000 tons per year.[14] The company's bentonite sales were chiefly for iron ore pellets (70%), foundries (20%), and oil and/or gas drilling (10%). Large deposits of high-quality clays were situated in the Laconia and Arcadia Provinces in Peloponnesia.[15] The clays were reported to be suitable for manufacturing high-quality ceramics and were the first deposits to be found that are in economically exploitable quantities.

India.—The nation's first ceramic floor tile plant was established in Andhra Pradesh in a joint venture with an unnamed U.S. company. The fully automated plant's output, capable of expanding to 25,000 tons per year, was targeted for the growing West Asian and Far Eastern export markets. The Geological Survey of India's recent publication, in its exploratory survey of the State of Orissa, listed reserves of fire clay and kaolin to be 150 million and 100 million tons, respectively.[16]

Netherlands.—Holland Laporte, a member of the Laporte Industries Group, acquired Dayton BV, an independent chemicals marketing and trading company.[17] Dayton has been active in marketing a significant portion of Laporte's bentonite products in Western Europe. This latest acquisition by Laporte followed its pattern of increasing its presence in European and Asian markets.

Pakistan.—The Government ordered further exploration and trenching to determine the bentonite reserves of the deposits in the hilly areas of Dera Ghazi Kahn to eliminate Pakistan's dependence on imports.[18] In other Government action, fire clay reserves of nearly 60 million tons were discovered in the mountainous region of the Kala Chitta District of Attock.[19] The Government claimed that this recent fire clay find would permit the country to be self-sufficient in refractory- and ceramic-grade clays for the foreseeable future. Large deposits of china clay have been located in the Tharparkar District by the Pakistan Mineral Development Corp. (PMDC).[20] Identified reserves were estimated to be about 4 million tons, but the new deposit is in difficult terrain. Nevertheless, PMDC developed a mining and clay washing procedure, which it forwarded to Government officials for evaluation.

Philippines.—A local company, Naga Hardwood Ltd., planned on developing its kaolin and industrial sand deposit with a joint venture partner experienced in sand kaolin technology and processing.[21]

Qatar.—A geological survey for industrial minerals carried out by the Industrial Development Technical Centre of Qatar located promising deposits of several different unspecified clay types.[22]

Senegal.—Société Sénégalaise des Phosphates de Thiès (SSPT), co-owned by the Government and Rhône-Poulenc S.A. of France, planned to treble its attapulgite production capacity at its Lam Lam Mine and mill complex in the Thiès District from 110,000 to 330,000 tons per year.[23] The clay is used principally by the West European domestic and industrial absorbent markets, the major outlet being for a pet waste absorbent line.

Spain.—The Government approved Laporte's (United Kingdom) plans to complete the acquisition of Minas de Gador S.A.[24] Minas de Gador mines bentonite in the Almería region in the south and bentonite and sepiolite in the Yuncos area, about 25 miles south of Madrid. The company produces a complete line of bentonites for use in foundries, drilling mud, animal feed, and bleaching earths for oil refining. In addition, sepiolite from Yuncos is also used in saltwater drilling muds and industrial and pet waste absorbents. Minas de Gador, which markets heavily in the European and African Mediterranean countries, was reportedly planning, under Laporte's direction, to increase its production capacity for specialty activated clays. In a related event, Laporte and Sociedad Tolsa S.A. agreed to exchange certain clay business sectors.[25] The agreement permits each company, Laporte through its newly acquired subsidiary, Minas de Gador, and Tolsa, to further specialize within their own areas of expertise. Tolsa is to specialize in the production of sepiolite, and Minas de Gador, in the production of bleaching earths (attapulgite and/or fuller's earth) and bentonite. This agreement freed additional production capacity at existing plants by ending competitive products.

Tolsa's Toledo plant planned to produce special rheological sepiolite grades to meet the shortfall, if it should materialize, for Tolsa's Madrid plant, which produces approximately 500,000 tons per year of absorbent-grade sepiolite granules. Tolsa continued to produce sepiolite in the Madrid-Toledo area at Vicalvaro-Yunclillos while the other Tolsa Group companies, Hifran S.A. and Minas de Torrejon S.A., continued to produce a sepiolitic marl at Lebriva in Seville and attapulgite at Torrejon el Rubio in Cáceres, respectively. Laporte's Minas de Gador became the sole Spanish bleaching earth producer. Its Yuncos plant capacity was increased an additional 30,000 tons per year.

A new 60,000-ton-per-year processing plant for the production of paper coater- and filler-grade kaolins from a kaolinitic sand, at Poveda de la Sierra in the Guadalajara Province about 100 miles northeast of Madrid, went on-stream.[26] The plant is owned by Cía. Española de Caolines S.A., a joint venture between English China Clays PLC (ECC) of the United Kingdom, Caobar S.A., and a private interest. The kaolin deposit is said to contain roughly 20 years' reserves of clays of sufficient brightness so as not to require the costly conventional bleaching and magnetic separation processing steps.

Turkey.—The State mining company Etibank evaluated proposals from foreign mining companies for jointly developing selected bentonite properties.[27]

U.S.S.R.—The bentonite mines and processing plants at Sarigyukh near Idzhevan in Armenia were reportedly the largest in the Soviet Union.[28] Their 1.3-million-ton-per-year output supposedly represents one-third of the total Soviet production.

United Kingdom.—ECC, the world's largest kaolin producer, increased its holdings in Watts Blake Bearne & Co. PLC (WBB), the world's largest ball clay producer, to nearly 21% of its outstanding shares.[29] WBB and ECC produce both kaolin and ball clay and are major factors in the domestic and international clay markets. ECC has reaffirmed its promise not to sit on WBB's board. An agreement was announced by Hepworth Ceramic Holdings PLC and British Steel Corp. (BSC) on merging their subsidiaries, G. R. Stein Refractories Ltd. and BSC Refractories Group, respectively, into G. R. Stein.[30] As a result of the merger, Hepworth held 78% and BSC held 22% of the enlarged company, which strived to combine manufacturing facilities and develop the latest refractories technology. The consequent rationalization of operating capacity, from 11 to 7 refractory, research, and development laboratories, and manufacturing facilities did not affect the Manual Works, which produced clay and/or alumina-silicate refractories, including bricks, shapes, and monolithics.

The Yorkshire Brick Co.'s Stairfoot, Barnsley, plant fired its natural gas tunnel kilns with inexpensive methane gas recovered and piped from the company's nearby quarries.[31] The quarries were once repositories for residential refuse. The plant's capacity was doubled to 20 million bricks per year to take advantage of the unexpected windfall.

Yugoslavia.—Reserves of high-quality ceramic-grade clay, estimated at 20 million tons, have been found near Arandjelovac in Serbia.[32] The deposit was reportedly the nation's richest, and plans were under way to develop a 70,000-ton-per-year mining operation.

Zambia.—The Development Bank of Zambia and others financed a ceramic whiteware factory in Kitwe scheduled to use indigenous clays.[33] The new plant, equipped with state-of-the-art West German and British manufacturing machinery, will produce sanitary ware, tiles, and tableware for local consumption.

Table 27.—Kaolin: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	21	17	19	[3]9	9
Argentina	74	80	160	100	110
Australia	188	168	127	[e]275	140
Austria (marketable)	87	85	92	110	95
Bangladesh[4]	11	6	3	3	[3]5
Belgium	60	58	66	76	76
Brazil (beneficiated)	518	544	463	536	550
Bulgaria	244	261	267	282	285
Burundi	[e]2	[e]2	4	2	[3]5
Chile	63	23	45	54	[3]54
Colombia	893	943	840	1,034	990
Costa Rica	1	1	[e]1	[e]1	1
Czechoslovakia	560	581	730	736	720
Denmark[e]	[r]11	[3]6	[r]11	[r]15	17
Ecuador	3	5	1	[e]1	2
Egypt	35	55	110	[r e]130	130
Ethiopia (including Eritrea)	10	[e]10	[e]10	([5])	NA
France[6]	365	[r]383	319	338	340
German Democratic Republic (marketable)[e]	220	230	220	190	190
Germany, Federal Republic of (marketable)	523	500	448	452	465
Greece	[r]35	49	67	101	80
Hong Kong	9	([7])	1	([7])	10
Hungary	58	50	41	43	[3]32
India:					
Salable, crude	432	585	610	555	570
Processed	126	[e]110	[e]110	128	120
Indonesia	89	85	66	92	90
Iran[e]	110	121	110	110	110
Israel	41	13	30	[e]30	30
Italy:					
Crude	82	59	58	58	[3]66
Kaolinitic earth	34	32	28	28	[3]29
Japan	232	218	254	248	[3]245
Kenya	[e]2	1	1	([7])	([7])
Korea, Republic of	766	690	754	795	725
Madagascar	2	3	[e]3	[e]3	3
Malaysia	49	49	63	80	90
Mexico	229	190	179	144	165
Mozambique	([7])	([7])	([7])	([7])	([7])
New Zealand	54	26	26	28	275
Nigeria	1	[e]1	[e]1	([7])	([7])
Pakistan	[r]45	[r]49	14	20	5
Paraguay	77	61	50	55	55
Peru[e]	7	7	7	7	7
Poland	[r]48	51	54	[e]55	56
Portugal	58	56	63	96	[3]102
Romania[e]	452	452	452	452	452
South Africa, Republic of	165	141	143	150	[3]142
Spain (marketable)[8]	872	763	782	921	940
Sri Lanka	8	9	9	12	11
Sweden	([7])	([7])	([7])	[e]([7])	([7])
Taiwan	100	96	113	88	85
Tanzania	[e]1	[e]1	1	2	2
Thailand	16	20	40	65	60
Turkey	49	[e]50	[e]60	61	60
U.S.S.R.[e]	2,800	2,900	2,900	3,100	3,200
United Kingdom	[r]2,897	[r]2,669	3,000	3,274	3,300
United States[9]	7,660	6,362	7,203	7,953	[3]7,793
Venezuela	72	[e]72	12	24	25
Vietnam[e]	1	1	1	1	1
Yugoslavia	248	[r]261	230	[r e]230	240
Zimbabwe	5	3	1	1	1
Total	[r]21,821	[r]20,264	21,473	23,354	23,361

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through July 15, 1986.
[2]In addition to the countries listed, China, Lebanon, and Suriname also produced kaolin, but information is inadequate to make reliable estimates of output levels. Guatemala and Morocco each produced less than 500 tons in each of the years covered by this table.
[3]Reported figure.
[4]Data for year ending June 30 of that stated.
[5]Revised to not available.
[6]Includes kaolinitic clay.
[7]Less than 1/2 unit.
[8]Includes crude and washed kaolin and refractory clays not further described.
[9]Kaolin sold or used by producers.

Table 28.—Bentonite: World production, by country[1]

(Short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Algeria[e 3]	38,600	38,600	33,100	[4]27,000	27,600
Argentina	135,274	135,864	149,439	89,876	99,000
Australia[3]	18,635	32,201	33,098	[r e]33,000	33,000
Brazil	183,356	180,845	141,857	221,592	220,000
Burma	2,554	1,613	895	799	[4]783
Cyprus[5]	51,809	14,330	35,300	35,715	[4]57,300
Egypt[e]	5,700	5,700	2,800	3,300	3,300
France	[e]3,307	3,627	3,407	3,831	3,500
Greece	343,862	343,921	759,427	857,600	827,000
Guatemala[e]	2,750	[4]2,750	8,800	[r]9,400	9,400
Hungary	88,770	93,624	87,972	70,722	[4]65,966
Iran[e]	11,000	12,100	11,000	11,000	11,000
Israel (metabentonite)	13,868	13,228	7,538	6,501	13,200
Italy	305,340	[r]261,200	327,183	340,600	[4]329,600
Japan	564,141	533,993	486,034	452,034	[4]508,749
Mexico	243,009	203,837	249,276	294,700	280,000
Morocco	3,203	4,913	4,515	2,012	2,200
Mozambique	789	1,604	276	446	440
New Zealand (processed)	2,078	6,856	2,158	7,075	2,200
Pakistan	[r]1,155	[r]1,572	735	1,918	1,800
Peru[e]	[4]33,620	34,200	34,200	35,300	35,300
Philippines	6,092	5,149	739	41,715	1,800
Poland[e]	55,000	77,000	77,000	77,000	83,000
Romania[e]	194,000	[r]193,000	[r]195,000	198,000	198,000
South Africa, Republic of	48,912	33,981	43,573	46,131	[4]47,910
Spain	[r]121,250	[r]123,800	90,976	80,008	80,000
Tanzania	55	55	[e]83	[e]83	83
Turkey	33,827	[e]34,200	[e]34,200	30,967	31,000
United States	4,947,000	3,244,800	2,886,870	3,437,940	[4]3,195,280
Zimbabwe	86,424	94,236	69,552	[r e]77,000	77,000
Total	[r]7,545,380	[r]5,732,799	5,777,003	6,493,265	6,245,411

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through July 15, 1986.

[2]In addition to the countries listed, Canada, China, the Federal Republic of Germany, the U.S.S.R., and Yugoslavia are believed to produce bentonite, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

[3]Includes bentonitic clays.

[4]Reported figure.

[5]Includes bleaching earths.

Table 29.—Fuller's earth: World production, by country[1]

(Short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	[r]5,600	[r]5,600	[r]5,500	[3]3,858	3,900
Argentina	5,783	13,002	7,431	3,980	5,500
Australia (attapulgite)	--	16,280	[e]16,500	[e]16,500	16,500
Italy[e]	[3]6,057	6,000	5,500	5,500	5,500
Mexico	72,067	46,835	45,827	50,372	50,000
Morocco (smectite)	21,771	27,121	30,187	36,824	37,000
Pakistan	[r]19,369	[r]15,205	23,298	21,097	19,000
Senegal (attapulgite)	[r]36,346	109,128	110,644	127,315	128,000
South Africa, Republic of	478	343	344	--	--
Spain (attapulgite)	52,059	47,318	49,223	48,399	49,000
United Kingdom	[r]203,927	[r]206,132	211,644	315,261	330,000
United States[4]	1,655,854	1,682,655	1,911,634	1,899,145	[3]2,059,281
Total	[r]2,079,311	[r]2,175,619	2,417,732	2,528,251	2,703,681

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Excludes centrally planned economy countries, some of which presumably produce fuller's earth, but for which no information is available. Table includes data available through July 15, 1986.

[2]In addition to the market economy countries listed, France, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

[3]Reported figure.

[4]Sold or used by producers.

TECHNOLOGY

The Bureau of Mines published the results of research on the pressure leaching of alumina from a typical dried air-floated and raw Georgia kaolin with hydrochloric acid (HCl).[34] The optimized pressure leaching step with excess 20-weight-percent HCl at temperatures that ranged from 150° C to 225° C successfully extracted greater than 90% alumina when digestion periods were 2 hours or less. These data indicate a choice in optimizing a flowheet for alumina from kaolin between a faster reaction at 200° C or a slower reaction at a lower pressure at 175° C.

An article described the working plan, clay extraction and preparation, and the chamotte[35] burning process.[36] The work highlighted the equipment, specifications, chemistry, and flowsheets used in the manufacturing process for chamottes. The solid-state transformation of refractory-grade kaolins or chamottes into mullitic grogs was studied extensively by nuclear magnetic resonance.[37] The kaolin was shown to decompose sequentially to a metakaolinite with expulsion of excess silica into a high-temperature crystalline form upon cooling. The metakaolinite was successfully indexed as a gamma-alumina structure formed simply by removal of hydroxyl ions from the kaolin structure by a diffusion controlled mechanism. The mullites, which are end products of these solid-state reactions, are widely used in refractory bricks and specialty products. The results of this basic research should allow refractories manufacturers to better control the physical properties of the mullite component to optimize the density of these high-performance refractories.

The relationship between pore structure and building brick durability was investigated.[38] The research showed that bricks of poor durability had a preponderance of pores smaller than 1 micrometer, while acceptable brick exhibited a majority of its pores larger than 2 micrometers. The results indicated that controlling raw material composition and forming methods were the key to superior brick production. Grog and shales larger than 200 mesh were recommended over pure clay, and soft-molding brick processes, over extrusion techniques. In addition, poor brick durability was successfully correlated with low porosity surfaces and/or high porosity interiors. This work should permit the brick industry to more readily predict the durability of material without resorting to the more cumbersome and tedious testing procedures presently used. The primary types of clay refractories, fire clay, semisilica, high-alumina, insulating and ladle bricks, and monolithic shapes used by the metal casting industry were the topic of a review article.[39] A feature of the article included definitions and specifications for each type of refractory commonly used and correlates its foundry applications with selected physical and chemical properties. Future refractory trends in metal casting processes, prompted by technological changes, were also discussed in detail.

The relationship of geologic setting and kaolin characteristics to filler applications were the topics of a technical oral presentation.[40] The paper pointed out the differences between the kaolins of the Georgia-South Carolina Clay Belt and correlated them with selected filler applications. A brief description of the general schemes for kaolin beneficiation in the Clay Belt were also outlined. The air-float and water-washed beneficiation processes along with individual details of the classification, leaching, filtration, drying, and slurry preparation steps were singled out for more elaborate treatment. Of particular interest was the correlation between the processing scheme practiced and the physical and chemical properties of the clay types encountered.

A comprehensive technical work was published on the acid-activated montmorillonite, hectorite, organoclay, saponite, white bentonite, sepiolite, attapulgite, and halloysite clays.[41] The work consisted of a series of articles on each of these individual clay types or products falling into the all-encompassing bentonite and fuller's earth categories. A special feature of each of the segments was the worldwide treatment afforded each clay as to individual companies and the major markets served. Another highlight of the report was the chemistry of the acid-activated and organoclay processes, the gelling mechanism, and the overall theory of organoclays.

A paper on the mineral requirements of the paint manufacturers in the United States, Western Europe, and Japan for increasing specialized grade materials was published.[42] The article also discusses the physiochemistry of the three main paint components: pigment, medium (binder or vehicle), and solvent (thinner). Special tables listing typical analyses for paint-grade kaolins as well as the current British standard specifications for china clay extenders in paint were also included. An interesting feature of the article was the wide range of substitutability possible in pigment material, chiefly to reduce raw material cost yet still capable of producing a high-quality competitive paint. A similar treatment was afforded the English cosmetics industry.[43] A highlight of this work was the technical specifications for face powder kaolins and special clays used for their absorbing, degreasing, thixotropic, and pigment suspending properties.

An indepth review was published of major industrial minerals, including bentonite, kaolin, plastic, and fire clays currently mined and processed in the Federal Republic of Germany.[44] The review covered the geology, mineralogy, output, production flowsheets, and consumption of clays by the domestic refractory, ceramics, glass, and paper industries. A special feature of the article was a table on major areas of application for crude, acid, alkaline, and organically activated bentonites. A similar detailed treatment, but more heavily oriented toward a geological, mining, and mineralogical approach, was afforded sepiolite, attapulgite, bentonite, and to a lesser degree, kaolin, produced in Spain.[45] Tables highlighting the physical and chemical properties of foundry and gelling bentonite and ceramic grades were also listed.

The geological and production aspects of the industrial minerals exploited in California,[46] Greece,[47] and Jamaica[48] were discussed briefly in other publications. The California paper stressed the mining and production flowsheets for the Ione kaolin, and the Greek work targeted bentonite and kaolin production. A highlight of the latter paper was an industrial minerals map of Greece depicting the major bentonite and kaolin production sites, largely on the islands of Lesvos and Milos. The Jamaican article, strictly an overview, dealt with its 16 major clay deposits, mostly bentonite, kaolin, and common clays, currently under investigation for ceramic and structural product manufacturing.

A concise but detailed study was published on the Chinese bentonite industry.[49] The article provides the latest information on Chinese bentonite resources, exploration, mining, processing, physical and chemical properties, research, and marketing goals. The Chinese bentonites are widely distributed, and China is regarded as being second only to the United States as a worldwide source of bentonites. Chinese specifications with typical analyses for sodium-exchanged, organoclad drilling-mud and foundry and iron ore grades of bentonite were listed and discussed. A case study of the Heishen open pit and Linan underground mines was included.

The differences in thermal decomposition of sodium and calcium bentonites and their role in foundry sand bonding during metal casting was explored in detail.[50] The data showed that bentonite burnout and consumption depend on many factors, but the sand-to-metal ratio, cooling time, and time of casting in the mold emerge as the most important. U.S. sodium and calcium bentonites were used throughout the investigation as the reference base and/or standard material. The technical rationale for the past, present, and future industrial minerals usage by the U.S. drilling industry was published.[51] The paper stressed the indispensability of bentonite gelling clays and new material usages, such as organoclays, in oil-based drilling fluids.

The preferential absorption of selected environmental toxins, such as dioxin, by modified smectites or bentonites was researched.[52] The investigation showed that smectites bound to hydroxy aluminum are three times more effective than activated carbon, at present the most commonly used industrial sorbent, in removing toxins from industrial effluents. Future work should lead to additional modified clay systems capable of removing other chemical pollutions and toxins. Clays have the advantage of being a relatively inexpensive commodity compared with other industrial and reagent chemicals, such as activated carbon and zeolites.

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Cobalt

By William S. Kirk[1]

Domestic cobalt consumption decreased after 2 consecutive years of increases. Apparent consumption dropped to 15.7 million pounds. A realignment of the international cobalt market occurred during 1985, precipitated when a Canadian cobalt producer concluded a contract for the purchase of feedstock that had formerly been refined in the United States. This action resulted in the closure of the sole domestic cobalt refinery. The spot price for electrolytic cobalt fell slightly, ending the year at $11.10 per pound. There was no domestic mine production of cobalt.

Domestic Data Coverage.—Domestic consumption data for cobalt are developed by the Bureau of Mines from two voluntary surveys of U.S. operations. Of the 695 operations to which a survey request was sent, 551 responded, representing 97% of the reported consumption shown in tables 1, 3, and 4. The remainder was estimated by contacting industry sources.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Consumption, reported	11,680	9,468	11,319	12,944	13,541
Imports for consumption	15,594	12,870	17,221	25,310	17,708
Stocks, Dec. 31:					
Consumer	1,411	1,327	1,441	1,368	1,131
Processor	1,519	1,161	1,366	1,781	1,557
Price: Metal, per pound	$17.26-$25.00	[1]$8.56	[1]$5.76	[1]$10.40	[1]$11.43
World: Production[2]	67,790	[r]54,062	52,292	[p]71,738	[e]79,734

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Based on weighted average of Metals Week prices.
[2]Based on estimated recovered cobalt.

Legislation and Government Programs.—In an effort to develop emergency response plans to avert accidents, such as the catastrophic leak in Bhopal, India, the Environmental Protection Agency compiled a list of 402 acutely toxic substances.[2] The list contained an extensive compilation of the substances' properties and health effects. Cobalt and cobalt carbonyl were included among the substances listed.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, cobalt would be categorized in tier I with a goal of 22.57 million pounds of cobalt and in tier II with a goal of 6 million pounds of cobalt. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

Cobalt-rich manganese crusts on Pacific sea mounts were not likely to be developed in the near future, according to the Office of Strategic and International Minerals, Minerals Management Service (MMS), U.S. Department of the Interior. The MMS announced that an Environmental Impact Statement (EIS) would be prepared for a proposed lease sale of the crusts within the Hawaiian Exclusive Economic Zone. After hearings and preparation of the final EIS, the Secretary of the Interior was to decide whether to proceed with a lease sale, which was scheduled to take place in middle to late 1987. Following the lease sale, detailed exploration was to take at least 5 years, and the construction of mining equipment and onshore facilities, another 5 or 10 years.

DOMESTIC PRODUCTION

The sole domestic cobalt refinery, at Braithwaite, LA, closed late in 1985 because it lost its source of raw material. AMAX Nickel Inc., owner and operator of the refinery, terminated the supply contract for the nickel-copper-cobalt matte, which had been produced in Botswana. The matte had accounted for about two-thirds of the refinery's feedstock, the remainder having come from the Agnew Mine in Australia, owned jointly by Seltrust Holdings Ltd. and Mount Isa Mines Ltd. AMAX Nickel was reported to be hoping for an expansion of production capacity at the Agnew Mine or an arrangement to have the Agnew matte toll refined. According to reports, however, the Agnew Mine was unable to increase its capacity owing to ground control problems, and AMAX Nickel was unable to interest other refiners in a toll-refining agreement. With insufficient raw material to support economical operations, AMAX Nickel was forced to close the refinery and withdraw from the cobalt market.

Following the completion of a feasibility study, Hall Chemical Co., Wickliffe, OH, awarded a preliminary engineering contract for its catalyst reclamation project. The project was expected to result in the construction of a plant, located in the gulf coast region, to be operational in late 1988. The facility was to process spent catalysts and have the capacity to recycle 650,000 pounds of cobalt per year to be used in the chemical industry.

Table 2.—U.S. cobalt products[1] produced and shipped by refiners and processors

(Thousand pounds)

	1984				1985			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Driers (organic compounds)	NA	1,329	NA	1,300	NA	1,188	NA	1,190
Hydrate (hydroxide)	NA	1,228	NA	1,219	NA	1,149	NA	1,014
Salts[2] (inorganic compounds)	NA	942	NA	803	NA	539	NA	612
Total	NA	3,449	NA	3,322	NA	2,876	NA	2,816

NA Not available.
[1]Figures on oxide withheld to avoid disclosing company proprietary data.
[2]Various salts combined to avoid disclosing company proprietary data.

CONSUMPTION AND USES

Cobalt consumption decreased after 2 consecutive years of increases. Although reported consumption was 13.5 million pounds in 1985, compared with 12.9 million pounds in 1984, the increase was due to improved statistical coverage. Apparent consumption, calculated from net imports, secondary production, and changes in industry and Government stocks, decreased to 15.7 million pounds, 12% less than that of 1984. The decline in consumption was due to weakened demand and inventory adjustments. In the last half of the year, consumers became aware that prices were declining and would continue to do so. They therefore began reducing their inventory levels.

Of the 6.4 million pounds of cobalt reported to have been consumed in the production of superalloys during the year, approximately 500,000 pounds was used in the production of prosthetic devices (surgical implants), according to industry sources. In general, alloys used in prosthetic devices and superalloys were produced in the same facilities.

Table 3.—U.S. consumption of cobalt, by end use

(Thousand pounds of contained cobalt)

End use	1984	1985
Steel:		
Full-alloy	W	W
High-strength, low-alloy	W	W
Stainless and heat-resisting	74	61
Tool	353	203
Superalloys	4,766	6,380
Alloys (excludes alloy steels and superalloys):		
Cutting and wear-resistant materials[1]	831	1,017
Magnetic alloys	2,209	1,455
Nonferrous alloys	176	[2]W
Welding materials (structural and hard-facing)	399	W
Other alloys	15	[2]122
Mill products made from metal powder	W	W
Chemical and ceramic uses:		
Catalysts	1,296	1,253
Drier in paints or related usage	1,258	1,139
Feed or nutritive additive	58	46
Glass decolorizer	41	42
Ground coat frit	617	724
Pigments	417	401
Miscellaneous and unspecified	434	698
Total	12,944	13,541

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Cemented and sintered carbides and cast carbide dies or parts.
[2]Data not comparable to 1984 data because of change in end-use definitions.

Table 4.—U.S. consumption of cobalt, by form

(Thousand pounds of contained cobalt)

Form	1981	1982	1983	1984	1985
Chemical compounds (organic and inorganic) other than oxide	2,421	1,643	2,297	2,226	1,850
Metal	7,450	6,055	7,165	8,746	9,463
Oxide	557	732	938	915	1,201
Purchased scrap	972	871	723	879	897
Other	280	167	196	178	130
Total	11,680	9,468	11,319	12,944	13,541

PRICES

The listed producer price for cobalt cathodes remained at $12.50 per pound, unchanged since 1982, but was no longer the price standard. The spot price for cathodes began the year at $11.50 per pound, reached $11.60 at midyear, and then experienced a slight and gradual deterioration, ending the year at $11.10. The decline occurred despite the efforts of Zaire to maintain an unofficial producer price of $11.70 per pound.

Table 5.—Yearend published prices of cobalt materials[1]

(Dollars per pound)

Material	1983	1984	1985
Cobalt:[2]			
Fine powder	10.11	[r]16.63	19.05
Powder	6.91	13.24	14.87
Cobalt oxide:			
Ceramic-grade (70% cobalt)	4.90	9.40	9.98
Ceramic-grade (72% cobalt)	5.04	9.66	10.26
Metallurgical-grade (76% cobalt)	5.21	9.86	10.61

[r]Revised.
[1]Metals Week.
[2]See table 1 for cathode price.

FOREIGN TRADE

Exports of unwrought cobalt metal and waste and scrap totaled 911,000 pounds, gross weight, with an estimated 643,000 pounds cobalt content, valued at $7.3 million. These exports were shipped to 35 countries, with the following, in descending order, receiving the largest quantities: Belgium, Japan, the Federal Republic of Germany, and the United Kingdom. Exports of wrought metal totaled 487,000 pounds, gross weight, valued at $8.2 million. Of the 20 countries to which cobalt was shipped, the major recipients, in descending order, were France, Canada, Japan, and the United Kingdom.

Imports of cobalt metal originating in south-central Africa, that is, imports from Belgium-Luxembourg (Zairian origin), Zaire, and Zambia, represented 56% of total cobalt imports compared with 71% from that area in 1984.

Table 6.—U.S. imports for consumption of cobalt, by class

(Thousand pounds and thousand dollars)

Class	1983	1984	1985
Metal:[1]			
Gross weight	15,853	23,316	16,613
Cobalt content[e]	15,853	23,316	16,613
Value	$110,076	$202,954	$181,379
Oxide:			
Gross weight	403	706	246
Cobalt content[e]	298	522	182
Value	$1,813	$5,285	$2,258
Salts and compounds:			
Gross weight	1,671	2,284	1,413
Cobalt content[e]	502	685	424
Value	$2,244	$5,371	$4,431
Other forms:[2]	568	787	489
Value	$1,969	$4,793	$3,356
Total content	17,221	25,310	17,708

[e]Estimated.
[1]Includes unwrought metal and waste and scrap.
[2]Contained cobalt in nickel-copper and nickel matte.

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of cobalt, by country

(Thousand pounds and thousand dollars)

Country	Metal[1]				Oxide[2]				Other forms[3]				Total content[4 5]	
	1984		1985		1984		1985		1984		1985			
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value	Cobalt content	Value	Cobalt content	Value	1984	1985
Australia	15	82	6	26	(6)	(6)	--	--	218	[7]1,341	82	[7]559	233	87
Belgium-Luxembourg	903	9,137	845	9,975	466	3,578	162	1,423	201	2,405	62	908	1,449	1,026
Botswana	--	--	--	--	--	--	--	--	569	[7]3,452	296	[7]2,027	569	296
Canada	3,044	29,016	3,047	33,568	71	481	36	317	32	175	32	212	3,128	3,105
Finland	958	9,498	984	11,712	--	--	5	126	--	--	10	270	958	994
France	298	1,332	62	543	2	40	--	--	1	15	(6)	13	301	66
Germany, Federal Republic of	69	821	109	1,280	47	344	--	--	68	496	22	252	171	131
Japan	224	1,134	132	912	--	--	--	--	14	128	17	423	238	149
Netherlands	202	2,294	300	3,738	--	--	--	--	2	57	--	--	204	300
Norway	1,382	6,312	1,693	18,601	--	--	--	--	--	--	--	--	1,382	1,693
South Africa, Republic of	39	288	14	151	--	--	1	5	285	1,395	275	[7]2,038	324	290
United Kingdom	439	2,948	192	1,443	74	565	42	387	68	547	75	942	563	298
Zaire	11,728	108,172	4,801	59,056	45	276	--	--	11	139	--	--	11,772	4,801
Zambia	3,796	29,662	4,318	39,958	--	--	--	--	--	--	--	--	3,796	4,318
Zimbabwe	--	--	(6)	1	--	--	--	--	--	--	--	--	--	(6)
Other	219	2,259	110	414	--	--	--	--	3	13	44	144	222	154
Total[5]	23,316	202,954	16,613	181,379	706	5,285	246	2,258	1,472	10,163	913	7,788	25,310	17,708

[1]Includes unwrought metal and waste and scrap.
[2]Gross weight figures for cobalt oxide do not indicate cobalt content.
[3]Contained cobalt in nickel-copper and nickel matte from Australia and Botswana. Salts and compounds were imported from the remaining countries.
[4]Estimated content cobalt.
[5]Data may not add to totals shown because of independent rounding.
[6]Less than 1/2 unit.
[7]Based on weighted average cobalt metal price of $10.40 per pound for 1984 and $11.43 per pound for 1985, multiplied by 0.6 (estimated factor for matte) for imports from Australia, Botswana, and the Republic of South Africa.

Source: Bureau of the Census.

Table 8.—U.S. import duties for cobalt

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Alloys, unwrought	632.86	9% ad valorem	9% ad valorem	45% ad valorem.
Chemical compounds:				
Oxide	418.60	1.2 cents per pound.	1.2 cents per pound.	20 cents per pound.
Sulfate	418.62	1.4% ad valorem	1.4% ad valorem	6.5% ad valorem.
Other	418.68	4.7% ad valorem	4.2% ad valorem	30% ad valorem.
Ore and concentrate	601.18	Free	Free	Free.
Unwrought metal, waste and scrap	632.20	do	do	Do.

WORLD REVIEW

After months of negotiations, Falconbridge Ltd., a Canadian cobalt and nickel producer, concluded a supply contract that resulted in a number of changes in the structure of the international cobalt market. Under the terms of the 14-year contract, Falconbridge was to receive the majority of the matte produced by Bamangwato Concessions Ltd. (BCL), of Botswana. All of the matte had formerly been sent to the AMAX Nickel refinery in Louisiana. BCL reportedly requested termination of the AMAX Nickel contract because of a better offer from Falconbridge. The termination of the contract was subject to a number of conditions, which included compensation for the balance of AMAX Nickel's 15-year contract and for the cost of the impending closure of the Port Nickel refinery. BCL matte production was estimated at 57,000 short tons per year. The contract provided for the delivery to the Faconbridge refinery at Kristiansand, Norway, of about 7,000 tons of matte in 1985, 23,000 tons in 1986, and its full allocation of 46,000 tons annually from 1987 until the end of the contract in 1999. The feedstock was to enable Falconbridge to produce an additional 500,000 pounds of cobalt in 1987 without installing additional cobalt production capacity. The Falconbridge acquisition of the BCL matte was due, in part, to a decision by Western Platinum Ltd. (Wesplat) of the Republic of South Africa, to build its own refinery, ending the practice of sending its matte to Kristiansand for refining. The remaining 11,000 tons per year of BCL matte was slated to go to Rio Tinto (Zimbabwe) Ltd. (RTZ). After the failure of AMAX Nickel to have the Agnew matte refined elsewhere, AMAX Nickel agreed to terms for the sale of the majority of the matte to Sherritt Gordon Mines Ltd., of Canada, and to Outokumpu Oy, of Finland. At yearend, the disposition of the remainder of the Agnew matte was undecided.

Albania.—The scheduled completion of a nickel-cobalt refinery was delayed owing to a scarcity of hydroelectric power. The facility, which was being built by Salzgitter Industriebau GmbH, a West German firm, was expected to be completed in late 1986.

Brazil.—Cia. Níquel Tocantins increased its cobalt production by signing a toll refining agreement with Falconbridge. The 2-year contract called for approximately 120,000 pounds of cobalt per year to be refined at Falconbridge's refinery in Norway. Tocantins' 1985 cobalt production capacity of about 150,000 pounds per year at its São Paulo facility was expected to double by yearend 1986.

Canada.—Inco Ltd. and Falconbridge, both cobalt and nickel producers, introduced voluntary early retirement plans in an effort to reduce the number of workers at their Sudbury, Ontario, facilities. In addition, Inco was trying to reduce the work force at its Port Colborne, Ontario, refinery.

The Ontario, Canada, Provincial government issued new standards on the emissions of sulfur dioxide, which were to have a direct impact on two cobalt and nickel producers. Inco was told to achieve a target level at its Sudbury operation of 292,000 tons per year of sulfur dioxide by reducing emissions by 77% from its 1980 base level of 1.273 million tons per year. Inco had already reduced its emissions by adjusting its feed to reduce the quantity of sulfur contained in the concentrates. Any further reduction, however, was to come from the use of new technology and was expected to be expensive. Falconbridge was to be required to reduce sulfur dioxide emissions from its Sudbury operations from the then-current 170,000 tons per year to 110,000 tons per year.

Inco improved its productivity by 13% in

1985, following a record 18% increase in 1984. The improvements were effected through the increased application of safer, less costly bulk mining methods and the use of automated mining equipment. This was combined with productivity improvements at smelting and refining facilities. In 1985, nearly 80% of the company's Canadian ore was mined using bulk methods, up from 70% in 1984.

China.—The West German firm of Friedrich Krupp GmbH secured a contract to oversee the construction of a cobalt and tungsten refinery. The contract called for Krupp to supply machinery, equipment, and technical expertise in a 2-year project to result in a plant to produce cobalt, tungsten carbide, and cemented carbides.

Cuba.—The Punta Gorda nickel-cobalt plant was reported to have come on-stream in December.

Indonesia.—Ni-Cal Technology Ltd., Bermuda, was reported to have signed a letter of intent with P.T. Aneka Tambang (Antam), an Indonesian mining company, to form a joint venture to build and operate a nickel and cobalt processing plant in Indonesia. Construction of the facility, which was expected to be able to process 850 tons of ore per day, was to begin after a 4-month feasibility study was completed. The facility was to be located at Antam's laterite mining operation on Gebe Island.

Japan.—In September, Japanese cobalt refinery production returned to a near-capacity level of over 5 million pounds per year for the first time since 1982. The production increase came after resumption of shipments of Philippine feed material to Sumitomo Metal Mining Co. Ltd.

South Africa, Republic of.—Wesplat commissioned a refinery at its Marikana Mine, near Rustenburg. The new refinery was built to recover cobalt, nickel, and copper from matte that had previously been sent to the Falconbridge refinery in Norway for treatment.

U.S.S.R.—A 5-year plan was concluded in Norilsk, which resulted in a 50% increase in cobalt production. Plans called for an additional increase in production in 1986.

Zaire.—Because of its efforts to maintain an unofficial producer price of $11.70 per pound for electrolytic cobalt, Zaire lost a significant share of the U.S. market in 1985. Based solely on imports, after quantities of cobalt destined for the National Defense Stockpile were subtracted, its share fell from 54% in 1984 to 27% in 1985. These figures, however, did not tell the whole story as there were strong indications that Zaire had built up its cobalt stocks in the United States in late 1984 in anticipation of transportation difficulties in the Republic of South Africa. Most of the cobalt exported by Zaire during the year was shipped through the Republic of South Africa.

Zimbabwe.—RTZ, having secured a source of feedstock from BCL, reopened its Eiffel Flats refinery in August. The facility had been closed since September 1983, when its supply of matte from BCL was diverted to the United States. RTZ was said to have reached an agreement on a 10-year contract to toll refine the BCL matte for Centametall AH, a Swiss trading company.

Table 9.—Cobalt: World production, by country[1]

(Short tons)

Country	Mine output, metal content[2] 1981	1982	1983	1984^{p}	1985^{e}	Metal[3] 1981	1982	1983	1984^{p}	1985^{e}
Albania^{e}	380	^{r}440	^{r}500	^{r}660	660	--	--	--	--	--
Australia[4]	1,616	1,631	$^{r\ e}$1,300	$^{r\ e}$1,200	920	--	--	--	--	--
Botswana	280	280	246	^{e}250	250	--	--	--	--	--
Brazil	NA	NA	131	^{e}110	110	--	--	--	--	--
Canada[5]	2,293	1,548	1,747	2,563	3,390	1,003	1,148	1,460	2,340	2,950
Cuba	1,890	1,650	1,787	1,540	1,570	--	--	--	--	--
Finland	1,140	^{r}1,142	1,141	1,050	1,050	1,355	1,604	1,709	1,602	1,600
France	--	--	--	--	--	493	^{r}626	144	128	120
Germany, Federal Republic of^{e}	--	--	--	--	--	160	160	110	110	110
Japan	--	--	--	--	--	2,669	2,141	1,512	998	[6]1,408
Morocco	870	873	--	--	--	--	--	--	--	--
New Caledonia[7]	407	299	$^{r\ e}$440	$^{r\ e}$550	750	--	--	--	--	--
Norway	--	--	--	--	--	1,592	1,094	969	1,313	[6]1,804
Philippines	1,099	^{r}514	182	71	[6]977	--	--	--	--	--
U.S.S.R.^{e}	2,400	2,500	2,600	2,900	3,000	4,700	4,700	5,000	5,200	5,300
United Kingdom^{e} [8]	--	--	--	--	--	800	400	--	--	--
United States	--	--	--	--	--	447	508	103	--	--
Zaire	^{e}17,000	^{e}12,460	^{e}12,460	$^{r\ e}$19,800	22,000	12,262	^{r}6,035	5,908	10,003	11,000
Zambia	4,410	3,584	3,527	5,090	5,090	2,833	^{r}2,696	2,653	3,828	3,830
Zimbabwe	^{e}110	^{e}110	^{e}85	^{e}85	100	104	109	81	86	95
Total	33,895	^{r}27,031	26,146	35,869	39,867	28,418	^{r}21,221	19,649	25,608	28,217

^{e}Estimated. ^{p}Preliminary. ^{r}Revised. NA Not available.

[1]Table includes data available through May 20, 1984.

[2]Figures represent recoverable cobalt content. In addition to the countries listed, Bulgaria, Cyprus, the German Democratic Republic, Greece, Indonesia, Poland, the Republic of South Africa, Spain, and Uganda are known to produce ores that contain cobalt. Information is inadequate for reliable estimates of output levels. Other copper and/or nickel producing nations may also produce ores containing cobalt as a byproduct component, but recovery is small or nil.

[3]Figures represent elemental cobalt recovered unless otherwise specified. In addition to the countries listed, Czechoslovakia presumably recovers cobalt from Cuban nickel-cobalt oxide and oxide sinter; Belgium has imported small quantities of partly processed materials containing cobalt, but available information is inadequate to form reliable estimates of cobalt recovery from these materials.

[4]Australia does not produce cobalt. Figures represent quantities of cobalt contained in intermediate metallurgical products (cobalt oxide and nickel-cobalt sulfide). Actual quantities of cobalt mined were as follows in short tons: 1981—3,199; 1982—3,911; 1983—2,521; 1984—2,340; and 1985—1,800 (estimated).

[5]Actual output is not reported. Data for mine output are total cobalt content of all products derived from ores of Canadian origin, including cobalt oxide shipped to the United Kingdom for further processing, and nickel-copper-cobalt matte shipped to Norway for further processing. Data presented for metal output represent the output within Canada of metallic cobalt from ores of both Canadian and non-Canadian origin.

[6]Reported figure.

[7]Series reflects recovery from ores and intermediate metallurgical products exported from New Caledonia to France, Japan, and the United States. The estimated content of total ores mined is as follows, in short tons: 1981—3,074; 1982—2,351; 1983—3,465; 1984—4,513; and 1985—5,720.

[8]Estimated recovery of elemental cobalt in refined cobalt oxides and salts from intermediate metallurgical products originating in Canada.

TECHNOLOGY

The Bureau of Mines performed a study of the availability of cobalt from market economy countries. In the study, 97 deposits were analyzed.[3] Since nearly all cobalt produced has been a byproduct of nickel or copper mining, the report focused on those deposits. An economic evaluation on each deposit was performed to determine its cost of production. The study also investigated the interrelationship of the recovery of cobalt and its associated primary commodities.

Bureau researchers continued to improve the process for recovering cobalt from copper leach solutions.[4] Among the most significant improvements were the reduction of the quantity of resin needed to process the solution, thereby significantly reducing the cost of the process, and the determination that solvent extraction procedures produced a cobalt sulfate solution suitable for electrowinning. The latter procedures remove impurities from the column eluates, separate the cobalt and nickel, and concentrate the cobalt.

Other Bureau research was conducted on the recovery of cobalt from Missouri lead ores.[5] These ores were unique because they represented the only domestic cobalt resource being mined. Froth flotation was used to recover up to 65% of the cobalt found in the mill tailings.

The Bureau of Mines developed and demonstrated an ammoniacal sulfate leach process for recovering cobalt and nickel from low-grade domestic laterite deposits. One of the process steps, solvent extraction of cobalt, required the reduction of hexammine complexes of cobalt in an ammoniacal leach solution. Previously, this reduction had been accomplished using cobalt metal shot in a column. The Bureau published a report that presented experimental results and an economic evaluation comparing two alternate techniques with that of the shot column.[6] The first technique involved an electrolytic reduction cell with an extended surface area cathode, whereas the second was direct electrowinning from purified leach solution using a cell with a fluid bed cathode. The second alternative eliminated the conventional solvent extraction-electrowinning steps. The operating costs for the shot column, and for electrolytic reduction, were essentially the same at $0.54 per pound of cobalt, but the cost of direct electrowinning, $1.71 per pound of cobalt, eliminated this method as a practical alternative.

Another Bureau report described an investigation of factors influencing economic viability of a proposed system to mine and process cobalt-containing manganese nodules.[7] The report concluded that nodule mining would not take place in the foreseeable future without significant financial incentives, such as price supports, tax breaks, or other programs.

The Bureau published a summary of a 5-year program sponsored by the National Oceanic and Atmospheric Administration to devise waste management plans for the processing of cobalt-containing manganese nodules.[8] Studies included summary descriptions of Pacific manganese nodules, process options and flowsheets, methods for characterizing nodules and their tailings, and results of analyses of laboratory and pilot plant generated tailings.

The Bureau of Mines investigated the effects of hydrogen chloride concentration and solution temperature on the solubility and crystal form of the chlorides of cobalt, nickel, and manganese when sparged with hydrogen chloride gas.[9] The results of the investigation indicated an improved method for the separation of cobalt and nickel when dissolved in hydrochloric acid.

As part of its continuing efforts to reduce U.S. dependence on foreign sources for strategic and critical metals, the Bureau of Mines conducted research to improve the technology for recycling these metals from superalloy scrap. The research approach involved melting and casting superalloy scrap into soluble anodes for electrodeposition of cobalt-nickel alloys by controlled potential electrolysis. A report was published that described the experimental results from tests using alloy anodes cast from elemental cobalt, nickel, and chromium, the main constituents of superalloys.[10] Baseline data from these tests were necessary before detailed experiments could be conducted on the more complex superalloy scrap. The report assessed the effects of cathode potential and other parameters on cathode current efficiency, alloy deposit composition, and deposition potential at a cell temperature of 55° C.

The Bureau investigated technology for increasing the leaching rate of bulk superalloy scrap by treating the scrap with zinc.[11] The treatment, which included dissolution of the superalloy scrap in molten zinc and vacuum distillation of the zinc for reuse, dramatically increased the leaching rate of superalloys.

Another metals recycling report was published that described Bureau of Mines work on the rapid identification and sorting of scrap metals.[12] One method, spark testing, was the examination of the pattern of sparks that resulted when a metal or alloy was ground on an abrasive wheel. The primary drawback of using this method was the necessity for having experienced sorters. Researchers developed a spectrophotometric method that eliminated the need for experienced sorters. The spectra of several alloys were measured, and it was found that the differences in the spectra were sufficient for identification.

A fundamental study was performed on the recovery of cobalt and nickel from iron-based molten alloys by using metal solvents.[13] The aim of this work was to investigate a pyrometallurgical process to directly recover cobalt and nickel from iron-based alloys. The results indicated that further research would be required to find better solvent systems for the recovery of cobalt.

Bureau of Mines research was conducted to devise a procedure for treating cobalt-nickel-bearing magnetic alloy grinding sludge to remove detrimental contaminants and produce an alloy powder for recycling.[14] The technique consisted of (1) treatment with solvent to remove most of the sulfur and oil contamination, (2) drying, light grinding, sizing, and magnetic separation of a major portion of the grinding media, (3) controlled oxidation roasting to remove residual sulfur and carbon, and (4) hydrogen reduction of metal oxides. Overall, more than 95% of the cobalt, nickel, and iron and about 90% of the copper were recovered from the starting sludge sample.

AMAX Inc., Greenwich, CT, announced that Compagnie Française d'Entreprises Minières, Metallurgiques et, d'Investissements (COFREMMI), its joint venture with Bureau de Recherches Géologiques et Minières (BRGM), the state-owned mining company of France, had made available for licensing a high-pressure, sulfuric acid leach process it had developed for the treatment of lateritic ores.[15] The COFREMMI process, a result of 15 years of extractive research and development, was said to provide high cobalt and nickel recovery rates and low energy and operating costs, while being highly adaptable to a variety of ores.

A process was developed at Argonne National Laboratory for recovering cobalt and manganese from low- and medium-grade ores.[16] In tests, which focused on deep sea nodules, the method extracted nearly 100% of metal values. The process was based on ores being dissolved into a molten salt mixture from which metals were separated by electrolysis. By proper control of the electrolysis potential, cobalt was able to be selectively recovered even in the presence of manganese and other transition elements.

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Columbium and Tantalum

By Larry D. Cunningham[1]

The United States remained dependent on imports of columbium and tantalum, and there continued to be no domestic production of either mineral. Imports for consumption of tantalum mineral concentrates declined significantly, reflecting a lack of activity in the spot tantalite market. Tantalum materials purchased for the National Defense Stockpile (NDS) in 1983 and 1984 were delivered and recorded as stockpile inventory. In July, the President approved National Security Council (NSC) recommendations for modernizing the stockpile. The Cabot Corp. announced a restructuring program to sell all its metals businesses except columbium and tantalum, while Mallinckrodt Inc. was forced to shut down its columbium and tantalum operations at yearend.

Domestic production and value of ferrocolumbium continued downward. However, reported consumption of columbium in the form of ferrocolumbium and nickel columbium continued to increase. Columbium consumption in all steel end-use categories increased, with the exception of stainless and heat-resisting steels. Demand for tantalum was down. Reported shipments of tantalum products and sales of tantalum capacitors were both down significantly compared with levels in 1984.

Columbium price quotations were unchanged, whereas most tantalum concentrates and related product prices declined. Net trade for both columbium and tantalum continued at a deficit, with overall trade volume and value lower than in 1984 for both exports and imports.

Thailand's chemical plant for the processing of columbium- and tantalum-bearing materials was completed. Commercial production is planned to begin by yearend 1986.

Domestic Data Coverage.—Domestic production data for ferrocolumbium are devel-

Table 1.—Salient columbium statistics

(Thousand pounds of columbium content unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Mine production of columbium-tantalum concentrates	(1)	(1)	--	--	--
Releases from Government excesses	--	--	--	--	--
Consumption of raw materials	1,983	e1,900	e1,900	e2,600	e2,000
Production of ferrocolumbium	1,145	W	W	W	W
Consumption of primary products: Ferrocolumbium and nickel columbium^e	6,244	3,679	4,318	5,399	5,968
Exports: Columbium metal, compounds, alloys (gross weight)^e	150	100	100	100	120
Imports for consumption:					
Mineral concentrates^e	1,050	580	730	1,790	1,290
Columbium metal and columbium-bearing alloys^e	(2)	9	2	10	1
Ferrocolumbium^e	6,068	3,128	2,539	4,343	4,699
Tin slags^e 3	842	636	W	W	W
World: Production of columbium-tantalum concentrates^e	r32,662	23,334	r18,911	r32,833	35,044

^e Estimated. ^r Revised. W Withheld to avoid disclosing company proprietary data.
[1] A small unreported quantity was produced.
[2] Less than 1/2 unit.
[3] Receipts reported by consumers; includes synthetic concentrates and other miscellaneous materials, after deduction of reshipments.

Table 2.—Salient tantalum statistics

(Thousand pounds of tantalum content unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Mine production of columbium-tantalum concentrates	([1])	([1])	--	--	--
Releases from Government excesses	--	--	--	--	--
Consumption of raw materials	1,269	e800	e900	e1,300	e1,100
Exports:					
Tantalum ores and concentrates (gross weight)[2]	99	235	121	156	122
Tantalum metal, compounds, alloys (gross weight)	205	382	211	352	369
Tantalum and tantalum alloy powder (gross weight)	97	115	123	151	143
Imports for consumption:					
Mineral concentrates[e]	650	440	180	680	230
Tantalum metal and tantalum-bearing alloys[3]	34	71	27	47	32
Tin slags[e 4]	896	576	W	W	W
World: Production of columbium-tantalum concentrates[e]	r889	r627	r690	r739	622

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]A small unreported quantity was produced.
[2]Includes reexports.
[3]Exclusive of waste and scrap.
[4]Receipts reported by consumers; includes synthetic concentrates and other miscellaneous materials, after deduction of reshipments.

Table 3.—Columbium and tantalum materials in Government inventories as of December 31, 1985

(Thousand pounds of columbium or tantalum content)

Material	Stockpile goals	National Defense Stockpile inventory		
		Stockpile-grade	Nonstockpile-grade	Total
Columbium:				
Concentrates	5,600	1,150	869	[1]2,019
Carbide powder	100	21	--	21
Ferrocolumbium	--	598	333	[1]931
Metal	--	45	--	[1]45
Total	([2])	1,814	1,202	3,016
Tantalum:				
Minerals	8,400	1,686	1,152	[3]2,838
Carbide powder	--	29	--	[3]29
Metal	--	201	([4])	[3]201
Total	([2])	1,916	1,152	3,068

[1]All surplus ferrocolumbium and columbium metal were used to offset the columbium concentrates shortfall. Total offset was 1,148,000 pounds.
[2]Overall goals, on a recoverable basis, total 4,850,000 pounds for the columbium metal group and 7,160,000 pounds for the tantalum metal group.
[3]All surplus tantalum carbide powder and tantalum metal were used to offset the tantalum minerals shortfall. Total offset was 271,000 pounds.
[4]100 pounds.

Sources: Federal Emergency Management Agency and General Services Administration.

oped by the Bureau of Mines from the annual voluntary survey for ferroalloys. Of the four domestic operations to which a survey request was sent, all responded, representing 100% of total production. Ferrocolumbium production data are withheld for 1985 to avoid disclosing company proprietary data.

Legislation and Government Programs.—The NDS goals for columbium and tantalum materials did not change during 1985, and there were no sales of stockpile excess materials.

Tantalum materials contracted for in late 1983 and early 1984 from Greenbushes Tin Ltd. of Australia and Amalgamet Inc., Bomar Resources Inc., and Norore Corp., all of New York City, were delivered and recorded as stockpile inventory. Yearend stockpile inventories reported by the General Services Administration for contained columbium in concentrates and contained tantalum in minerals increased by 213,000 pounds and 254,000 pounds, respectively.

However, inventories of all columbium and tantalum materials continued to be considerably below their respective goals. As of yearend 1985, under the offset concept, 57% of the goal for columbium concentrates and 37% of the goal for tantalum minerals were met.

On July 8, the President approved NSC recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, columbium would be categorized in tier II, and the goal would be 2,532,419 pounds of columbium metal equivalent. Tantalum would be categorized in both tier I and tier II, and the goals would be 1,900,700 pounds and 1,023,320 pounds of tantalum metal equivalent, respectively. At yearend this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The Environmental Protection Agency (EPA) set final rules for new effluent limitation guidelines and standards for nonferrous metals-forming operations, based on "best practicable, available, and demonstrated technologies to handle industry's waste water discharges."[2] The standards include columbium and tantalum and are part of EPA's water pollution effluent guidelines program under the Clean Water Act for Nonferrous Metals.

DOMESTIC PRODUCTION

No domestic mineral concentrate production of either columbium or tantalum was reported in 1985.

Domestic production of ferrocolumbium, expressed as contained columbium, was virtually unchanged from that of 1984. Value of ferrocolumbium production decreased to an estimated $8.7 million. The regular grade continued to be favored over the high-purity grade of ferrocolumbium in the production mix.

Tantalum content of raw materials consumed by processors in the production of tantalum compounds and metals was estimated to be about 1.1 million pounds, down by 15% from that of 1984. In addition, consumption of purchased metal scrap was estimated at about 90,000 pounds.

On December 19, Avon Products Inc. entered into an agreement with International Minerals & Chemical Corp. (IMC) to sell its Mallinckrodt Div. for $675 million in cash.[3] The acquistion of Mallinckrodt, a specialty chemicals and medical product operation, reportedly reflects IMC's long-term strategy to broaden the company's sources of income beyond its agricultural businesses. At midyear, Mallinckrodt announced that its long-term tolling arrangement with NRC Inc., for conversion of columbium- and tantalum-bearing concentrates, would not be renewed in 1986.[4] By yearend, Mallinckrodt, representing about one-third of the domestic tantalum raw material processing capacity, was forced to shut down its columbium and tantalum operations because alternative tolling arrangements could not be made.

On October 16, Cabot announced a restructuring program to sell those assets not meeting the company's financial performance objectives.[5] Cabot's divestiture program includes the Westar natural gas transmission system and all specialty metals businesses, except columbium and tantalum. The businesses to be sold represent approximately 40% of Cabot's total assets. The company estimates that its work force will be reduced by more than 2,000 employees worldwide upon completion of the program. With metal interest directed at columbium and tantalum, Cabot commissioned a $3 million vacuum-arc remelt furnace in Boyertown, PA. The furnace will be used to produce columbium metal and columbium-titanium alloys for superconducting magnet applications.[6]

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1985

Company	Plant location	Products[1]						
		Metal[2]		Carbide		Oxide and/or salts		FeCb and/or NiCb
		Cb	Ta	Cb	Ta	Cb	Ta	
Avon Products Inc.: Mallinckrodt Inc.	St. Louis, MO	--	--	--	--	X	X	--
Cabot Corp.	Boyertown, PA	X	X	--	--	X	X	--
Do	Revere, PA	--	--	--	--	--	--	X
Fansteel Inc	Muskogee, OK	X	X	--	--	X	X	--
Do	North Chicago, IL	--	X	--	--	--	--	--
Kennametal Inc	Latrobe, PA	--	X	X	X	--	--	--
Metallurg Inc.: Shieldalloy Corp.	Newfield, NJ	--	X	X	X	--	--	X
NRC Inc.[3]	Newton, MA	X	X	--	--	--	--	--
Reading Alloys Inc	Robesonia, PA	--	--	--	--	--	--	X
Teledyne Inc.: Teledyne Wah Chang Albany Div.	Albany, OR	X	X	--	--	X	--	X

X Indicates processor and/or producer.
[1]Cb, columbium; Ta, tantalum; FeCb, ferrocolumbium; NiCb, nickel columbium.
[2]Includes miscellaneous alloys.
[3]Jointly owned by Omicron Holdings Inc. and Hermann C. Starck Berlin.

CONSUMPTION, USES, AND STOCKS

Overall reported consumption of columbium as ferrocolumbium and nickel columbium rose by about 10%. Consumption of columbium by the steelmaking industry rose 15%, with the percent of columbium usage per ton of steel produced rising significantly. Consumption in all steel end-use categories was up with the exception of the stainless and heat-resisting steels, which experienced a slight decline. Consumption in carbon steels increased by about 18%. Columbium demand in high-strength low-alloy steels advanced by more than 20%, exceeding 2 million pounds for the first time since 1981.

A new columbium-base nitrided alloy, Tribocor 532N (columbium, 30% titanium, 20% tungsten), was developed and test-marketed by Fansteel Inc. Potential applications for the alloy, which is suited for environments involving both wear and corrosion, include seal rings, oil well components, and spray nozzles.

Demand for columbium in superalloys declined slightly. However, that portion used in the form of nickel columbium continued to rise by nearly 30% to about 540,000 pounds, reflecting a shift from ferrocolumbium.

The Tantalum Producers Association reported a 21% drop in overall tantalum shipments, indicating a sizable decline in the market. The powder and anodes and the mill products segments, both of which had experienced significant growth in 1984, declined 31% and 19%, respectively. Tantalum for cemented carbide dropped 30%. The decline was influenced by the growing popularity of coated cutting tools and by the automotive industry's emphasis on producing smaller vehicles, which required less metal cutting. Tantalum as an alloy additive was the only major segment in the market showing an increase and was up by 63%. Tantalum continues to be a key and important strengthening element in many nickel- and cobalt-base alloys for application in the growing market for heat-resisting turbine engine components.

Factory sales of tantalum capacitors decreased by over 20% from the record-high sales in 1984, as reported by the Electronic Industries Association. Weak demand for tantalum capacitor products by computer manufacturers, a major market, contributed substantially to the decline. The Sprague Electric Co. conducted a restructuring program throughout 1985 to reduce the number of capacitor manufacturing facilities through consolidation of operations. The consolidation was done without a significant loss of production capacity, but employment at the company was reduced by 26%.[7]

Data on aggregate stocks of columbium and tantalum raw materials reported by processors for 1985 were incomplete at the time this chapter was prepared. Aggregate stocks of columbium and tantalum raw materials reported by processors for yearend 1984 were both down from yearend 1983, by about 30% for columbium and by more than 15% for tantalum.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1984	1985
Columbium products:		
Compounds including alloys	941,820	1,149,120
Metal including worked products	529,800	404,300
Other	500	300
Total	1,472,120	1,553,720
Tantalum products:		
Oxides and salts	45,900	27,600
Alloy additive	86,630	141,420
Carbide	128,760	90,210
Powder and anodes	665,500	459,800
Ingot (unworked consolidated metal)	9,500	220
Mill products	307,600	249,500
Scrap	39,000	48,300
Total	1,282,890	1,017,050

Source: Tantalum Producers Association.

Table 6.—Consumption, by end use, and industry stocks of ferrocolumbium and nickel columbium in the United States

(Pounds of contained columbium)[1]

	1984	1985
END USE		
Steel:		
Carbon	1,463,886	1,720,554
Stainless and heat-resisting	951,020	935,469
Full alloy	(2)	(2)
High-strength low-alloy	1,693,464	2,056,532
Tool	(3)	(3)
Unspecified	27,941	29,135
Total	4,136,311	4,741,690
Superalloys	1,240,295	1,204,249
Alloys (excluding alloy steels and superalloys)	19,454	21,716
Miscellaneous and unspecified	3,185	--
Total consumption	5,399,245	5,967,655
STOCKS		
Dec. 31:		
Consumer	W	W
Producer[4]	W	W
Total stocks[e]	950,000	720,000

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included in "Total stocks."
[1]Includes columbium and tantalum in ferrotantalum-columbium, if any.
[2]Small; included with "Steel: High-strength low-alloy."
[3]Included with "Steel: Unspecified."
[4]Ferrocolumbium only.

PRICES

The published price for pyrochlore concentrates and columbium products based on them remained unchanged. The price for pyrochlore concentrates produced in Canada by Niobec Inc. continued to be quoted at \$3.25 per pound of contained columbium pentoxide (Cb_2O_5), f.o.b. Canada, for concentrates with a nominal content of 57% to 62% Cb_2O_5. The quoted spot price of regular-grade ferrocolumbium containing 63% to 68% columbium was unchanged at \$5.66 per pound of contained columbium, f.o.b. shipping point.

The quoted price for high-purity ferrocolumbium containing 62% to 68% columbium continued to be quoted at \$17.70 per pound of contained columbium, f.o.b. shipping point. Nickel columbium was reported to be selling at yearend for about $17 per pound of contained columbium. Columbium metal price quotes were unchanged. The spot price for columbite concentrates was quoted throughout 1985 at $3.50 to $5.00 per pound of combined Cb_2O_5 and tantalum pentoxide (Ta_2O_5), c.i.f. U.S. ports. Columbium oxide was reported to be selling at yearend for about $6.50 per pound of oxide.

Most tantalum prices were down from the 1984 levels, with declining tantalum demand and a continued lack of activity in the spot tantalite market. The published spot market price for tantalite, on the basis of 60% combined Cb_2O_5 and Ta_2O_5, c.i.f. U.S. ports, which began the year at $30 to $32, was being quoted at $21 to $24.50 by yearend, the lowest level since first quarter 1983. The contract price for tantalite from the Canadian tantalum producer, Tantalum Mining Corp. of Canada Ltd. (Tanco), quoted at $45 per pound of contained pentoxide since midyear 1982, was suspended on January 1, 1985. The contract price for tantalite from Greenbushes in Australia remained suspended. Published price quotations for tantalum mill products and powders were down by 10% and 20%, respectively.

FOREIGN TRADE

Net trade continued at a deficit for both columbium and tantalum. Overall trade volume and value were down for both exports and imports. Exports and reexports of tantalum ores and concentrates declined more than 20% to 122,000 pounds valued at $1.6 million. The Federal Republic of Germany, Japan, and the Netherlands were the principal recipients, altogether accounting for more than 90% of total shipments.

Imports of raw materials and intermediates, such as ferrocolumbium and columbium oxide, exceeded the value of exports of upgraded forms of columbium and tantalum by almost 80%. Imports for consumption from Brazil included more than 7.2 million pounds of ferrocolumbium with a value of $22.2 million, compared with 6.7 million pounds valued at $20.4 million in 1984. Imports for consumption of columbium oxide from Brazil decreased almost 40% to 725,000 pounds valued at $4.7 million, compared with 1.2 million pounds valued at $6.8 million in 1984. Contained in the columbium oxide imports were an estimated 14,000 pounds of tantalum oxide valued at about $500,000. Estimated data for the ferrocolumbium and the columbium and tantalum oxides were based on entries in nonspecific classes.

Imports for consumption of columbium mineral concentrates declined more than 10% from those of 1984. Average unit value for overall imports declined by 13% owing to the low unit value of concentrates from Canada, which was about 97% of the total quantity. Imports were estimated to contain 1.18 million pounds of columbium and 5,000 pounds of tantalum at an average grade of approximately 59% Cb_2O_5 and less than 1% Ta_2O_5.

Imports for consumption of tantalum mineral concentrates declined by 66% with average unit value up nearly 30%. Brazil and Canada were the leading sources, together providing about 60% of both total quantity and total value. The imports from Canada were the first since 1982. Imports were estimated to contain 225,000 pounds of tantalum and 110,000 pounds of columbium at an average grade of approximately 38% Ta_2O_5 and 21% Cb_2O_5.

Data on receipts of raw materials other than mineral concentrates were incomplete.

Imports for consumption of columbium-tantalum synthetic concentrates totaled 2.75 million pounds with a value of $18.4 million, compared with 2.1 million pounds valued at $13.7 million in 1984. These figures are not included in the salient statistics data.

Table 7.—U.S. foreign trade in columbium and tantalum metal and alloys, by class

(Thousand pounds, gross weight, and thousand dollars)

Class	1984		1985		Principal destinations and sources, 1985
	Quantity	Value	Quantity	Value	
EXPORTS[1]					
Tantalum:					
Powder	151	17,026	143	15,188	France 42, $4,505; Japan 26, $2,894; West Germany 23, $2,831; United Kingdom 16, $1,879.
Unwrought and waste and scrap	252	10,050	305	8,304	West Germany 185, $5,180; Japan 13, $1,060; Belgium-Luxembourg 25, $785; France 9, $574.
Wrought	100	13,099	64	9,339	Japan 17, $2,869; United Kingdom 19, $2,690; West Germany 11, $1,514; France 8, $1,247.
Total	XX	40,175	XX	32,831	West Germany $9,500; Japan $6,800; France $6,300; United Kingdom $4,600.[2]
IMPORTS FOR CONSUMPTION					
Columbium:					
Ferrocolumbium[e]	6,682	20,445	7,229	22,207	All from Brazil.
Unwrought metal and waste and scrap	7	125	8	31	United Kingdom 7, $21; West Germany ([3]), $10.
Unwrought alloys	13	103	([3])	2	All from Japan.
Wrought	([3])	35	([3])	8	All from West Germany.
Tantalum:					
Waste and scrap	183	4,866	134	5,518	West Germany 51, $2,770; Belgium-Luxembourg 13, $782; Netherlands 8, $523; France 15, $356.
Unwrought metal	46	4,878	22	2,282	West Germany 16, $1,776; Belgium-Luxembourg 5, $439; United Kingdom 1, $63.
Unwrought alloys	1	33	--	--	
Wrought	1	48	9	254	West Germany 1, $200; Belgium-Luxembourg 8, $49.
Total	XX	30,533	XX	30,302	Brazil $22,200; West Germany $4,800; Belgium-Luxembourg $1,300; Netherlands $900.[2]

[e]Estimated. XX Not applicable.
[1]For columbium, data on exports of metal and alloys in unwrought and wrought form, including waste and scrap, are not available; included in basket category.
[2]Rounded.
[3]Less than 1/2 unit.

Sources: Bureau of the Census and Bureau of Mines.

Table 8.—U.S. imports for consumption of columbium mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1984		1985	
	Gross weight	Value	Gross weight	Value
Brazil	143	431	--	--
Canada	2,498	4,089	2,821	4,496
Germany, Federal Republic of[1]	17	38	--	--
Malaysia	105	163	--	--
Netherlands[1]	8	24	--	--
Nigeria	495	1,284	77	177
Total[2]	3,265	6,030	2,899	4,673

[1]Presumably country of transshipment rather than original source.
[2]Data may not add to totals shown because of independent rounding.

Sources: Bureau of the Census and Bureau of Mines.

Table 9.—U.S. imports for consumption of tantalum mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1984		1985	
	Gross weight	Value	Gross weight	Value
Australia	371	4,799	150	2,032
Belgium-Luxembourg[1]	21	81	--	--
Brazil	351	3,895	231	2,262
Canada	--	--	233	2,553
China	22	203	--	--
French Guiana[1]	3	36	5	70
Germany, Federal Republic of[1]	205	2,291	--	--
Guyana[1]	1	14	--	--
Malaysia	341	1,354	--	--
Mozambique	16	152	--	--
Netherlands[1]	105	701	--	--
Portugal	11	90	--	--
Rwanda	37	753	--	--
Singapore[1]	10	122	--	--
South Africa, Republic of	7	32	--	--
Spain	71	672	--	--
Taiwan[1]	8	93	--	--
Thailand	609	3,688	60	502
Venezuela[1]	--	--	1	20
Zaire	11	79	57	748
Total[2]	2,199	19,054	737	8,187

[1]Presumably country of transshipment rather than original source.
[2]Data may not add to totals shown because of independent rounding.

Sources: Bureau of the Census and Bureau of Mines.

WORLD REVIEW

World production data on columbium and tantalum minerals exclude columbium or tantalum recovered from contemporary and old tin slags and from struverite. Tantalum contained in tin slags produced in 1981, 1982, 1983, 1984, and 1985 was, in thousand pounds, 1,006, 991, 1,049, 828, and 877, respectively, according to data from the Tantalum International Study Center.

Regarding the shipments of old tin slags, data continued to be available only from Thailand. Shipments of old tin slags from Thailand in 1985 declined significantly to 22 short tons from 326 tons in 1984. Data were not available as to the disposition of the shipments.

Developments having potential effects on tantalum supply included the International Tin Council's (ITC) announcement on October 24 that the council could no longer continue its tin price support operations owing to lack of funds. The announcement precipitated immediate suspension of trading on world tin markets, including the London Metal Exchange (LME) and the Kuala Lumpur Tin Market (KLTM). Tin trading on the LME and KLTM remained suspended throughout the year. In Thailand, the Government announced new regulations aimed at curtailing tin smuggling activities. The regulations include a ban on transporting tin at night; trucks and boats transporting tin must display identification of the cargo; and tin storage sheds must have concrete walls and floors to resist break-ins. Also, at midyear, the Government reportedly approved a 50% reduction in the Thai tin miner's share of the country's contributions to the ITC.

Australia.—For the fiscal year (FY) ending June 30, 1985, Greenbushes reported that throughput and production of tin and tantalum from soft-rock reserves exceeded budgeted estimates. Ore treated was 2.1 million tons in FY 1985, compared with 1.7 million tons in FY 1984. Tantalum oxide produced in concentrates increased to 136,800 pounds from 105,200 pounds in FY 1984. The chemical plant, which operated on one shift thoughout the year, produced 40,100 pounds of Ta_2O_5 and 4,400 pounds of Cb_2O_5 in FY 1985. Tantalum oxide contained in tantalum glass production was 74,100 pounds in FY 1985, compared with 48,500 pounds in FY 1984, with the tin smelter operating at about 50% of available capacity. The tailings retreatment plant remained inactive, but construction was under way to reestablish the plant with an annual throughput capacity of 1.6 million tons of tailings. Annual production capacity was planned to be 110 tons of tin and about 100,000 pounds of Ta_2O_5. The company expected the operation to be its lowest cost tantalite source, with cost of production estimated at less than $20 per pound of Ta_2O_5.

Greenbushes completed construction of the primary crushing station for its hard-rock project, which was commissioned using spodumene ore. Installed ore capacity exceeds 1.1 million tons per year. However, the secondary crushing and concentrating sections of the project were deferred until June 1986. When they are completed, initial ore production capacity is envisioned at 330,000 tons of ore annually, producing about 220,000 pounds of Ta_2O_5 and 310 tons of tin.

Developments reflecting Greenbushes' long-term view of its role in the tantalum market included the start of production of tantalum carbide in the United States under a conversion agreement with Metallurgical Technologies Inc., Houston, TX. Greenbushes was also converting tantalite concentrates to potassium tantalum fluoride and metallurgical-grade tantalum powder through tolling arrangements with Métallurgie Hoboken-Overpelt SA in Belgium.

Talmina Trading Co. reportedly started production at its new Finnis River tantalite mine located about 30 miles southwest of Darwin, Northern Territory. Production was planned at about 24,000 pounds of tantalum concentrates per month. Measured ore reserves were estimated at 161,000 tons containing 3.26 pounds of Ta_2O_5 per ton of ore.

Brazil.—Early in the year, Cia. Brasileira de Metalurgia e Minerção announced plans to invest $4.6 million in equipment to start production of columbium metal at its plant in Araxa. Commercial production was envisioned by midyear 1988 at an initial annual capacity of about 100 tons of columbium metal.

Brazil's total production and exports of all columbium products were 19,500 tons and 16,000 tons, respectively, compared with the 1984 totals of 18,200 tons and 14,600 tons, respectively.

Canada.—As reported by Teck Corp. for the FY ending September 30, production of columbium oxide at the Niobec Mine at St. Honoré, Quebec, declined 7% to 6.4 million pounds, compared with 6.9 million pounds in 1984. The operation was closed by a strike from October 19 through November 24, 1984. Ore milled was down 9% to 745,724 tons from 819,772 tons in 1984, as the mill operated on the average at 2,382 tons per day, compared with 2,240 tons per day in 1984. Recovery improved to 61.7% from 60% in 1984, with the Cb_2O_5 grade of ore declining to 0.70% from 0.71% in 1984. Ore reserves increased at the end of the FY to about 12.1 million tons assaying 0.66% Cb_2O_5, compared with 11.8 million tons assaying 0.66% Cb_2O_5 in FY 1984.

The Hudson Bay Mining and Smelting Co. Ltd. reported that tantalum mining and milling activity, which ceased at yearend 1982 at the Bernic Lake, Manitoba, operation of Tanco, remained suspended. Sales of tantalum concentrates by Tanco during 1985 were made from existing stockpiles. However, the tantalum mill continued to be used as a pilot plant to produce lithium-containing spodumene concentrates. Based on favorable pilot test results, Tanco started construction of a full-scale spodumene plant at the Bernic Lake site. The plant, estimated to cost $6.4 million, was planned for completion by yearend 1986, to serve the specialty ceramics and glass markets.

Japan.—Production of ferrocolumbium rose to 1,182 tons from the 1,136 tons produced in 1984. Columbium ore imported for ferrocolumbium production declined to 2,176 tons, with Canada providing almost 90%, compared with 2,251 tons in 1984. Ferrocolumbium imports increased more than 40% to 3,163 tons compared with 2,260 tons in 1984. The bulk of imports came from Brazil. Tantalum ore imports totaled 244 tons, compared with 303 tons in 1984; over 60% of the imports came from Malaysia.

Toho Titanium Co. Ltd. announced plans to construct a refining plant in Chigasaki, Kanagawa Prefecture, capable of producing 4.4 tons per month of columbium metal. Construction of the plant was scheduled to start in early 1986. When completed, the plant will be used to produce columbium metal for superconducting magnet applications.

Late in the year, an agreement was reached between Fansteel Inc. and V-Tech Corp. to form a joint venture to produce columbium and tantalum products in Japan. Fansteel will hold a 51% interest in the venture, V Tech-Fansteel Inc. Operation of a pilot plant near Mito, Ibaraici Prefecture, was planned to begin by midyear 1986, with a commercial-scale plant following in 1988.[8]

Table 10.—Columbium and tantalum: World production of mineral concentrates, by country[1]

(Thousand pounds)

Country[2]	Gross weight[3]					Columbium content^{e} [4]					Tantalum content^{e} [4]				
	1981	1982	1983	1984^{p}	1985^{e}	1981	1982	1983	1984	1985	1981	1982	1983	1984	1985
Australia: Columbite-tantalite	582	256	258	$^{r\,e}$455	410	105	45	45	80	80	205	90	90	155	140
Brazil:															
Columbite-tantalite	659	443	582	375	400	138	97	134	86	90	178	130	170	110	116
Pyrochlore	65,887	43,195	37,099	66,330	70,550	27,673	18,142	15,582	27,860	29,630	--	--	--	--	--
Canada:^{e}															
Pyrochlore	9,040	10,500	^{r}6,700	^{r}9,700	10,900	[5]4,224	4,730	2,770	4,380	4,900	--	--	--	--	--
Tantalite	640	590	--	--	--	19	18	--	--	--	[5]188	170	--	--	--
Malaysia: Columbite-tantalite	51	18	148	60	[5]168	8	3	22	9	25	4	2	10	4	12
Mozambique:															
Microlite	107	65	51	22	22	NA	NA	NA	NA	NA	54	33	25	7	8
Tantalite	75	48	31	15	15	NA	NA	NA	NA	NA	24	15	10	5	5
Namibia: Tantalite	24	20	6	15	10	6	5	2	4	3	7	6	2	4	3
Nigeria:															
Columbite	831	397	192	$^{r\,e}$265	220	363	180	85	120	90	48	24	11	16	13
Tantalite	4	2	^{e}2	^{e}2	2	(6)	(6)	(6)	(6)	(6)	2	1	1	1	1
Portugal: Tantalite	20	13	7	--	--	5	4	2	--	--	5	4	2	--	--
Rwanda: Columbite-tantalite	126	137	111	115	[5]61	38	40	33	34	18	28	30	24	25	13
South Africa, Republic of:															
Columbite-tantalite	8	22	1	1	(6)	2	7	(6)	(6)	(6)	2	6	(6)	(6)	(6)
Spain: Tantalite	129	118	104	70	70	NA	NA	NA	NA	NA	[5]36	[5]31	[5]33	[5]21	20
Thailand: Columbite-tantalite	108	86	1,210	1,052	[5]591	18	15	205	180	100	23	20	278	284	160
United States: Columbite-tantalite	(7)	(7)	--	--	--	(7)	(7)	--	--	--	(7)	(7)	--	--	--
Zaire: Columbite-tantalite	^{r}176	^{r}132	112	220	350	48	36	30	60	95	50	37	32	62	100
Zimbabwe: Columbite-tantalite	99	79	5	130	[5]88	15	12	1	20	13	35	28	2	45	31
Total	^{r}78,566	^{r}56,121	46,619	78,827	83,857	32,662	23,334	18,911	32,833	35,044	889	627	690	739	622

^{e}Estimated. ^{p}Preliminary. ^{r}Revised. NA Not available.

[1]Excludes columbium- and tantalum-bearing tin ores and slags. Table includes data available through July 1, 1986.

[2]In addition to the countries listed, China, the U.S.S.R., and Zambia also produce, or are believed to produce, columbium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

[3]Data on gross weight generally have been presented as reported in official sources of the respective countries, divided into concentrates of columbite, tantalite, and pyrochlore where information is available to do so, and reported in groups such as columbite and tantalite where it is not.

[4]Unless otherwise specified, data presented for metal content are Bureau of Mines estimates based, in most part, on reported gross weight. Metal content estimates are revised as necessary to reflect changes in gross weight data.

[5]Reported in official country sources.

[6]Less than 1/2 unit.

[7]A small unreported quantity was produced.

Rwanda.—Late in the year, the Société Minière du Rwanda (SOMIRWA) reportedly had gone into receivership after declaring a cessation of payments backdated to July. A heavy debt burden, low prices, and currency difficulties were cited as reasons for SOMIRWA's problem. SOMIRWA, owned 49% by the Rwandan Government and 51% by the Belgian Compagnie Geologique et Minière des Ingenieurs et Industriels Belges, has produced about 60 tons of tantalite ore annually.

Thailand.—Columbite-tantalite production continued to decline and was over 40% lower than in 1984; there was no reported production of struverite, compared with 33 tons produced in 1984.

By midyear, Billiton Thailand Ltd. had closed its offshore tin dredging operation. Billiton indicated that cutbacks in production under the ITC's export quota for Thailand and declining ore reserves had made the operation unprofitable. However, the closure of the offshore operation was not expected to affect production at Billiton's tin smelter, Thailand Smelting and Refining Co. Ltd. (Thaisarco) in Phuket, which secures its tin concentrates from all Thai tin miners. By yearend, proposals by former employees of the company to buy Billiton's facilities and resume offshore dredging activities had been turned down by Thai authorities.

At yearend, Thailand's Mineral Resources Department and Thaisarco were taking steps to establish a tin market in Phuket. Prior to suspension of trading on tin markets in late October, Thaisarco was required to buy local tin concentrates on the basis of the Malaysian KLTM price but sold most of its tin output on the basis of the lower LME price.

In midyear, Thaisarco announced an agreement to supply most of its high-grade tantalum-bearing tin slags to the Thailand Tantalum Industry Corp. Ltd. (TTIC) for use at TTIC's columbium and tantalum extraction facility in Phuket. Shipments reportedly were to begin in July. Thaisarco, with a tin metal capacity of about 42,000 tons annually, formerly exported all of its tin slag production, and two U.S. firms, Cabot and Fansteel, were major recipients.

The TTIC completed construction of the chemical plant phase of its columbium and tantalum extraction facility, with commercial production planned by yearend 1986. Reports indicate that the plant will have an initial annual capacity to produce in excess of 300 tons each of Cb_2O_5 and Ta_2O_5, and over 500 tons of potassium tantalum fluoride.

The Thai Pioneer Enterprise Co. Ltd. (TPE) reportedly was seeking $5.5 million in financing to reopen its tin smelter, which had been closed since midyear 1982. The smelter, with an annual tin metal capacity of about 4,000 tons, also had produced tantalum-bearing tin slags. Also, the Thai Government reportedly granted TPE an exemption from the 4.4% tax normally applied to tin metal exports.

Early in the year, the Thai Ministry of Science, Technology and Energy reportedly signed a $1.78 million technology transfer agreement with Japan's Metal Mining Agency. Under the terms of the agreement, Japan will provide the expertise needed to develop a technique to separate and extract columbium, tantalum, and other rare metals contained in waste derived from milling tin ores in Thailand.

Zaire.—Commercial-scale production of pyrochlore from the Lueshe carbonatite deposit reportedly was planned by yearend 1986. Production had been delayed awaiting decision on the choice of power for the new operation. A 1984 study had suggested two power alternatives, a linkup with the existing Bukavu-Goma powerline or the construction of a new powerplant at Kwindi.

TECHNOLOGY

The Bureau of Mines working with the Defense Reutilization and Marketing Service (DRMS) developed identification and separation techniques for recovery of tantalum from electronic scrap. The joint effort enabled DRMS to sell 200 pounds of discarded tantalum capacitors for $12.61 per pound. All U.S. Department of Defense scrapyard personnel handling electronic scrap were to be trained to perform the separation.

The Bureau of Mines studied columbium and tantalum occurrences in Alaska. This study is to serve as a basis for possible future field and laboratory research.[9] Where columbium and tantalum concentrations are relatively high, these minerals may be recoverable as byproducts of tin, tungsten, gold, or uranium mining. Approximately 135,000 pounds of Cb_2O_5 are inferred from the tin- and gold-bearing Tofty placer deposits in the Manley Hot Springs District.

A general trend in the chemical industry is to increase operating temperatures and pressures, requiring stronger materials with better corrosion resistance. Additions of 1% to 3% molybdenum to tantalum reportedly had a pronounced effect on decreasing the susceptibility of pure tantalum to hydrogen embrittlement in severe corrosion conditions. Also, the corrosion rate of tantalum is decreased significantly by the molybdenum additions, while mechanical properties such as strength and room temperature workability are improved.[10]

A process of leaching columbium oxide from pyrochlore concentrate using hydrofluoric acid was described in results from a study initiated by the Canadian Government.[11] Also, the optimum conditions for extraction of columbium oxide from the leach solution, using either the methyl isobutyl ketone (MIBK) or the tributyl phosphate (TBP) process, were determined. The main work was performed with a pyrochlore concentrate prepared from the St. Honoré carbonatite deposit at the Niobec Mine in Quebec. Investigation showed that the TBP process extracts columbium oxide at a lower acid rate than does the MIBK process, while the MIBK process gives a higher purity product.

The levitation melting technique was employed in examining the refining behavior of columbium.[12] The starting material used for the study was impure columbium in the form of columbium-thermite produced by aluminothermic reduction of columbium oxide. The purity of the levitation-melted columbium is compared to that of columbium produced by the conventional electron beam drip-melting process. The technique's inherent advantages include noncontamination due to its containerless feature, melt homogeneity owing to effective magnetic stirring, and precise temperature and atmospheric control during melting and melt holding.

High-chromium irons are used frequently when abrasion resistance is required. In a brief review, initial results of an investigation of columbium as an alloying element in high-chromium irons were described.[13] Melts were prepared in an induction furnace with superheating to 1,500° C for 5 minutes. Pouring temperatures were 1,430° C to 1,450° C. Results suggest that cast iron with a base composition of 18% chromium, 3% carbon, and the balance iron can have its wear characteristics improved by optimum alloying with up to 3% columbium.

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[1]Physical scientist, Division of Ferrous Metals.

[2]Federal Register. U.S. Environmental Protection Agency. Nonferrous Metals Forming and Metal Powder Point Source Category; Copper Forming Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards. Final Rule. V. 50, No. 164, Aug. 23, 1985, pp. 34242-34334.

[3]Avon Products Inc. 1985 Operations Annual Report. 16 pp.

[4]Metals Week. V. 56, No. 24, June 17, 1985, p. 8.

[5]Cabot Corp. 1985 Annual Report. 46 pp.

[6]American Metal Market. Alloys and New Materials. V. 93, No. 106, June 3, 1985, p. 27.

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Copper

By Janice L. W. Jolly[1]

By yearend, most U.S. copper mining companies planned, or were implementing, programs to lower production costs in order to regain profitability. International monetary debts and exchange rate problems, chronic oversupply, excess world capacity, competing alternative materials, and generally weak economic activity within some domestic markets and on the international market all contributed to depressed prices for 1985. Although two U.S. firms reported profits from their copper operations, most of the domestic copper mining industry was unprofitable.

Table 1.—Salient copper statistics

(Metric tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Ore produced ____ thousand metric tons__	[r]277,516	[r]181,826	[r]177,930	[r]171,814	162,210
Average yield of copper _____percent__	0.51	0.55	0.51	[r]0.58	0.62
Primary (new) copper produced:					
From domestic ores, as reported by:					
Mines ___________________	1,538,160	1,146,975	1,038,098	[r]1,102,613	1,105,758
Value _________ thousands__	$2,886,440	$1,840,856	$1,751,476	[r]$1,625,116	$1,632,483
Smelters __________________	1,294,962	940,547	888,130	[r]989,924	941,575
Percent of world total _______	16	12	11	12	11
Refineries ________________	[r]1,419,189	[r]1,050,445	[r]1,028,423	[r]1,089,584	1,003,636
From foreign ores, matte, etc., as reported by refineries _________________	[r]124,828	[r]176,333	[r]153,667	[r]75,016	53,529
Total new refined, domestic and foreign _______________	1,544,017	1,226,778	1,182,090	[r]1,164,600	1,057,165
Refined copper from scrap (new and old) ____	[r]482,837	467,549	401,668	[r]324,949	379,181
Secondary copper recovered from old scrap only ____________________	[r]591,805	517,726	449,478	[r]460,695	502,695
Exports: Refined __________________	24,397	30,558	81,397	91,414	37,937
Imports for consumption:					
Refined ___________________	330,625	258,439	459,568	444,699	377,725
Unmanufactured[1] ______________	[r]447,140	[r]524,830	[r]675,343	[r]551,802	443,932
Stocks, Dec. 31: Total industry and COMEX:					
Refined ____________________	465,000	676,000	672,000	[r]544,000	291,000
Blister and materials in solution ______	277,000	233,000	174,000	[r]245,000	146,000
Consumption:					
Refined copper (reported) __________	2,025,169	1,658,142	1,803,931	[r]2,122,732	1,905,634
Apparent consumption, primary and old copper (old scrap only) ___________	[r]2,271,050	[r]1,761,385	[r]2,013,739	[r]2,106,580	2,152,648
Price: Weighted average, cathode, cents per pound, producers_________________	84.21	72.80	76.53	66.85	66.97
World:					
Production:					
Mine_______ thousand metric tons__	[r]7,777	[r]7,619	7,712	[p]7,986	[e]8,114
Smelter ________________do____	[r]8,002	[r]7,933	8,143	[p]8,344	[e]8,386
Refineries_______________do____	[r]9,178	[r]9,022	9,230	[p]9,136	[e]9,230
Price: London, high-grade, average cents per pound _______________________	[2]79.35	67.14	72.13	[r]62.45	64.27

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Incudes copper content of alloy scrap.
[2]Based on Jan.-Nov. monthly averages.

With the shutdown of several domestic fire-refining plants and higher prices for Chilean ingot prevailing on European markets, copper stocks on the Commodity Exchange of New York (COMEX) became highly sought after by domestic brass mills and foundries. As a result, the refined copper inventories on the COMEX continued to be worked down over much of 1985, reaching the lowest level in 5 years by yearend. World stocks, especially those on the London Metal Exchange (LME), however, rose rapidly at midyear in response to reduced demand.

U.S. import reliance,[2] as a percentage of the apparent consumption of refined copper, was 28% in 1985, the highest rate since 1946, largely as a result of the drawdown of inventories from the COMEX. Apparent consumption of copper by U.S. fabricators was highest early in 1985, but was moderated considerably in the second half of the year. A substantial increase in exports of copper concentrates occurred during the year as a result of a shortage relative to available international smelter capacity and the sale of a significant portion of a domestic mining facility to a Japanese firm. In addition, U.S. exports of scrap increased as a result of weakening domestic sales and more favorably priced markets in Canada, Europe, and the Far East.

Changes in ownership of domestic mines and copper-producing plants continued during the year as companies moved to improve their financial status. The new owners included some foreign firms and employee-based partnerships. Several domestic copper smelters and refineries closed during the year with the result that primary annual copper smelting capacity decreased from 1.54 million metric tons in 1984 to about 1 million tons by yearend 1985. Capacity at operating copper mines, estimated at the beginning of the year to be 1.51 million tons of recoverable copper per year, declined by about 230,000 tons during the year as mines were closed, including the largest domestic mine.

Domestic Data Coverage.—Domestic production data for copper are developed by the Bureau of Mines from seven separate, voluntary surveys of U.S. operations. Typical of these surveys is the mine production survey. Of 72 operations to which a survey request was sent in 1985, 85% responded, representing an estimated 93% of the recoverable copper content in the total mine production shown in tables 7, 9, and 10. Production for the remaining 11 companies was estimated using data from other surveys.

Legislation and Government Programs.—A group of U.S. Congressmen formed the Congressional Copper Caucus to lobby for the domestic copper industry. The 32 Senators and Representatives pursued legislation during the year to support the copper industry. The group reviewed a whole range of policy options, emphasizing copper's economic and strategic importance.

Several bills that pertained to copper were introduced in the House of Representatives and the Senate during the year. Most were referred to various committees. Some of the more significant were as follows:

H.R. 217, January 3. A bill to return to the 95% copper penny.

H.R. 936, February 4. A bill to amend the Bretton Woods Agreements Act and recommend abolishment of the Compensatory Financing Facility (CFF) of the International Monetary Fund (IMF).

H. Res. 126, and S. Res. 114. Resolutions to abolish the CFF.

H.R. 1520, March 7. National Copper Policy Act of 1985. A bill to negotiate copper production limits among major copper producers.

H.R. 1562, March 19. Textile and Apparel Industry bill with Copper Free Market Restoration Act of 1985 attached. A bill to limit copper production and stabilize foreign copper production.

S. 1670, and H.R. 3410, September 19. A bill to establish a Government-to-Government International Copper Action Commission.

H.R. 2187. Superfund Improvement Act of 1985.

H.R. 2557, June 20. Supplemental appropriations bill with attached Senate amendments pertaining to international loans.

H.R. 3714, November 7. A bill to revitalize the U.S. copper industry by negotiation of agreements to temporarily limit copper production.

S. 351, January 31. The American Copper Production Act of 1985. A bill to impose limits on amounts of certain copper articles that may be imported over a 5-year period.

S. 353, January 31. A bill to increase the duty on imported copper by the amount offsetting the cost of domestic environmental requirements.

S. 627, March 7. National Copper Policy Act of 1985. A bill to set terms for negotiation of production cutbacks by major copper producers of the world.

Two stockpile bills: H.R. 3743, November 13, to adjust stockpile goals, and S. 1155, May 16, to amend the 1979 stockpile act.

Of the various bills described, the textile trade bill, H.R. 1562, was passed by the Congress and vetoed by the President. A call for negotiations with foreign countries to limit their production of copper was contained in H.R. 2577, which was signed into law in December, that provided continuing appropriations for a number of agencies of the Federal Government. As with the message on copper negotiations that was part of the textile trade bill, H.R. 1562, the language in the funding measure called for U.S. trade officials to undertake negotiations with countries producing more than 200,000 metric tons of copper per year. However, the report language of the bill was nonbinding.

Multilateral lending institutions were also subjects of several congressional initiatives, including amendments to the Supplemental Appropriations bill, H.R. 2557. One amendment, section 501, instructed U.S. representatives to the International Bank for Reconstruction and Development (World Bank) and other multilateral lending institutions to vote against proposed loans intended to expand copper production in developing nations while copper is in oversupply on the international market. The other amendment, section 502, enunciated a policy statement against multilateral loans that would result in overproduction of any commodity, including copper. Three criteria were established in section 502 for considering a negative U.S. vote: (1) Analysis indicates that reasonable commercial financing is available; (2) surplus capacity for the industry for production of the commodity would exist over one-half of the project life; and (3) U.S. imports of the commodity are more than 50% of domestic production, where the United States is a substantial producer of such commodities. The CFF used IMF funds to compensate nations that suffered a drop in export earnings because of low commodity prices. The sponsors of the bill contended that by allowing the IMF to offer low-interest loans and compensation payments to copper producers in the developing nations, the U.S. Government was indirectly undermining the domestic industry because foreign overproduction of copper was considered a prime reason for low prices and U.S. companies' losses. Between 1979 and 1983, the CFF provided about $1.35 billion per year in subsidies to developing countries, according to one study.[3] CFF supporters described these loans as cushions, helping a commodity-dependent country get through poor economic periods. Opponents described these loans as crutches, allowing countries to keep producing regardless of the impact on prices.

Other legislative proposals were under consideration that would affect U.S. trade, such as H.R. 2451, which would permit the imposition of countervailing duties on imports benefiting from upstream subsidies of raw materials from which the products are made. Congress was also seeking changes in the U.S. Trade Act of 1974 that would take away Presidential discretion in such areas as section 201. Section 201, commonly known as the escape clause, provides for temporary relief for a domestic industry that has suffered or been threatened with serious injury from imports. Trade bills calling for 25% surcharges on imports from Brazil, Japan, the Republic of Korea, and Taiwan were introduced. The bills presented a complicated formula aimed at focusing on countries that maintain trade surpluses by using a variety of unfair barriers against imports.

On September 30, Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), expired. In December, the House of Representatives passed a tax bill (H.R. 2817) to extend the Superfund, which included taxation of certain copper chemicals, including cupric oxide, cupric sulfate, and cuprous oxide. The proposed tax for these chemicals was about $6.90 per ton. The Senate voted in September to expand the Superfund toxic waste cleanup program nearly fivefold and levy a new tax on manufactured goods to pay for it. Called the Superfund Improvement Act of 1985, it would reauthorize the 5-year-old Superfund law through 1990 and provide $7.5 billion to clean up the worst of the Nation's toxic dumps.

Nine western members of Congress persuaded the Administration to negotiate an agreement with the Mexican Government to prevent a new Mexican copper smelter from opening without pollution controls. An agreement was reached spelling out expectations for environmental controls. The Mexican Nacozari and Cananea smelters were expected to operate in 1986 without environmental control for the near future because of a lack of funds to build sulfuric acid facilities.

A group of domestic producers requested the Administration to consider the benefits of supporting a Producer/Consumer Forum Group that could be patterned after the International Lead and Zinc Study Group. This forum would meet regularly to collect and discuss current monthly copper statistics, develop quantitative information on end uses, provide details of existing capacities, and provide for discussions among representatives of industry and of member governments concerning the problems and opportunities of the copper industry.

In a letter to the Congress in November 1985, the President replied to a congressional request, which was made last year, that the Administration would not try to negotiate voluntary production restraints with major copper-producing nations. The President's letter stated that such negotiations would be inconsistent with the Administration's market-oriented trade and economic policy objectives, and that voluntary production restraints would raise serious antitrust concerns, be too costly to the U.S. consumer, and be too hard to implement. In lieu of these measures, the Administration offered to provide relief to the copper industry through the U.S. Department of Labor, which had begun to implement a plan to assist workers displaced from the copper industry.

On July 8, the President approved the National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, copper would be categorized in tier II, and the goal would be 26,353 tons, considerably reduced from the previous goal of nearly 1 million tons. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

In an effort to aid the State's depressed copper industry, legislation was passed by the State of New Mexico at midyear to lower New Mexico's excise tax on copper processing by about two-thirds, beginning July 1. The tax on copper processors will be cut to 0.25% from the former 0.75% for 3 years, until July 1988.[4]

DOMESTIC PRODUCTION

Mine Production.—Copper was produced in 12 States during 1985, with Arizona comprising 72% of the total, and New Mexico and Utah in second and third place, respectively. The number of copper-producing mines dropped considerably from 115 mines in 1982 to a total of 68 mines in 1985. In 1985, there were 27 producing copper mines and 41 mines from which copper was produced as a byproduct of gold, lead, silver, or zinc. Total U.S. operating mine capacity, in terms of recoverable copper per year, was estimated to be 1.51 million tons, with 22 major producers accounting for more than 1.45 million tons. Several operating mines closed during the year affecting about 230,000 tons of operating capacity; these included the largest mine in the United States, Kennecott's Bingham Canyon pit in Utah, and Anamax Mining Co.'s Twin Buttes, AZ, electrowinning operation. At the same time, however, some new or reactivated mine capacity was added. The White Pine Mine in Michigan began production late in the year, with a capacity of 73,000 tons per year, and some new or renewed capacity was added at the Morenci, Pima, Ray, and Tyrone Mines. The net result was a mine production that was slightly higher than in 1984. Capacity utilization at active mines was 73% in 1985.

About 3% of total U.S. production of gold and 25% of total silver production was derived as a byproduct of copper mining. By comparison, copper mines had produced about 42% of U.S. gold production in 1979. The estimated value for recovered gold and silver from copper ores was $82.8 million, down significantly from that of 1984. The proportion of copper ore extracted by open pit mining was 88%, compared with 12% extracted by underground methods.

The average cash cost (including byproduct credits and taxes, but excluding depreciation) was further reduced to 58 cents per pound in 1985, from 79 cents per pound in 1981 and 65 cents per pound in 1984, according to Bureau of Mines estimates. When recovery of capital is included, the production cost per pound was 70 cents in 1985. While most copper-producing companies took some losses during the year, two companies, Phelps Dodge Corp. and Cyprus Minerals Co., reported a profit from their copper mines. By comparison, the average cost to produce (with byproduct credits, depreciation, and taxes included) for 110 major international copper mine producers was 67 cents per pound in 1985, including milling, smelting, refining, and transportation charges.

Productivity in terms of tons of copper produced per average hour worked at copper mines and smelters also improved during the year. The average number of copper mine and mill workers, including office workers, for 1985 was 9,854, who worked a total of 18,831,046 employee-hours. For 1984, the comparable numbers were 12,461 workers and 22,587,340 hours. U.S. Department of Labor statistics indicated employment at copper smelters and refineries for 1985 was an average of 5,900 workers; this compared with 8,600 smelter and refinery employees for 1984 and 10,100 workers for 1983. Productivity in terms of employee-hours per ton of copper produced at mines increased from 27.4 hours per ton in 1983, to 20.7 hours per ton in 1984, to 17.0 hours per ton in 1985.

The U.S. Department of Labor awarded the State of Utah a grant for about $2.6 million to aid unemployed miners. The grant was awarded under the Job Training Partnership Act and was part of a title III grant fund that was established to aid dislocated copper and steel workers in 24 States.

In an attempt to reduce costs and improve productivity, AMAX Inc. eliminated 1,500 positions, including headquarters and operating personnel. Reductions were made at the corporate headquarters in Greenwich, CT, at its Golden, CO, offices, and at its domestic and overseas energy and mining divisions. AMAX's losses for 1985 were reported as $621 million, compared with $238.3 million in 1984.[5]

Atlantic Richfield Co.'s subsidiary, Anaconda Minerals Co., continued to sell off its mineral holdings during the year, both in the United States and abroad. Anaconda Minerals sold the idled Montana mining properties at Butte to Washington Corp., a Missoula, MT-based construction company. Montana Resources Co., a subsidiary of Washington Corp., planned to open the mine if sufficient cuts could be made in energy, labor, tax, and other costs. At the time of the shutdown, Anaconda Minerals had estimated production costs at about $1.25 per pound. Washington Corp. estimated the major predeterminable mining costs as follows: 27% for freight and smelting; 15% for employee wages and benefits; 12% for energy; and 7% for taxes.[6] Negotiations for concentrate contracts were being held with 18 different smelters and traders in Asia, Europe, and North America.

In addition, Anaconda Minerals' Carr Fork, UT, property was sold to Kennecott and the mill facilities at Carr Fork to Ok Tedi Mining Ltd. of Papua New Guinea. The company's Los Pelambres deposit in northern Chile was sold to Antofagasta Holdings Ltd. near yearend. A group of investors formed Buffalo Brass Co. Inc. to buy Anaconda Industries' American Brass Div. plants and then announced the sale of two of the plants in Connecticut to another investor group, Valley Brass Corp. Buffalo Brass was to continue to operate plants in Buffalo, NY, Kenosha, WI, and Franklin, KY. Buffalo Brass's Paramount, CA, brass mill was purchased by Cerro Metal Products Corp.

Anamax closed its Twin Buttes Mine in October 1985, laying off most of the company's 156 employees. Jointly owned by AMAX and Anaconda Minerals, Twin Buttes ceased copper mining in 1983, but continued operating a small copper oxide and solvent extraction-electrowinning (SX-EW) plant from existing oxide ore stockpiles. The operation, about 20 miles south of Tucson, AZ, had been for sale, and much of the equipment had already been sold. At its peak in the mid-1970's, the Twin Buttes Mine employed about 2,100 people.

Anamax began reclamation work at the Twin Buttes minesite. The entire tailings area covers about 1,400 acres, containing about 160 million tons of tailings. The company planned to cover the tailings with 6 to 12 inches of alluvium, taking about 15 months to complete the work. Terracing and revegetation were conducted along with mining since 1969, so revegetation is essentially complete. Although the pumps in the open pit mine were shut off in late 1985, the pit water was not expected to become more than 400 to 500 feet deep, taking decades to reach that depth.

ASARCO Incorporated experienced a net

loss after taxes of $62 million in 1985, down from a loss of $306 million experienced in 1984.[7] As part of its strategy to reduce costs, Asarco increased ore reserves at its Mission complex by acquiring the Pima Mine for $12.5 million in September. Pima was owned 75% by Cyprus Minerals and 25% by Utah International Inc. The Pima Mine, which had been shut since 1982, occupied one end of a continuous open pit that was shared by Asarco's Mission complex. Acquisition of Pima permitted control of the entire pit and more efficient mining and milling operations at Mission. All ores from the complex, including the Eisenhower, Mission, Pima, and San Xavier Mines, were to be processed through the Mission mill. According to the company's annual report, 8.9 million tons of ore was milled in 1985, containing 53,500 tons of copper. Ore reserves at the Mission complex were estimated to be 259.8 million tons containing 0.12 ounce of silver per ton and 0.62% copper. At Asarco's Silver Bell Mine, ore reserves were estimated at 19 million tons containing 0.07 ounce of silver per ton and 0.68% copper. No ore was milled during 1985; the entire production of 3,900 tons of precipitate copper was produced through leaching of the oxide ores.[8]

Asarco also operated several coproduct mines that produce copper in Idaho and Montana. In Idaho, Asarco operated the Coeur and Galena Mines. The Troy Mine in Montana was considered a silver mine with a large copper production. In 1985, because of the depressed silver price, the value of copper production exceeded that of silver. About 2.5 million tons of ore containing 3.6 million ounces of silver and 15,240 tons of copper was mined at Troy in 1985. At Coeur, 137,000 tons of ore was milled containing 2.6 million ounces of silver and 1,089 tons of copper. About 180,000 tons was milled at Galena with a production of 1,090 tons of copper and 4.1 million ounces of silver. Ore reserves were given as follows: Coeur, 806,000 tons with 18.74 ounces of silver per ton and 0.94% copper; Galena, 984,000 tons with 15.58 ounces of silver per ton, 0.63% copper, 10.04% lead, and 0.11% zinc; and at Troy, 37.5 million tons of ore containing 1.40 ounces of silver per ton and 0.75% copper.[9] Copper was expected to be a very minor byproduct in the West Fork, MO, mine, which started up in September 1985 and was reported to have reserves of 14 million tons of ore with a content of 0.27 ounce of silver per ton, 5.50% lead, 1.20% zinc, and 0.04% copper.

Environmental studies were continued during 1985 at Asarco's Rock Creek copper-silver project in the Cabinet Mountains Wilderness Area of northwestern Montana. These studies, based on proposed underground mining with access outside the wilderness, were being done as part of the required Environmental Impact Statement and subsequent operating permit applications. An operating plan for the Rock Creek copper-silver mine in the Cabinet Mountains Wilderness Area was submitted to the U.S. Forest Service by Asarco in 1984. The permitting process was expected to take a minimum of 2 years. The Rock Creek ore body lies in the same formation as the company's Troy Mine, which is 15 miles away. The Rock Creek deposit is larger and has a higher ore grade than the Troy deposit.

Echo Bay Mining Ltd. of Edmonton, Canada, completed the sale in late 1985 of Copper Range Co. to Northern Copper Co., a newly formed company comprised 70% of the United Steelworkers of America (USWA) union and mine employees and 30% of Mine Management Resources Inc. Northern Copper paid $23.7 million for the mine and smelter facilities. Financial assistance was obtained from the State of Michigan, Philipp Brothers Inc., and commercial banks. Northern Copper was formed as a vehicle to buy the mine, but the company then merged to officially become Copper Range Co., the name with which it has been historically identified. The White Pine Mine was reopened on November 25, 1985, with 227 workers and at 40% of capacity. The mine was capable of producing 60,000 tons of copper and 1.3 million ounces of silver per year. The mine reportedly had 39 years of ore reserves at this production rate. The miners, represented by the USWA, accepted wages averaging $3 per hour below the average for the industry. Wages were $8.50 per hour, plus profit-sharing and productivity pay. The USWA, representing the workers, agreed to a new 5-year labor contract. The workers were to receive stock in return for wage and benefit concessions. By yearend, the mining complex employed 587 workers, increasing to 900 when the site is at full operation. The smelter was not expected to be fired-up until mine production had reached 15,000 tons of ore per day.

In January, Standard Oil Co. (Indiana) announced plans to spin off its Amoco Minerals Co. into a separate company called Cyprus Minerals. The Amoco spinoff, which was done in the form of tax-free distribution of shares, was accomplished in July 1985. The newly spun-off Cyprus Minerals sustained a loss of $452.1 million for 1985, owing principally to a write-down of some assets. Cyprus Minerals wrote down $195 million of the $385 million valuation of the Bagdad Mine. The Cyprus Bagdad Copper Co. mine, however, was profitable for the year. Cyprus Minerals was selling mining and milling equipment from its Cyprus Pima Mining Co. and Cyprus Johnson Copper Co. operations in Arizona. Pima's reserves were sold during the year to Asarco, but Johnson was to keep producing electrowon cathode from leach dumps through 1986, but at a lower level.

The Wisconsin State Department of Natural Resources was in the process of completing its environmental impact statement on the proposed Exxon Minerals Co. Crandon Mine project. The company expected to start construction in 1987, following approval of permits; production could start about 3 to 4 years later.[10] The deposit had 68.7 million tons of ore that contained about 5.2% zinc and 1.2% copper and minor gold, lead, and silver. Exxon made the discovery northeast of Mole Lake in 1974 and has spent about $75 million on mining preparation since that time.

Echo Bay concluded its agreement with Standard Metals Corp. of New York to acquire the shut Sunnyside gold, silver, and copper mine and mill complex near Silverton, CO, for $20 million plus 30% net profits royalty payable to Standard Metals. Echo Bay planned to refurbish the complex and restart operations in mid-1986 under the name Sunnyside Gold Corp. In 1983, the last full year of production, the mine produced 300,000 tons of ore containing copper, lead, silver, and zinc, in addition to its main product, gold.

Sunshine Mining Co. obtained an option to buy the Gold Fields Mining Corp.'s St. Cloud Mine in New Mexico and was to make a feasibility study to determine ore reserves during the option period, which was to end June 1, 1986. Gold Fields was to operate the mine during the option period at a reduced level of 1,840 tons of ore per month. Ore reserves had been estimated to be 366,598 tons averaging 5.93 ounces of silver, 1% lead, 0.85% copper, 0.3% zinc, and 0.04 ounce of gold per ton. The property had been valued at $1.2 million by Gold Fields.[11]

By various improvements, Inspiration Consolidated Copper Co. (ICC) increased copper production at its mines to 70,000 tons in 1985.[12] ICC's gross copper revenues in the United States and Canada rose from $233.6 million in 1984 to $258.6 million in 1985. Even so, the company's net losses were larger, losing $8.7 million in 1985, compared with $5 million in 1984. By comparison, ICC's parent company, Inspiration Resources Corp., had a net loss of $291.4 million in 1985, compared with a $101.3 million net loss in 1984 and an $82.7 million loss in 1983.[13] While production costs were significantly reduced at ICC, exploration (mostly precious metals) and development expenses increased. Reserves at Inspiration Resources' open pit at Miami, AZ, were estimated to be 240 million tons with 0.53% copper, according to the company annual report. In further cost-cutting moves, ICC was expected to direct increased attention to the more cost-effective dump leaching-SX-EW operation, where the cost of producing copper was about 30 cents per pound. The company determined that it had sufficient oxide and leachable sulfide in the Live Oak-Bluebird-Red Hill area to operate the electrowinning circuit and reduce the mining operations by 40% until economic conditions improve. Inspiration Resources spent $3.2 million in 1985 for the integration of Bluebird Mine into its other operations.

The Southern Pacific Railroad filed an application with the Interstate Commerce Commission to abandon the only rail line that supplies rail service to Inspiration Resources' operation at Miami, AZ. Inspiration Resources protested the abandonment, and a Commission judgement was to be made sometime in April 1986.

The Standard Oil Co. of Ohio (Sohio), parent company of Kennecott, reported a drop in net income for 1985 to $308 million, compared with $1.49 billion in 1984. Sohio's 1985 special charges related to the decision to spend $400 million to modernize Kennecott's Utah Copper Div. Sohio's metal mining operations, principally Kennecott, lost $165 million, compared with $160 million in 1984.[14] Kennecott shut down its Utah Copper Div. in Salt Lake City, UT, on March 31, laying off about 2,200 employees. A care-and-maintenance work force of about 250 employees was retained. The Bingham Canyon Mine had been operating at slightly below one-third of capacity. The company had processed all of its material by the end of June. Kennecott speculated that the expected physical improvements, and labor cost reductions that it hoped to negotiate in 1986, would allow it to cut costs by more than 20 cents per pound.[15] Anaconda's Carr Fork, UT, copper mine was sold to Kennecott. The purchase was to solve boundary line problems and facilitate any future underground mining of the North Ore Shoot, which is contiguous with Carr Fork's reserves. Carr Fork was reported to contain 91 million tons averaging 1.87% copper, 0.02% molybdenum, and 0.27 ounce of silver per ton.

The closure of the Bingham Canyon Mine allowed the associated 5,000-acre tailings pond to dry out, increasing dust complaints. Kennecott planned to increase the discharge of water over the pond and to spend up to $6 million per year on dust control, compared with $2.5 million spent while the mine was operating.

The Nevada State Division of Environmental Protection issued a fugitive dust citation to Kennecott in early November. The company outlined a plan at yearend to the agency to keep dust levels down from the tailings remaining from its closed mine at Ely. Under Kennecott's plan, permanent water-spraying devices would be placed around the dry areas so water could be pumped across it all year. Another part of the plan calls for fertilizer to be spread to maintain plant growth.

Under pressure to operate profitably, Kennecott's Ray Mines Div. laid off 24 workers in May 1985, reducing the total work force to 667. In addition, the operations were monitored monthly after the Utah Copper Div. shut down in late March, and ten, 170-ton trucks were returned to Ray Mines from Utah. The SX-EW plant at Ray Mines was reactivated in December, after being shut since May 1982. The SX-EW plant treats copper-bearing silicate material that cannot be processed through the sulfide concentrator. The ore is crushed and heap leached in vats. Kennecott was selling its production from both Ray Mines and Chino Mines, since its principal refining and rod-mill facilities were closed. Some Ray Mines concentrates were treated at Asarco's smelter in El Paso on a toll basis, with anodes delivered to Phelps Dodge's refinery nearby. Concentrates smelted at Hayden were bought by Asarco.

Chino Mines Co., a two-thirds Kennecott, one-third Mitsubishi Metal Corp. partnership, instituted a radio-computer control system to further lower unit costs at the company's open pit. On August 13, a radial arm stacker attached to and supporting the coarse ore conveyor collapsed, shutting the Chino concentrator down until late September.

Newmont Mining Corp. reported a net loss of $34.2 million for 1985 compared with a net income of $42.3 million for 1984. The 1985 loss included $68 million in special pretax charges, primarily a $40.3 million write-down of Magma Copper Co.'s Superior Mine and a $24.7 million pretax charge for the write-down of Newmont's 40.2% holding in O'okiep Copper Co. Ltd. in the Republic of South Africa. Newmont's subsidiary, Magma, lost $54.1 million before taxes, compared with losses of $44.1 million and $53.3 million in 1984 and 1983, respectively. The resumption of development at the San Manuel Mine had a negative impact on 1985 results, despite stringent cost-cutting measures adopted during 1984. Losses declined at Newmont's Pinto Valley Copper Corp. where the open pit mine and mill operated at full production in 1985, compared with only 8 months in 1984.[16] Newmont Mining reorganized its operations in late 1985, consolidating the management under four group executives. The company's nonferrous metals operations now included the Magma and Pinto Valley subsidiaries in Arizona as well as the Newmont operations in Canada, Peru, and the Republic of South Africa.

In December, Magma took a $40.3 million loss for the labor-intensive Superior Mine and planned to close it if unable to sell or lease it; the operation had been on standby since August 1982. The mine contained ore grading 4.5% copper and had produced about 39,000 tons of copper per year.

Newmont's operating objectives for Magma included cost reductions in four principal areas: (1) lower labor costs; (2) production of ore leach copper; (3) improved mining methods, and (4) higher grade mining plans. Ore reserves at San Manuel were expected to be exhausted in 1993 and the additional reserves available at Kalamazoo would require about $60 million in development costs. A lower cost, mechanized mining system was being developed in the Kalamazoo ore. Magma renegotiated coal, gas, utility, and other supply contracts, withheld pay increases for salaried personnel, and restructured the organization by eliminating or combining jobs. The cost per pound for producing copper at the underground mine at San Manuel remained higher in 1985 than the selling price for copper. The cost of labor was reported to account for just over 50% of the production cost[17] in 1985. Between 1974 and 1985, the average producers' copper price per pound declined from 77 cents to 67 cents, while the average wage at Magma rose from $5.58 per hour to

$13.54 per hour.

Magma announced in March that it would invest an estimated $71 million to develop an open pit mine in the oxide ore deposit that overlies its San Manuel Mine, construct a heap leach pile and build a SX-EW plant. The new plant, with a rated capacity of about 23,000 tons of electrolytic-grade copper per year, was scheduled to begin production by mid-1986. The company was also studying the possibility of developing an in situ leaching operation on another, much larger underground oxide ore body. The new open pit oxide mine was to be in the subsidence area created by the block-caving methods used for mining the first portion of the San Manuel sulfide ore body. Magma indicated that there was between 45 million and 55 million tons of treatable oxide ore available in the new open pit mine, averaging 0.47% acid-soluble copper. No crushing and very little drilling and blasting was expected.

Reserves at San Manuel as of December 31, 1985, were estimated as follows: 51 million tons of oxide ore, containing 0.468% copper; and 270 million tons of sulfide ore containing 0.694% copper, 0.028% molybdenite, 0.029 ounce of silver, and 0.00158 ounce of gold per ton. In the underlying Kalamazoo deposit, 322 million tons of ore was estimated to contain 0.715% copper, 0.28% molybdenite, 0.029 ounce of silver, and 0.0158 ounce of gold per ton. During 1985, about 15.8 million tons of ore was treated at San Manuel, recovering 99,000 tons of copper.[18]

Joining Newmont in 1983, Pinto Valley began shipping copper concentrates to the San Manuel smelter in May 1984, enabling Magma to increase its throughput at the smelter and refinery and thereby reduce unit costs. Magma also has been able to use Pinto Valley's continuous mining machines and experience with mechanized mining methods to good advantage at the San Manuel Mine. There were 607 Pinto Valley employees in 1985, and a 25% reduction in staff positions was made at Pinto Valley during the December 1985 reorganization. At Pinto Valley, the expected mine life was about 11 years, and reserves were estimated at 322 million tons of 0.40% copper and 0.015% molybdenite. About 17.8 million tons of ore was treated during the year with 72,000 tons of copper recovered. All ore grading less than 0.4% copper was leached. Leach solutions at the Pinto Valley Mine were processed by a SX-EW plant adjacent to the mine. A second SX-EW plant was associated with leaching of the old subsidence area of what was once the Miami Copper Co. underground mine. At Miami, leaching solutions percolated through the caved area and were pumped to the surface, producing about 340 tons of electrowon cathode per month. The company was examining the possible in situ leaching of additional oxide ore just north of its Miami underground leach operations to supplement current Miami output. Pinto Valley also owned the Miami East underground mine, which had reserves of about 6 million tons of ore with an average of 3% copper at a depth of about 3,500 feet. Only supply and ventilation shafts and some access drifts had been developed prior to its shutdown in the spring of 1982, shortly before it was scheduled to begin production. The mine was scheduled for flooding and abandonment as soon as equipment is removed.

Phelps Dodge reported earnings from continuing operations of $29.5 million in 1985. Phelps Dodge's mines produced 372,000 tons of copper, according to the company annual report, making it the country's leading copper producer. The company adhered to a rigorous program of reducing operating, personnel, and overhead costs. The copper-producing operations, including mining through copper rod casting, earned $62 million in 1985, compared with a $101.9 million loss in 1984. Phelps Dodge was continuing with the sale of some of its foreign holdings. The assets put up for sale included the company's 10% share in Asian Cables Corp. of India, the 40% interest in Phelps Dodge Philippines Co., and a 53% share in three wire mills in Thailand. Its 44.6% share in Black Mountain Mineral Development Co. (Pty.) Ltd., which operated a copper-lead-silver-zinc mine in the Republic of South Africa, was also to be sold, as was the company's 33% interest in the Woodlawn zinc-copper mine in Australia.

The new SX-EW plant at Tyrone, NM, which was operated by Burro Chief Copper Co., produced over 20,000 tons of copper in 1985, its first full year of operation.[19] The plant started production in April 1984 with costs estimated at below 30 cents per pound. In 1985, the company completed a $15 million program to double the SX-EW plant at Tyrone. The plant began to produce at the expanded rate in December. By 1986, the company expected to produce about 32,000 tons of low-cost copper from this facility. At the Tyrone Mine, an expansion of tailings disposal facilities completed in 1984 enabled the mine to achieve greater production and substantially improved unit costs by moving to a continuous operating schedule. Production was increased and unit costs reduced at both the Morenci, AZ, and Tyrone Mines by increasing the cutoff grade of ore fed to the concentrators and by segregating lower grade material for future treatment by SX-EW. Phelps Dodge's highest cost mine, the Ajo Mine, remained closed throughout the year.

In December, Phelps Dodge announced plans to build a SX-EW facility at the Morenci Mine at a cost of $90 million. The Morenci plant was to produce at an initial rate of 32,000 tons per year, increasing to 41,000 tons about 3 years later. The Tyrone ore body was expected to be mined out no later than the early 1990's, although leach production will continue there for many more years. The Morenci electrowinning facility will replace part of the Tyrone production at significantly lower costs. Further cost improvements were expected to result from the addition of two additional ball mills at Morenci in January 1986, permitting expanded throughput at favorable costs. Perhaps the most significant development was the sale of a 15% undivided interest in the Morenci copper facilities (excluding the closed smelter) to a jointly owned subsidiary of Sumitomo Metal Mining Co. Ltd. and Sumitomo Corp. of Japan for $75 million. Sumitomo was to take a share of Morenci production. The company also expected to sell another 15% interest in Morenci during 1986.

Copper ore reserves at each of Phelps Dodge's U.S. mines and at its Safford, AZ, deposit at yearend 1985 were estimated as follows: Morenci, 722 million tons with an average grade of 0.75% copper; Safford, 238 million tons with an average grade of 0.88% copper; Ajo, 190 million tons with an average grade of 0.50% copper; and Tyrone, 149 million tons with an average grade of 0.80% copper. The company did not visualize reactivating the closed Ajo Mine until the copper price is well above 80 cents per pound.[20] The reserves at Morenci do not include the Western Copper property, purchased in 1981, that adjoins the mine and that was estimated to contain 167 million tons of copper-bearing material containing 0.64% copper, or the low-grade material that will be leached in the proposed SX-EW operation.

After taking a write-down of $100 million for metals assets in connection with the decision to discontinue the metals mining business in 1984, Pennzoil Co.'s board of directors authorized a further write-down of $123 million in 1985 for its metals assets.[21] At yearend, sale of the Sierrita copper deposit had not been finalized, though Cyprus Minerals was expected to purchase the corporation's Arizona copper deposits early in 1986, including the Sierrita Esperanza copper-molybdenum property near Tucson and the Mineral Park copper-molybdenum property near Kingman, AZ. In July, Pennzoil spun off Battle Mountain Gold Co., its former Nevada gold operation, to shareholders.

Duval Corp., Pennzoil's subsidiary, operated Sierrita at full capacity. To cut costs, a 15% wage cut for all employees was started in 1984, two extra shifts per month were added, and the output increased from 85,000 tons to 105,000 tons of ore per day. Employees had been working without a contract since 1983 when Sierrita workers crossed picket lines and voted to decertify their unions. The haulage system at Sierrita had undergone several generations of development, each one an improvement. The shuttered Esperanza Mine mill was restarted in 1984 and linked with Sierrita by conveyor to offset Sierrita's crushing limitations. The portable in-pit crusher had been in operation at Sierrita since 1983, but the mine needed three crushers. In 1985, the operation was close to breaking even at producer prices of 67 cents per pound of copper and $3.75 per pound of molybdenum oxide.[22] Nippon Mining Co. purchased 145,000 tons of copper concentrates from Sierrita in 1985.[23]

The Tennessee Chemical Co. announced in January that it would phase out its copper mining operations near Copperhill in the eastern Tennessee Ducktown copper mining district. Most of the reductions were planned for 1987, but personnel layoffs began in 1985. A total of 900 jobs were expected to be lost. The sulfuric acid plant was expected to stay in operation. The company determined that it was more economical to buy sulfur for the acid plant than to mine the sulfide ore feed. Full production capacity at Copperhill was estimated to be 2.0 million tons of ore per year, from which copper, iron, and zinc sulfide concentrates were separated. Although 60% of the company's sales are from sulfuric acid and liquid sulfur dioxide, copper reportedly accounted for 15% of the sales, with another 15% from copper carbonate and copper sulfate. About 100,000 troy ounces of byproduct silver was recovered per year.

Table 2.—Production capacity of major U.S. copper mines

(Thousand metric tons, unless otherwise specified)

State and mine	Company	Status	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Arizona:													
Bagdad	Cyprus Minerals Co	Operating	22	22	68	68	68	68	68	68	78	78	78
Eisenhower/Paloverde	Anamax Mining Co./ ASARCO Incorporated.	do	--	--	--	--	--	45	45	45	45	45	45
Esperanza	Duval Corp	Leach only, 1982	25	25	25	25	25	25	25	6	6	6	6
Inspiration	Inspiration Consolidated Copper Co.	Operating	45	45	45	45	45	50	70	70	70	70	70
Lakeshore	Noranda Lakeshore Mines Inc.	Leach only, 1984	--	20	20	--	--	22	22	22	22	10	10
Magma/Superior	Newmont Mining Corp	Closed 1982	40	40	40	40	40	40	40	40	--	--	--
Mineral Park	Duval Corp	Closed 1981	18	18	18	18	18	18	18	--	--	--	--
Mission	ASARCO Incorporated	Operating	40	40	40	40	40	40	40	40	40	40	40
Morenci/Metcalf	Phelps Dodge Corp	do	150	190	190	190	190	190	190	190	190	215	235
New Cornelia (Ajo)	do	Leach only, 1985	50	50	50	50	50	50	50	50	50	50	1
Pima	ASARCO Incorporated	Operating	80	80	80	--	80	80	80	80	--	--	--
Pinto Valley	Newmont Mining Corp	do	70	70	70	70	70	80	85	85	85	85	85
Ray	Kennecott	do	90	90	90	90	90	90	110	110	100	100	100
Sacaton	ASARCO Incorporated	Closed 1984	22	22	22	22	22	22	22	22	22	22	--
San Manuel/Kalamazoo	Newmont Mining Corp	Operating	120	120	120	120	120	120	120	120	120	120	120
San Xavier	ASARCO Incorporated	Closed 1985	10	10	14	14	14	14	14	14	14	14	14
Sierrita	Duval Corp	Operating	100	100	100	100	100	100	100	100	100	100	100
Silver Bell	ASARCO Incorporated	Leach only, 1985	23	23	23	23	23	23	23	23	23	23	6
Twin Buttes	Anamax Mining Co	Closed 1985	42	130	130	130	130	130	130	130	130	33	33
Total			947	1,095	1,145	1,045	1,125	1,207	1,252	1,215	1,095	1,011	943
Michigan:													
White Pine	Copper Range Co	Operating	73	73	73	73	73	73	73	73	--	--	10
Montana:													
Arbiter Leach	Washington Corp	Closed 1978	15	15	15	15	--	--	--	--	--	--	--
Berkeley Pit	do	Inactive 1983	85	85	85	85	85	85	85	85	85	--	--
Butte Hill Leach	do	Leach only	10	10	10	10	10	10	10	10	10	10	10
Continental East	do	Closed 1975	15	--	--	--	--	--	--	--	--	--	--
Kelly	do	do	10	--	--	--	--	--	--	--	--	--	--
Total			135	110	110	110	95	95	95	95	95	10	10
Nevada:													
Ruth	Kennecott	Closed 1978	30	30	30	30	--	--	--	--	--	--	--
Yerrington	Anaconda Minerals Co	do	35	35	35	35	--	--	--	--	--	--	--
Total			65	65	65	65	--	--	--	--	--	--	--

Table 2.—Production capacity of major U.S. copper mines —Continued

(Thousand metric tons, unless otherwise specified)

State and mine	Company	Status	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
New Mexico:													
Chino	Kennecott/Mitsubishi Metal Corp.	Operating	65	65	65	65	65	65	65	65	110	110	110
Continental	Sharon Steel Corp	Inactive 1982	22	22	22	22	22	22	22	22	--	--	--
Tyrone	Phelps Dodge Corp	Operating	100	100	100	100	100	100	100	100	100	115	115
Tyrone Leach (SX-EW)	Burro Chief Copper Co	do	--	--	--	--	--	--	--	--	--	15	25
Total			187	187	187	187	187	187	187	187	210	240	250
Tennessee:													
Copperhill	Tennessee Chemical Co	Operating	12	12	12	12	12	12	12	10	10	10	10
Utah:													
Bingham	Kennecott	Inactive 1985	230	230	230	230	230	230	230	230	230	230	230
Carr Fork	do	Closed 1981	--	--	--	--	1	5	14	--	--	--	--
Total			230	230	230	230	231	235	244	230	230	230	230
Total major producers			1,649	1,772	1,822	1,722	1,723	1,809	1,863	1,810	1,640	1,501	1,453
Small producers			91	74	72	62	47	47	48	41	19	19	17
Byproduct producers			37	37	36	31	27	28	32	47	45	46	44
Total all mines			1,777	1,883	1,930	1,815	1,797	1,884	1,943	1,898	1,704	1,566	1,514
Number of operating mines:													
Copper mines			48	46	44	42	40	41	41	36	31	31	27
Byproduct mines			65	39	48	42	40	38	57	79	74	45	41
Total			113	85	92	84	80	79	98	115	105	76	68
Mill head grade, copper producers (percent copper, weighted average).			.65	.65	.63	.62	.61	.58	.61	.65	.63	.68	.70

Smelter Production.—Domestic copper smelting from primary and foreign ores continued to contract under the impact of high environmental and energy costs. U.S. smelter production decreased in 1985 compared with that of the previous year, and three primary smelters, which had a combined annual blister production capacity of 364,000 tons, closed by yearend. Eleven primary smelters operated during the year with a total production capacity of 1,384,000 tons of copper. About 208,000 tons of secondary smelter capacity operated during the year at nine plants. Two secondary plants also were closed in 1985.

AMAX began to phase out its U.S. Metals Refining Co.'s copper smelting and refining operations at Carteret, NJ. In recent years, the Carteret facility specialized in processing complex metal scrap and flux for their precious metal content. Although smelting electrolytic refining operations were expected to cease, the company was planning to continue to produce its oxygen-free, high-conductivity copper, retaining 60 employees of the total 700 workers currently employed. The plant had a smelting capacity of 68,000 tons and electrolytic refining capacity of 100,000 tons per year.

Other companies had looked into purchasing the copper smelter at Carteret, but declined because of the environmental problems. U.S. Metals Refining planned to carry out its final smelting and cleanup operations during early 1986. Delays were expected, however, because of concerns voiced by various environmental organizations. The New Jersey Department of Environmental Protection expressed concern about lead emissions at the plant, and the U.S. Environmental Protection Agency (EPA) said the plant was releasing higher levels of dioxin than a dozen other sites in the country. The plant was fined a total of $213,000 by the New Jersey Department of Environmental Protection for pollution violations.

Asarco's copper smelter at Tacoma, WA, was permanently closed in March 1985. Asarco reported 7,530 tons of blister copper produced, compared with 53,000 tons produced in 1984 and 58,100 tons in 1983.[24] The company's El Paso, TX, smelter had a capacity of 104,000 tons of blister copper and produced 77,746 tons of blister in 1985. Blister production of 159,000 tons in 1985 at Asarco's Hayden smelter exceeded its design capacity of 151,400 tons, according to the company's annual report. Asarco cited low copper prices, a shortage of suitable concentrates, and the estimated $150 million cost of meeting Federal, State, and local sulfur dioxide emissions standards as the reasons for closure of Tacoma. The Tacoma plant was one of the few in the world equipped to handle copper-bearing ores that contained substantial amounts of arsenic and had been the largest market economy country producer of arsenic trioxide. The smelter became the focus of national attention in 1983 when EPA proposed standards for limiting the amount of arsenic emitted in the air, including an 82% cutback for Tacoma. The company was looking for a buyer for its associated liquid sulfur dioxide production plant. Asarco's Federated Metals Co.'s secondary plant in Houston, TX, also closed during the year. Asarco's flash smelter at Hayden, AZ, which was completed in November 1983, was capable of processing 54,000 tons of copper concentrates per month and had a concentrate contract with Kennecott's Ray Mines Div. to process up to 25,000 tons per month. In addition, E. I. du Pont de Nemours & Co. Inc. had agreed to purchase 270,000 tons of sulfuric acid per year from the Hayden plant.

Copper Range expected to restart the White Pine smelter and refinery by spring of 1986. Meanwhile, Philipp Brothers was to market White Pine concentrates. The company hoped to produce at least 15,000 tons of ore per day to provide sufficient stockpiles by February 1986 to begin smelter production.

Inspiration Consolidated Copper Co. had smelting contracts with Duval and Cyprus Minerals, which provided about 56% of Inspiration Copper's smelter feed in 1985. The Arizona Department of Health Services (ADHS) brought proceedings against Inspiration for smelter violations. As a result, smelting must be entirely curtailed when the acid plant is not operating. Compliance resulted in reduced smelter production during the second half of 1985. The smelter treated 120,000 tons of Inspiration concentrates and 282,000 tons of toll and purchased concentrates, producing about 120,000 tons of blister copper and 299,000 tons of sulfuric acid during the year.[25]

Smelting was shut down in February at Kennecott's Chino, NM, smelter because of an accident at the acid plant, which caused about $2.5 million in damages to the plant and a production loss estimated at $1.5 million. Mining and milling continued through the monthlong smelter shutdown. Chino also closed the smelter in September for a month to rebrick the furnace following the temporary shutdown of the mill owing to an accident at the mine. The modernized smelter at Chino was started up in October 1984, marking the completion of a $350 million mine, concentrator, and smelter modernization and expansion project that started in 1981 and cut operating costs by about 31 cents per pound. The new Inco flash furnace raised annual smelter capacity to 120,000 tons of copper metal per year. In July, Chino approved installation of a $4.5 million anode furnace and expected to begin production by January 1986. Chino had ceased fire-refining in July 1984.

Kennecott closed its 210,000-ton-per-year smelter at Garfield, UT, in April, following the Bingham Canyon Mine closure. The company was to begin modernization of the associated mining and milling facilities in 1986. The smelter had been converted to a modified Noranda continuous smelting process in 1978 at a cost of about $280 million. The modified smelter captured over 86% of the sulfur, compared with 55% recovery at the old facilities.

Magma was studying the cost and practicality of constructing a new flash smelter to process 2,700 tons of concentrates per day at its San Manuel Mine in Arizona to comply with environmental regulations. It would require an investment of $135 million to retrofit the San Manuel smelter.

Phelps Dodge's Hidalgo, NM, smelter benefited from 1984's $27 million rebuilding and improvement project and smelted a record high 153,300 tons of copper, according to the company's annual report. The corporation determined that it would defer the capital expenditures necessary to bring its smelters at Ajo and Morenci, AZ, into compliance, and consequently, those smelters were closed in December 1984 and April 1985, respectively. Concentrates produced at its mines that exceeded what could be handled by the two operating smelters at Douglas and Hidalgo, AZ, were being sold. A $10 million project was in progress to relocate a relatively new oxygen plant from the Morenci smelter, where production was suspended at the end of 1984, to Hidalgo. The addition of oxygen enrichment at Hidalgo was expected to improve energy and pollution control efficiencies and benefit unit costs there.

Refinery Production.—Compared with the 1984 level, production of refined copper from U.S. primary and secondary plants was down in 1985. This was largely the result of decreased production at primary plants. In 1985, 10 electrolytic refineries, 10 electrowinning plants, and 6 fire-refining facilities operated. During the year, however, four of these refineries had closed. At yearend, total U.S. refinery capacity, estimated to be 1,838,300 tons, comprised 1,407,800 tons being utilized for primary metal production and 430,000 tons as secondary capacity.

AMAX closed its Port Nickel refinery in Braithwaite, LA, at the end of November. The remaining 265 employees were laid off. AMAX also began phasing out its secondary copper and precious metals refining operations at Carteret, NJ. Approximately 130,000 tons of copper refining capacity would be withdrawn through the closure of the two AMAX facilities.

According to the company's 1985 annual report, Asarco's Amarillo, TX, copper refinery had a capacity of 414,000 tons of cathode and produced 376,000 tons of copper, compared with 314,000 tons in 1984. The refinery set a new monthly record-high production of 37,345 tons of refined copper in May. The plant was designed to produce 32,000 tons per month, but the increase in electric current efficiency provided by Asarco's patented Reatrol process enabled the capacity to be exceeded. The Amarillo refinery no longer produced wirebar. With completion of a $6 million rod cleaning system in early 1984, the continuous casting copper rod mill at Asarco's Amarillo copper refinery was able to produce up to 50 tons, or about 70 miles, of continuous cast copper rod per hour without interruption. About 820 employees worked at the Texas operation.

Duval closed its 5,000-ton-per-year Battle Mountain, NV, electrowinning plant in 1984, but continued to produce copper precipitates. United Technologies Essex Inc. permanently closed its 34,000-ton-per-year fire-refining facility at Three Rivers, MI, in April 1985, transferring its home-scrap reprocessing activity to a new continuous cast scrap processing operation in Indiana. The fire-refining facility of the Metal Bank of America in Philadelphia, PA, was closed at yearend 1984, as was Chino's fire-refining plant in New Mexico.

According to the Inspiration Resources 1985 annual report, refining copper production from its refinery complex at Miami, AZ, was 70,000 tons in 1985, compared with 77,000 tons in 1984. Sales of refined copper in the United States increased during the year to $164 million from $144.4 million in 1984, as a result of increased concentrate purchases and higher mine production. Inspiration Consolidated Copper finished a renovation of its rod plant in Claypool, AZ, registering increased efficiency and production in 1985.

Kennecott restarted its copper SX-EW plant at Ray Mines Div. in December, which had been shutdown since 1982. The SX-EW plant recovers copper from silicate type ore and can produce about 20,000 tons of high-purity copper per year. In June, Kennecott closed its 195,000-ton-per-year electrolytic refinery at Garfield, UT.

Magma's San Manuel refinery had an annual design capacity of 195,000 tons of electrolytic copper. The associated rod plant had a capacity of 145,000 tons of continuous cast copper rod per year. Gold recovered at the refinery from the San Manuel Mine ore in 1985 amounted to 20,132 troy ounces and sold at an average price of $321.73 per ounce, providing a total revenue of $6.5 million. In addition to gold, the company recovered 384,976 ounces of silver and 85,495 pounds of selenium from San Manuel ore. Byproduct molybdenite, recovered at the mill, brought the company $9.6 million in 1985. Total revenues from metals other than copper from the San Manuel Mine was $2.5 million, which paid for 21% of its $97 million payroll in 1985.[26]

Magma's new SX-EW plant was expected to considerably lower copper production costs at San Manuel when it begins production in mid-1986. The pregnant leach solutions from the leach pads and later, from the in situ deeper level oxide zone, were to be pumped to the SX-EW plant, where at least 85% of the acid-soluble copper available for dump leaching was expected to be recovered at a rate of about 22,000 tons of refined copper annually. The new plant was to use new technology by applying an Australian technique that employs permanent steel cathode starter sheets, and a Magma-patented mechanism for controlling tankhouse fumes. The company expected to spend about $71 million to develop the oxide ore open pit mine, construct the heap leach pads, and build the SX-EW plant. Production costs of less than 55 cents per pound were anticipated. Newmont's Pinto Valley was producing about 12,000 tons of electrowon cathode per year at the Pinto Valley and Miami Mines. The company may also expand the Pinto Valley electrowinning facility. Newmont's MCR Products Co. started shipping copper rod to customers in early April 1985 from its newly acquired 127,000-ton-per-year continuous cast rod plant at Cicero, IL.

A new system of vertical furnace melting and anode casting was installed in 1985 at Phelps Dodge's El Paso, TX, electrolytic refinery plant. Improved technology also was being put in place in the tankhouse to improve productivity, and a $7 million energy cogeneration project was nearing completion, all of which were expected to strengthen the cost-competitive position of this plant. Two modern continuous cast copper rod mills in El Paso, TX, and Norwich, CT, operated at a combined annual capacity of 385,500 tons in 1985. The corporation was increasing the proportion of refined copper sold as rod, and more than 68% of its refined copper sales outside of the corporation was as rod in 1985, compared with only 41% in 1983. The new expansion to the SX-EW plant at Tyrone, NM, started producing cathode on December 1, a month ahead of schedule. Burro Chief Copper was the operating company for the electrowinning operations at Tyrone.

Louisiana Land and Exploration Co. (LL&E) was to lease the White Pine refinery to Copper Range with the option to purchase through 1988. Meanwhile, Copper Range was expecting to be producing blister from the White Pine smelter by the end of April 1986. LL&E wrote down $29.9 million against the value of the electrolytic copper refinery in 1985.

Copper Sulfate.[27]—Copper sulfate was produced from copper scrap, blister copper, copper precipitates, electrolytic refinery solutions, and spent electroplating solutions by at least seven companies. Imports, primarily from Canada, Italy, and Peru, accounted for about 8% of domestic consumption during the year. The estimated end-use distribution of shipments from domestic producers was 46% for agricultural uses such as fungicides and fertilizers; 42% for industrial uses such as metal finishing, mineral froth flotation, and wood preservatives; and 12% for water treatment.

Chevron Chemical Co., which produced a small quantity of copper sulfate during 1984, had no production in 1985, and Anaconda Minerals permanently closed its small Twin Buttes, AZ, operation during the last quarter of 1985.

Kocide Chemical Corp., a major producer of copper sulfate, was planning to start up an in situ leaching operation at the old underground Van Dyke Mine at Miami, AZ, to secure a supply of copper precipitates for feedstock at the company's Casa Grande, AZ, copper sulfate plant. Ore reserves at the mine were estimated at 90 million tons of 0.5% copper in oxide ore, and initial precipitate production was planned at 3,000 tons of copper per year.

Table 3.—Copper sulfate producers in the United States in 1985

Company	Plant location
Anaconda Minerals Co	Twin Buttes, AZ.
CP Chemicals Inc	Sewaren, NJ, and Sumpter, SC.
Kocide Chemical Corp. (formerly International Metals Recycling Corp.).	Casa Grande, AZ.
Madison Industries Inc	Old Bridge, NJ.
Phelps Dodge Corp	El Paso, TX.
Southern California Chemical Co	Santa Fe Springs, CA, Union, IL, Garland, TX.[1]
Tennessee Chemical Co	Copperhill, TN.

[1]Production from these plants is not included in production data.

Sulfuric Acid Production.—Sulfuric acid production as a byproduct of copper smelting in the United States was valued at $31.8 million for 1985. Four smelters in Arizona produced 998,000 tons, and six smelters in New Mexico, Tennessee, Texas, Utah, and Washington produced 1.27 million tons of sulfuric acid. Of the total, about 63,500 tons was consumed at the smelters themselves for purposes other than manufacturing acid. Total sulfuric acid produced in 1985 as a byproduct of all copper, lead, and zinc acid smelters and zinc roasters in the United States was 2.9 million tons, valued at $56.3 million.

CONSUMPTION

Annual demand for copper in the market economy countries was about 7.5 million tons in 1985, which was about 9% higher than the low consumption of 1982. About 82% of the total was consumed in three industrialized regions of Western Europe, Japan, and the United States. The United States comprised about 29% of the total in 1985.

Consumption of copper-mill products in 1985 by U.S. manufacturers was distributed among the end-use sectors and was reported by the Copper Development Association Inc. (CDA)[28] as follows: CDA estimates included electrical product uses distributed among the market sectors, and the end-use allocations are distributed based on gross weight of copper and copper alloy shipments during the year. Consumption of brass mill, wire mill, foundry, and powder mill products was down 7.2% from that of 1984 and was distributed among the following market sectors: construction, 40%; electrical, 23%; machinery, 14%; transportation, 12%; and other (including ordnance), 11%. According to CDA,[29] the top 10 markets in the United States during 1985 were, in order of importance, plumbing, building wire, telecommunications, power utilities, in-plant equipment, air conditioning, automobile electrical, automobile nonelectrical, business electronics, and industrial valves and fittings.

Based on copper content of U.S. apparent consumption of copper, including copper content of all old scrap, and calculated with electrical and electronic uses extracted from all sectors except that used in ordnance, the end-use distribution, according to the Bureau of Mines, was as follows: electrical, 65%; construction, 18%; machinery, 6%; transportation, 5%; ordnance, 2%; and other, 4%. The most significant change in recent years has been the increase in copper consumption relative to other sectors by the electrical and electronic end-use sector, from about 58% of copper consumption in 1979 to about 65% in 1985. This also was reflected in the increased relative percentage of refined copper consumption at wire mills, which in 1979 consumed 69% of reported refined copper consumption and in 1985 consumed 72%.

Recent observations[30] by the International Copper Research Association Inc. (INCRA) indicated a swing away from using copper in communications, internal combustion vehicles, and printed circuit boards. Telecommunications cable was the most threatened product of the copper wire market. While substitution by optical fibers was important, at least five other factors were also a threat: (1) microwave transmission, including satellites; (2) thinner gauge wire; (3) multiplexing; (4) digital systems; and (5) electronic switching. Another source[31] indicated that in 1985, the telecommunications sector experienced a 26% drop from that of the previous 5 years. In 1985, according to INCRA, 80% of all cars made in Western Europe had aluminum radiators, but only 30% of U.S. cars and 4% of Japanese cars.[32] In addition, radiator tank components were being increasingly made of plastics for both copper and aluminum radiators. In 1980, the average U.S. auto contained 34 pounds of copper, distributed one-third for radiators and heaters, one-third for wiring harnesses, and one-third for alloys used in the engine and elsewhere. In 1985, the average automobile weighed 3,100 pounds and used about 31 pounds of copper.[33] Automobile wiring has been increasing, but increased use of microprocessors may slow this growth. Between 1977 and 1983, downsizing, material substitution, and increased engine efficiency accounted for a loss of 15.8% of the copper consumed in this industry on a worldwide basis. Chrysler Corp. announced in 1985 that it would retain copper radiators in its U.S. vehicles.[34] The major usage of copper radiator strip in Europe was in the replacement market and/or heavy vehicles. There was no imminent threat from aluminum in those segments.

Four new market opportunities of significance for copper were also indicated by INCRA's research:[35] heat pumps, solar power, desalination facilities, and electric vehicles. Solar power was a promising area, with passive solar the main area for growth during the next 20 years. Use of copper solar radiator systems in the United States consumed more than 10,000 tons annually and was growing slowly. Large-scale solar electric generation plants were not considered economically favorable. Energy-efficient heat pumps were being used more extensively in heating and cooling buildings. Sales rose from 100,000 units in 1970 to 500,000 units in 1980 in the United States. By 1990, it was expected that over one-third of new homes will be equipped with heat pump facilities and the total market for the United States will exceed 1.0 million units. Desalination and other marine applications accounted for about 100,000 tons of copper alloys per year. The largest applications continued to be ship propellors and condenser tubes for heat exchangers in coastal power generating plants. Desalination plants remained a long-term opportunity for copper. Copper usage was also expected to increase in copper alloy tooling in fabrication of aerospace and automobile advanced composite structures, in power handling systems, in electronically controlled devices used in automated machinery, as power supplies for lasers, and in superconducting devices.

Nuclear canisters were also seen by CDA as a growth market. Spent nuclear fuel will remain radioactive for about 1 million years. The CDA was working on a feasibility study under a $6 million contract with the U.S. Department of Energy to examine the possibilities for the use of copper as nuclear containers. The French were currently using a solid copper canister.[36]

Changes in the U.S. copper alloy and brass mill industry continued during the year. From being the fourth largest basic industry in the United States, the nonferrous foundry industry had decreased considerably in importance over the 3 years ending with 1985. During this time, about 33% of the U.S. casting production was lost to overseas foundries, mostly to foundries in Taiwan. Much lower wages and significant currency devaluations have been largely responsible. The average U.S. foundry worker was paid $350 per week compared with $25 per week in Taiwan. With the possible exception of the highly automated high-production foundries, the U.S. foundry industry has a very serious and continuing problem. Furthermore, what happens to the nonferrous foundries determines what happens to the brass and bronze sales volume of the copper and copper-alloy ingot maker and the volumes of scrap sold to these processors. All experienced drastic decreases in recent years.[37] H. Kramer & Co., a major brass ingot maker, filed for bankruptcy in Chicago. The company's El Segundo, CA, plant was sold to Cerro Metal Products. Among the larger producers, Century Brass Products Co. closed its brass mill in Waterbury, CT, in February 1985. The mill closed after the labor union's rejection of a request for wage and benefit concessions. A group of investors formed Buffalo Brass to buy out Anaconda Industries' American Brass Div. plants. The company then sold two of the Connecticut plants to Valley Brass. Buffalo Brass would continue to operate plants in Buffalo, NY, Kenosha, WI, and Franklin, KY.

STOCKS

High-grade copper sales, contracts, and inventories and their relationship with commodity exchange copper contracts compared with the demands of the copper marketplace spawned some new market elements. The problem of a large quantity of poor-quality wirebar inventories and other forms deliverable against COMEX and the LME higher grade copper contracts had been perceived for some time as holding down the price of genuine higher grade copper, which was also deliverable to these contracts. With a major proportion of stocks in the LME high-grade, and COMEX copper contracts actually unsuited to the high-grade consumer's needs, a system of off-market premiums evolved for good-quality copper. The price of this copper was depressed to such an extent that the LME standard cathode contract traded at a premium to its higher grade companion for a time in 1984. In addition, the high-grade contract failed at mid-1985 to attract sufficient material into warehouses to prevent backwardation forming; the tightness was exacerbated by the presence in what little stock there was of poor-quality wirebars. The cost of buying these wirebars and reprocessing them to raise their quality was beyond the resources of the producing countries, so this solution was not taken. Eventually, in 1985, the LME decided to opt for a two-contract system—standard and Grade-A. The standard contract was to include all grades, including Grade-A deliverable material. The Grade-A contract would include high-grade cathode plus some select wirebar brands. The new LME two-contract system, with the Grade-A contract deliverable against the standard contract, avoided the need to declare the poor-quality wirebars nondeliverable. Three-month trading of the new Grade-A contract was scheduled to begin on April 1, 1986, with cash trading beginning July 1.

The Midamerica Commodity Exchange in Chicago, IL, submitted recommendations at yearend to the Commodity Futures Trading Commission (CFTC) that would bring that exchange's copper futures contract more in line with the LME. An increase in the contract size from 12,500 pounds to 55,000 pounds of high-grade copper, compatible with LME's higher grade contract, was recommended. It also recommended that both U.S. and European warehouses be registered as delivery points, a move that would give the new contract access to immediate liquidity, as well as making the contract truly arbitrable with Europe. The contract was expected to start in 1986.

COMEX also submitted a proposal to the CFTC for a new high-grade contract plus an amendment to the current contract, increasing the premium for No. 1 electrolytic cathode by 1 cent to 1.5 cents per pound, in an effort to upgrade the exchange's existing contract in keeping with the dominance of high-grade copper in the international marketplace. Only No. 1 electrolytic cathode would be deliverable under the proposed contract, but its size, all delivery points, and trading hours would remain the same as in the current contract. There was a shortage of copper coming into COMEX warehouses, owing to the poor quality of existing COMEX stocks, the lack of new low-grade copper supplies on the market, and the low COMEX contract price.[38] The only available refined copper supplies on the market were high-grade, but COMEX prices would have to increase 3 to 4 cents per pound before high-grade metal will go to COMEX rather than to the consumer. Brokers and dealers were sometimes transacting their own business and writing their own contracts with their own terms rather than working through an exchange broker because of the confusion in the contract terms.

The contraction of COMEX stocks during the past 2 years was attributed to domestic refined copper production cutbacks and steady demand for COMEX material by brass mills. At the end of 1983, COMEX copper inventories stood near a record high of 371,000 tons. By the end of 1984, inventories had receded to 251,000 tons. This dramatic decrease continued through 1985 to 109,000 tons at yearend, the lowest level in almost 5 years. Most of the remaining stocks on COMEX were standard cathode and fire-refined ingot at yearend 1983. As a result, brass mills have constituted the single largest consumer of COMEX inventories over the past 2 years. The standard COMEX grades and shapes were reportedly more energy efficient than No. 1 scrap and were preferred despite the COMEX premium of 3 to 4 cents over the price of No. 1 scrap. In addition, some Chilean ingot bars that previously had been exported to the United States were being shipped to Europe because of slightly higher prices prevailing in continental markets.[39] Primary fire-refined copper ingot from Chino also ceased with the startup of their new anode furnace.

The increase in LME stocks during 1985 was 63,000 tons, but in October was as high as 80,500 tons. Stocks of copper in the LME warehouses fell from 205,600 tons in the first week of October to 184,025 tons in early December, of which 131,825 tons was high-grade cathodes, 48,650 tons was wirebars, and 3,550 tons was standard-grade cathodes. At the beginning of January 1985, LME inventories were 125,075 tons, comprised of 69,950 tons of wirebar, 47,150 tons of high-grade cathode, and 7,975 tons of standard-grade cathode.

In copper, the normal range of inventories was the equivalent of 1 to 1.75 months worth of current consumption, according to some analysts. It was speculated that one aspect of the inventory-price relationship that might be increasingly important, and one that might help to explain some of the metal price weakness since 1983, was the greater role of exchange warehouses as the location of metal inventories. The percentage of total metal stocks held on the exchanges peaked in 1983 compared with those held by producers. High inventories have a more negative effect on prices, the closer those inventories are to the market. The more inventory held by producers, the greater resistance to selling at just any price. Inventory levels might therefore be the most important guide to price trends.[40]

PRICES

The strength of the U.S. dollar and the seasonal weak demand of domestic semifabricators were two major factors for U.S. copper price weakness through much of 1985. Copper prices on the COMEX improved to about 70 cents per pound in the second quarter in response to the continued drop in refined copper inventories, but remained depressed at about 66 cents per pound from July through November as refined copper stocks accumulated in response to seasonal lower demand. However, the weakening dollar and renewed drawdown of refined copper stocks on the COMEX in September exerted a modest upward influence on U.S. prices by yearend. The COMEX price averaged 63.2 cents in December.

Suspension of trading of tin on the LME in October also temporarily dampened demand and price for copper. The tin crisis broke on October 24, and the nature of trading on all LME rings altered markedly. Between October 24 and October 31, the LME price for copper decreased by up to 5.8% as traders made adjustments for the International Tin Council members who were in default to members of the exchange. However, there was little evidence that trading had become distorted to the extent that LME prices for copper had become seriously divorced from the market fundamentals.

According to some analysts,[41] the changes in exchange rates in recent years have had their largest effect among metals markets on the copper market. The copper-producing nations had the largest devaluations in excess of inflation than producers for other metals. Low copper prices triggered devaluations in those countries where it was a major source of export income. Currency fluctuations were considered a major factor in making some mining and production operations profitable or unprofitable. It was suggested that had the excessive devaluations not occurred, copper prices in U.S. dollars would have been 27% higher in 1984 than was the case. In other words, instead of the LME price of 62 cents per pound, the price would have been about 79 cents per pound. A 79-cent producer-realized price would allow almost all U.S. mines at least to break even and show a small profit. The strength of the dollar seemed to have been the major factor behind the supply-demand fundamentals relationship with price, including lower levels of consumption, higher levels of production, and corresponding changes in inventory that eroded part of the gains in dollar prices.

Market conditions during the past several years brought about some pricing changes by U.S. producers for their cathode and rod in an attempt to address the needs of the consumer. Some producers adopted a flexible premium structure based on COMEX prices, while others regularly adjusted prices to follow the COMEX spot price but were not tied to it. Phelps Dodge has been using a COMEX-based pricing method for its copper rod for more than 2 years. In January 1985, Corporación Nacional del Cobre de Chile (CODELCO-Chile) also switched to this premium pricing method for its cathode sold in the United States. In November, Newmont announced an intention to put into effect its premium pricing system over the COMEX settlement price for its cathode sales beginning in January 1986, breaking a longstanding tradition of producer pricing. Inco Ltd., Kidd Creek Mines Ltd., and Noranda Mining Inc. also had COMEX-related pricing structures. Asarco, Duval, Inspiration Resources, and Phelps Dodge all retained producer cathode price structures.

Phelps Dodge's rod premium was 9.5 cents per pound more than COMEX prices through the end of 1985. Premiums for cathode sold by merchants on the east coast averaged 5 cents per pound over COMEX at yearend; by comparison, premiums were as low as 5 cents when Phelps Dodge first switched to a COMEX-based pricing system on January 1, 1984. Prior to that change, the company had priced its rod on the basis of a 4.85 cents per pound premium over its published cathode price.

No. 2 copper scrap was stable in price throughout 1985 at about 37.50 cents per pound average per month. This compared with an average monthly price for 1984 that in January was 41.17 cents per pound and decreased to 35.67 cents in December. The average price of No. 2 copper scrap during 1984 was 39.81 cents. The average price for red brass solids ended 1985 at 39.5 cents per pound, compared with a January price of 40.50 cents per pound.[42]

Representative prices of brass and bronze ingots, in cents per pound, as quoted by ingot makers, effective June 7, 1985, were as follows: alloy 100 at 91 cents; alloy 110 at 90.25 cents; alloy 193 (88-10-2 group) at 209.50 cents; alloy 327 (80-10-10 group) at 88.25 cents; and alloy 295 at 164.00 cents. In the yellow group, alloy 400 was quoted at 71.25 cents and alloy 409 at 82.25 cents.[43]

TRADE

The U.S. import reliance for refined copper was at a record high during 1985. As a percentage of apparent consumption of refined copper, the U.S. import reliance reached 28% in 1985; this compared with an import reliance of 1% as recently as 1982. This was attributed to the drawdown of inventories from COMEX in lieu of increased refined imports, which although high, were at a lower level than refined copper imports of 1984. At the same time, domestic exports of copper in scrap and concentrates increased significantly during the year, largely as a result of a slowdown in domestic brass mill and copper smelter activity. A shortage of high-grade copper concentrates relative to available international smelter capacity, and the sale of a significant portion of a domestic copper mining facility to a Japanese firm, resulted in a substantial increase in export of copper ores and concentrates to Canada, Japan, the Republic of Korea, and Taiwan during the year.

The surge in imports over the past 2 years of lower priced copper and copper alloy semimanufactures also was seen as being responsible for the weakening of scrap sales to domestic brass mills. As a result of soft U.S. markets, scrap dealers reportedly turned to Asian, Canadian, and European markets for sales. Scrap exports accordingly jumped by two-thirds, primarily to the more favorably priced markets in Belgium, Canada, the Federal Republic of Germany, Italy, Japan, the Republic of Korea, and Taiwan, where scrap demand by expanding copper semimanufacturing industries had grown.

Imports of brass mill products (copper rod used for electrical wire purposes is not included) fell by 17.6% during 1985 to 216,700 tons, compared with the record high of 263,000 tons imported in 1984. However, the amount imported was still significantly higher than the 182,000 tons imported in 1983. Exports of copper and brass mill products leveled off at near 1984 levels, reaching 30,700 tons during 1985. This was down considerably from the record high of 96,400 tons exported in 1980. Most brass mill product exports went to Canada and Mexico.

CODELCO-Chile USA assumed responsibility from Cerro Sales Corp. as CODELCO-Chile's sales agent in the United States and Canada, effective January 1, 1986. Cerro Sales had been CODELCO-Chile's sales agent in the United States and Canada for 10 years and handled about 125,000 tons per year of CODELCO-Chile's copper. Westinghouse Corp.'s Abingdon continuous cast rod mill's business was shifting from tolling to more direct rod sales and it increased copper purchases from Chile during the year to provide the material for this new direction. CODELCO-Chile was reported as selling 1,500 tons of refined copper per month and Empresa Nacional de Minería (ENAMI) 750 tons per month to Westinghouse, which had an annual capacity of 60,800 tons of continuous cast rod.[44]

Final antidumping duties of 3.3% were to be imposed on imports of low-fuming brazing copper wire and rod from the Republic of South Africa as a result of a ruling by the International Trade Commission at yearend. The unfair trading cases were aimed at subsidiaries of McKechnic Bros. Ltd., a United Kingdom-based firm with operations in both the United Kingdom and the Republic of South Africa, and were filed in February 1985 by American Brass Co., Century Brass, and Cerro Metal Products. The International Trade Commission also found that imports of low-fuming copper brazing rod and wire from New Zealand had caused injury to domestic producers. Importers of New Zealand material will be required to pay a combination of antidumping and countervailing duties equivalent to 26.93% of the product value.

WORLD REVIEW

World mine production of copper rose by nearly 130,000 tons in 1985, reaching 8.1 million tons; most of that increase was in market economy countries. Australia, Canada, Chile, Papua New Guinea, and Peru accounted for most of the increased production. World refined production also increased marginally. Copper consumption rose at a moderate rate during the first part of 1985, and for a while, industry and terminal market stocks plummeted weekly. For the year, world copper consumption decreased slightly to 9.7 million tons. Market economy country consumption of refined copper decreased during the year owing to cutbacks in Canada, Japan, and some Western European countries. Increased consumption was indicated for Australia, Belgium, Brazil, China, the Republic of Korea, Mexico, Sweden, the United States, and centrally planned economy countries.[45] At yearend, lower oil prices and a further decline in the value of the dollar helped to stimulate consumption in the United States. The strengthening Japanese yen had the opposite effect upon Japan's copper consumption, where imports of refined copper in 1985 were down sharply from those of 1984.

At the beginning of 1985, a slight deficit developed in the market economy countries' balance of copper supply and demand, largely as a result of the strong inventory drawdown that had occurred in 1984 and early 1985. Strikes in Australia and Peru, the earthquake in Chile, and the shutdown of the Bingham pit in the United States early in the year were also factors in reducing world supply. The deficit was eliminated by the third quarter, however, and LME refined copper stocks rose rapidly in response to reduced demand. Although total refined copper stocks decreased in the United States by about 253,000 tons during 1985, commercial stocks outside of the United States increased during the year by about 78,000 tons, according to the World Bureau of Metal Statistics.[46]

Major copper producers started setting their 1986 cathode premium structures in October. CODELCO-Chile lowered its premium for an average pricing by $3.04 to $4.56 per ton and reduced its premium for unknown pricing by $4.56 to $24.30 per ton. All sales in Europe and Japan were to be based on the LME higher grade settlement price through June 30, 1986, and on the new Grade-A contract that was to start July 1, 1986. The Metal Marketing Corp. of Zambia Ltd. (Memaco) announced that its premiums were to be unchanged from the 1985 contract—specifically, a $38-per-ton premium for fixed known prices, and a $30.40-per-ton premium for unknown prices. In addition, Zambia's customers were to be offered less tonnage in 1986 than they contracted for in 1985 since Memaco overcommitted itself for 1985 contracts.[47]

The LME Committee approved four brands of copper wirebar as deliverable against the new Grade-A copper contract approved in late 1985: Chile's CCC/MR, Poland's HMG Zaire's UMK, and Zambia's REC refined copper wirebar brands. Twelve wirebar brands were initially considered.[48]

Exports of copper concentrates increased from Australia, Chile (increased by 100,000 tons), Peru, the United States, and Zaire. Exports of refined copper decreased significantly from Zambia from 530,100 tons in 1984 to 474,500 tons in 1985. Decreased exports of concentrates and refined copper were also reported by Canada. Imports of concentrates by Finland, the Federal Republic of Germany, Japan, and the Republic of Korea were up marginally. Only Belgium, China, India, Italy, the Republic of Korea, and the United Kingdom indicated increased imports of refined copper.[49]

Smelting and refining charges for concentrates that had dropped on international markets from about 8 cents refining charge (R/C), $60 per ton of concentrate treatment charge (T/C) to about 4 cents per pound R/C and under $20 per dry ton T/C in mid-1984, stabilized at yearend 1984, and ranged from 6 to 7 cents R/C and $40 to $50 per ton T/C during 1985. The drop in custom concentrate supplies, owing to mine closures in Canada and the Philippines, was balanced by smelter cutbacks in Japan and smelter closures in the United States.

The Governments of Chile and China agreed in principle that China would buy Chilean copper concentrates and sell Chile petroleum in exchange. The accord was announced near the end of 1985 at the closing of the eighth Sino-Chilean Trade and Commerce Conference. The copper-petroleum agreement was being organized by CODELCO-Chile and the China International Trust Investment Corp. China hoped to become less dependent upon copper imports during the 5-year plan that begins in 1986, according to the China National Nonferrous Metals Import-Export Corp. (CNNMIEC). Cuts in imports would be made possible by increasing domestic output. Imports of copper into China in 1985 were 356,000 tons[50] compared with 254,045 tons in 1984 and 485,863 tons in 1983.

The 12 European Economic Community (EEC) nations will be authorized to export about 30,200 tons of copper scrap and 25,000 tons of copper ash in 1986, according to export quota restrictions set by the EEC. In addition, 10 of the EEC nations will be allowed to export 14,000 tons of copper scrap and 5,000 tons of copper ash to Spain. The levels set were roughly similar to those fixed for 1985 and were presumed necessary to prevent supply shortfalls on European copper scrap markets.[51]

The copper price rise of the late 1970's prompted plans and discussions for new capacity. Many of these had since been placed on hold, but with changing exchange rates, lowered labor rates, and technological and economical innovations, some of these projects were being reactivated or reconsidered in 1985 with lower production costs quoted. Although the yen and other industrialized countries' currencies strengthened vis-a-vis the dollar near yearend, the copper-producing countries' currencies continued to weaken during the year, thereby effectively lowering production costs. The currencies of Australia, Brazil, Canada, Chile, Mexico, Peru, the Philippines, Zaire, and Zambia all weakened significantly against the U.S. dollar during 1985. Projects reactivated in Canada included the Brenda Mine, which had previous production costs quoted at 80 cents per pound. Projects being reconsidered in Chile included Cerro Colorado, previously requiring prices of about $1.10 per pound. In Mexico, a copper price of $1.00 to $1.10 was to have been required to expand the Cananea open pit. In Peru, the Cobriza project had a break-even point of $1.30 per pound, with cash costs in 1984 of about 84 cents per pound for the expanded production. Cerro Verde II sulfide ore would have required 90 cents per pound to break even. Revised plans for a smaller operation indicated a break-even level at only 56 cents per pound. Development plans also were announced during the year at both the Ok Tedi deposit in Papua New Guinea and at the Roxby Downs deposit in South Australia.

Australia.—In 1985, average copper prices in Australia were $2,066 per ton, 30% higher than in 1984 mainly because of the relative weakness of the Australian dollar. Australian copper prices began 1985 at $1,600 per ton, the year's minimum, and increased steadily to reach the high for the year of $2,440 per ton on April 29. Prices closed the year at $2,100 per ton.

Western Mining Corp. Holdings Ltd. (WMCH) and British Petroleum Ltd.'s (BP) BP Australia Ltd. announced that the Olympic Dam Project at Roxby Downs would proceed with construction beginning in early 1986. The project was to cost between $550 and $600 million and produce 55,000 tons of copper, 2,000 tons of uranium oxide, and up to 90,000 ounces of gold per year. The initial gold production was to start in 1987 with copper and uranium production to begin in 1988. Copper production was scheduled to begin in 1988 at the rate of 30,000 tons per year, rising to 55,000 tons per year in the second phase. Ore reserve base estimates[52] were given as 2 billion tons of 1.6% copper demonstrated, or about 32 million tons of contained copper. The two firms outlined at the end of 1983 a major high-grade ore body within the main ore body containing probable ore reserves of 450 million tons at 2.5% copper, 0.8 kilogram of uranium oxide per ton, 0.6 gram of gold per ton, and 6 grams of silver per ton. WMCH's subsidiary, Roxby Mining Corp., will be a 51% owner of the project, and BP Australia will hold a 49% interest.

At CRA Ltd.'s mine in Cobar, western New South Wales, the installation of new underground ore handling facilities was completed as part of an expansion project involving development of the lower levels of the mine to raise capacity to about 850,000 tons of ore per year. CRA and the New South Wales government reached an agreement in May that helped to keep the Cobar copper mine open. The government gave undisclosed concessions in return for the company's pledge to spend $4.8 million in development on the deeper ore bodies. The arrangement followed an earlier agreement with unions at the mine that led to major changes in work practices. With these changes, output from the mine was expected to rise from 600,000 tons of ore per year to 850,000 tons per year.

Belgium-Luxembourg.—Major projects for the financial year at Métallurgie Hoboken-Overpelt SA's Hoboken facilities included the continued construction of two electric furnaces as part of the smelter modernization program that was started in June 1984. One furnace started up in September 1985; the other was to start up in 1986. In addition, a modernization of the blast furnaces at Hoboken was in process, including an increase in the capacity of one of the furnaces. At Olen, a plant was under construction for the continuous melting and refining of copper in a vertical furnace. Both the feed charging and anode removal operations were to be highly mechanized and operational by mid-1986.[53] Copper smelter capacity at Belgium's two smelters, Beerse and Hoboken, was estimated to be 172,000 tons of blister copper per year. The 100,000-ton-per-year Beerse smelter was owned by La Metallo Chimique SA. Refining capacity in 1985 was estimated to be 480,000 tons of copper per year at Beerse, Hoboken, and Olen.

Brazil.—In January, Caraíba Metais S.A. brought on-line its underground mine at Jaguarari, Bahia State. The company was already operating an open pit at the site, producing about 32,000 tons of copper in concentrates in 1985. Output from the new underground mine was expected to reach 15,000 tons per year when at full capacity in 3 years. Production from the Pedra Verde Mine, operated by Guanordeste Mineração e Comércio Ltda. started in 1984 at a rate of 80 tons per month of contained copper. Brazil's state-owned Cia. Vale do Rio Doce was to start up a $6 million pilot plant at the Salobo Mine in Carajás in March 1986. The plant was part of a $600 million development scheduled to come on-stream in 1988. The deposit was estimated to contain 1.2 billion tons of ore with an average grade of 0.85% copper. Cathode production at Brazil's Caraíba Metais refinery was 93,880 tons in 1985, 62,100 tons in 1984, 55,074 tons in 1983, and 2,901 tons in 1982. The smelter has a blister capacity of 150,000 tons per year.

Burma.—Mitsui Mining Co. of Japan negotiated a contract during 1985 with Burma's No. 1 Mining Corp. for 15,000 tons of concentrates from the Monywa Mine. Ore reserves at the mine were given as 117 million tons with a grade of 0.734% copper at yearend 1984. Projected life of the mine was estimated at 48 years at current production rates.

Canada.—Despite the fall of nickel and zinc prices at the end of 1985, which had a negative impact on Canadian copper production, mine production of copper increased compared with that of 1984 and was well above 1981 and 1982 levels. There was no Canadian producer mining only copper during the year. The largest copper producer was the nickel company Inco, followed by Kidd Creek Mines.

BP Canada Inc. was planning a $125 million project to bring a new zinc-copper-silver ore body into production at Les Mines Selbaie, northwest Quebec, by late 1986. The move follows BP Canada's acquisition of Hudbay (Quebec) Ltd., formerly owned 87.5% by Dome Petroleum Ltd., giving the company two-thirds ownership in the Selbaie Mine. A production of 27,400 tons per year of copper was expected from the open pit mine by November 1987. The Quebec government was to provide 20% of capital costs via a grant of up to $18 million. In December, Esso Minerals Canada Ltd. agreed to purchase a 35% interest in BP Canada's Selbaie operations.

Gibraltar Mines Ltd. was to build a leach facility for leaching waste and low-grade dumps at its copper-molybdenum mine near McCleese Lake, British Columbia. The $12.3 million unit will include an SX-EW plant with 5,000-ton-per-year copper capacity. The mine had been operating at a loss since 1981, producing about 150,000 tons per year of 26.6% copper concentrates with byproduct molybdenum in 1985. Plant construction was to be completed in October 1986.

Less than a month after Noranda put its Rudolf Wolff Group up for sale, the company restructured its operations, splitting Noranda Minerals into three operating groups, Noranda Copper, Noranda Mining, and Noranda Zinc. Noranda Copper included, in increasing order of processing, the Horne smelter, Canadian Copper Refineries (CCR); the Gaspe Div.; Chadborne; Bell Copper; Remnor; and Micrometallic, a computer scrap business in the United States. Noranda Mining will consist of Geco Div. (copper, silver, zinc); Mattabi Mines (copper, silver, zinc); Lynn Lake Div. (copper, lead, silver, zinc); Golden Giant (gold); Central Canada Potash; Brenda Mines (copper, molybdenum); Pamour (gold); and Mining Corp., a mine development contracting concern. A combination of British Columbian government assistance, labor cooperation, and lower electric and tax rates allowed Noranda to reopen its Bell and Brenda copper mines in British Columbia early in September.[54] The British Columbia Legislature recommended in June 1985 that both the Bell and Brenda Mines should be given some Provincial assistance to reopen. Labor contracts were extended without salary increases to June 30, 1987, with the addition of a profit-sharing plan. The company expected to produce 21,300 tons per year of copper in concentrate at the Bell Mine, which had been closed since 1982, as well as 25,000 ounces of gold and 125,000 ounces of silver. Bell had reserves of 42.7 million tons of ore grading 5.1% copper. The Noranda Brenda copper-molybdenum mine only produced for 7 months in 1984, closing on December 14, 1984. Brenda had a capacity of 14,000 tons per year of copper and 6 million pounds per year of molybdenum. Both mines were expected to cease operations by yearend 1988 after exhaustion of economic reserves.

Sherritt Gordon Mines Ltd. took a $23.2 million charge against its 1985 earnings as a provision for write-down of its lower grade ore reserves at its Ruttan Mine in Manitoba. Nonetheless, production was scheduled to increase at Ruttan, with operating plans calling for about 31,300 tons of copper in concentrate plus zinc for 1986 compared with a production of 20,400 tons of copper and 15,900 tons of zinc in 1985. Sheritt's copper and zinc concentrates were sold to the Flin Flon smelter of Hudson Bay Mining and Smelting Co. Ltd.

Lornex Mining Corp. Ltd. and Cominco Ltd. planned to combine their assets in Highland Valley, British Columbia, to form one of the largest copper mines in North America. Annual concentrate output from the combined Highland operations will contain in excess of 180,000 tons per year of copper and significant quantities of gold and silver. Cominco's higher grade Valley Mine had ore reserves of 800 million tons of 0.48% copper plus gold and silver values. The Lornex Mine had ore reserves of 385 million tons of 0.38% copper and 0.03% molybdenum. Cominco and Lornex were to share control and management of the venture, and expansion work was to start in May 1986.

Teck Corp. held 22% of Lornex Mining, which was a member of the Rio Tinto Zinc Group and 68.1% owned by Rio Algom Ltd. Teck also held a 73% interest in the Afton copper-gold mine with Metallgesellschaft Canada Ltd. Afton, which is east of Kamloops, British Columbia, returned to profit during the year, producing 22,400 tons of copper and 48,559 ounces of gold. Rio Algom's East Kemptville tin mine started trial production. About 1,500 tons of byproduct copper in concentrates per year was expected to be produced at full capacity.

Falconbridge Ltd. agreed to acquire Kidd Creek Mines for $446 million from Canada Development Corp. (CDC), an 11% Provincial government-owned firm with investment in chemicals, energy, and mining. Not included was the company's interest in the Allen potash mine and lead-zinc mine on Baffin Island. CDC will receive a 20% stake in Falconbridge as part of the agreement that is to be completed in 1986. Earlier in the year, Dome Mines and its affiliate McIntyre Mines Ltd. had taken a 30% share of Falconbridge, which gained Kidd Creek's newly modernized Timmins metallurgical complex that included a zinc smelter and a copper smelter and refinery. Kidd Creek Mines had invested about $300 million to modernize the Timmins copper refining and smelting plants, which were raised from 59,000 tons of copper per year to a capacity of 90,000 tons per year. Kidd Creek's Timmins smelter, which used the Mitsubishi smelting process, was shut beginning in April for 51 days for major modifications to the smelter acid plant and related equipment as part of the expansion program. The casting line at the copper smelter-refinery also was closed for nearly a month because of an anode furnace spill.

The Quebec government announced regulations in February to control the emission of sulfur dioxide. Noranda's Gaspe and Horne smelters will be required by the end of 1990 to contain 65% and 50%, respectively, of the sulfur entering the plants. The Horne smelter will be also required to contain 35% of the sulfur entering the plant by the end of 1989. Noranda's Gaspe smelter operated through the year with imported concentrates from South America and those produced at the Needle Mountain Mine; the Copper Mountain open pit remained closed.

The Canadian Government was to provide up to $107 million in financial assistance to the smelting industry to cut sulfur dioxide emissions in half over the next 10 years as part of a long-range acid rain cleanup program. The Ministry of the Environment set a target date of 1994 for smelters to reduce emissions by 50% throughout the country. Estimates of the total cost of improving the five largest sulfur dioxide emitters range from $504 million to $720 million.[55]

Chile.—Copper production in Chile in 1985 amounted to 1.36 million tons, up about 5% over that of 1984. CODELCO-Chile accounted for 1.08 million tons of the total. The Chuquicamata Div. produced 51% of CODELCO-Chile's mine output, followed by the El Teniente Div., 30%; the Andina Div., 10%; and the El Salvador Div., 9%. CODELCO-Chile reported pretax profits of $437.6 million on revenues of $1.6 million in 1985, compared with $332.6 million on gross revenues of $1.5 million in 1984. Over $411 million was transferred to the Chilean Government during 1985, or about $100 million less than in 1984.[56] Chile received $850.1 million from the IMF for a 3-year funding program. Under the terms of the program, Chile would have immediate access to $60 million in IMF credit and an additional $73.1 million in compensatory financing to make up for loss of export income amounting to $244.5 million during the 12 months ending in March 1985. Most of the shortfall, about $161.6 million, was attributable to a drop in the export volume and unit value of copper. Chile's economic program for the next 2 years, which the loan was aimed at supporting, required an expansion of exports. To stimulate foreign investment, Chile approved changes in the foreign investment code including the extension from 10 to 20 years of the guarantees of a fixed 49.5% tax rate and other tax benefits. Chile was attempting to establish better conditions for financing several copper projects under study, including the Cerro Colorado copper mine and the La Escondida copper mine.[57]

Chile's small- and medium-sized mines obtained a $100 million loan from the World Bank. One-half of the money was to be used by ENAMI to improve the efficiency of its Ventanas refinery, two smelters, and several concentrators, and the rest for mine development and other investments at small- and medium-sized mines. In 1985, La Sociedad Nacional de Minería (SONAMI) members produced 263,900 tons of copper, up from 257,000 tons in 1984.

CODELCO-Chile expected to invest $310 million in its four operating divisions in 1985, and another $300 million during 1986 to maintain existing production levels. Of the planned investments, $97 million was to go toward pollution control. CODELCO-Chile noted that about $250 million already had been invested in environmental protection equipment at Chuquicamata Div. Planned investments at Chuquicamata included $17.7 million for a refinery program, $22 million for a flash smelter and related equipment, $13.6 million for a sulfuric acid plant for the flash smelter, and $81 million for power improvements. At El Salvador Div., $6 million was allotted for mine development, and at Andina Div., $5.4 million for tailings disposal. At El Teniente Div., mine infrastructure was to receive $39.2 million; transport and storage of tailings, $20.1 million; and expansion of the Colon concentrator, $14.1 million. CODELCO-Chile planned to invest $1,200 million at its Chuquicamata Div. over the next 5 years.

CODELCO-Chile was to begin development of two new mines, Chuquicamata Norte and Elabra. Copper production capacity was to be raised at Chuquicamata from the current rate of 550,000 tons of copper per year to about 850,000 tons per year upon completion of the investment. The concentrator was to be expanded to 153,000 tons of ore per day by 1987. A new 30,000-ton-per-day in-pit ore crusher recently was installed. About 100,000 tons of ore per day was processed with an average grade of 1.6% copper, yielding about 4,000 tons of concentrates per day from the Chuquicamata pit, which was about 2 kilometers wide, 3.8 kilometers long, and 478 meters deep. Reserves were estimated at 1.7 billion tons of copper ore containing an average of 1.04% copper.

A $90 million, 4-year investment program at the Andina Div. of CODELCO-Chile was completed on March 31, boosting annual copper production capacity to 118,000 tons of contained copper per year. Andina's open pit Sur Sur Mine was used to supplement the block-caving operation in the Cerro Blanco ore body. CODELCO-Chile planned to increase production from the current 20,000 tons of ore per day to 26,000 tons per day by 1987 to compensate for an expected drop in average ore grade.

In March, El Teniente suffered earthquake damage to its tailings flume, concentrator, and Caletones smelter. The ports of San Antonio and Valparaíso and several roads and rails were also damaged, delaying copper deliveries.

The underground mine at El Teniente was CODELCO-Chile's second largest producer, with reserves estimated at 47.6 million tons and an average ore grade of about 1.2% copper. The mill-head grade of 1.4% copper was expected to fall to 1.2% copper by 1989 and to 1.0% copper by the end of the century. Ore treatment capacity was expanded during 1985 to 80,000 tons of ore per day.

El Salvador Div. was an underground block-caving operation and associated concentrator, Potrerillos smelter, and refinery. Situated in the Atacama Desert, the mine had a capacity of about 34,500 tons of ore per day, producing 710 tons of 38% copper concentrate per day and 6.5 tons of 56% molybdenum concentrate per day. El Salvador had 20 to 30 years of ore reserves with an average grade of about 1% copper and 0.023% molybdenum.

Antofagasta Holdings of the United Kingdom acquired the Los Pelamberes copper-molybdenum deposit for $6.4 million in northern Chile from Anaconda Minerals near yearend. Anaconda Minerals had postponed the project after it was unable to find partners to provide part of the $1 billion to $2 billion needed to develop the ore, which had about 400 million tons of ore grading 0.9% copper and 0.015% molybdenum.

Texaco Oil Co. sold its 50% share in the $1.3 billion Escondida project to a consortium comprised of The Broken Hill Pty. Co. Ltd. of Australia (BHP) (10%), Rio Tinto Zinc Corp. Ltd. (30%), and Mitsubishi Corp. (10%). The purchase price was less than $100 million, and brought BHP's stake to 60%, which it held through its subsidiary, Utah International. The consortium was starting a yearlong feasibility study and was arranging financing and sales contracts. Mine production was planned for 1990 and called for an open pit, a 160-kilometer slurry pipe, and port facilities. Projected annual production was 300,000 tons of copper in concentrate per year. Escondida is one of the richest undeveloped copper deposits in the world with proven reserves of 545 million tons of ore grading 2.16% copper and 0.01% molybdenum. Most of the concentrate was planned for shipment to Japan for smelting.

Cía. Minera San José Ltda., a subsidiary of St. Joe Minerals Corp., operated two open pits at the El Indio Mine, 420 kilometers north of Santiago. El Indio had reserves of 4.6 million tons of 5% copper as well as 9.6 grams of gold per ton and 122 grams of silver per ton.

Cía. Minera Disputada de las Condes S.A., an Exxon Minerals Chile Inc. subsidiary, approved a 2-year, $73 million expansion project at the company's El Soldado Mine and El Cobre treatment plant. The decision was made despite Disputada's continuing losses, which were about $41.5 million in 1984. Since taking it over from ENAMI in 1978, El Soldado had never been profitable.[58] Disputada produced about 77,000 tons of copper concentrate in 1985 compared with 61,575 tons in 1984. The increase was from higher production at El Soldado, where a concentrator expansion completed in September 1984 boosted capacity to 5,500 tons of concentrates per day from 3,700 tons per day. Exxon Minerals was studying a $70 million to $80 million expansion that would increase the rate at El Soldado to 11,500 tons per day. Startup of the operations was scheduled for the second half of 1987. Of a total $71 million to be invested in the expansion project, $23.6 million will be spent on the El Cobre plant. Current reserves at El Soldado were estimated at 48 million tons of 1.7% copper. The company was also looking at a $350 million to $400 million expansion at Los Bronces.

Development of the Cerro Colorado copper deposit in Chile was delayed indefinitely after Finland withdrew its planned support. The project was to cost $240 million with contributions coming from Canada's Rio Algom ($60 million), the West German Government ($80 million), the Finnish Government ($35 million), and the Chilean State Economic Corp. ($30 million). In addition, the United Kingdom's export credit guarantee department agreed in principle to secure bank loans amounting to $35 million for purchase of domestic equipment and engineering services. Chile's industrial development corporation, Corporación de Fomento de la Producción, was also to loan

$30 million. Production of 60,000 tons of copper per year was planned for about 1988. Nippon Mining Co. Ltd., Tokyo, Japan, previously had abandoned the project in 1980 because of uninspiring cost-benefit prospects. Cerro Colorado's resources are estimated at 70 million tons of about 1.3% copper.

Chuquicamata Div.'s smelter consisted of four reverberatory furnaces, seven Peirce-Smith converters, and one modified Teniente converter and had a capacity of 1,500 tons of cast anodes per day. Sulfuric acid production at the smelter was to be increased from 500 to 3,000 tons per day by 1989, and a new 200,000-ton-per-year flash smelter was to be added by 1990. Anode casting capacity was to be increased to 1,800 tons per day. Mitsubishi of Japan signed a $78 million contract to build the new acid plant, providing 100% of the project's financing.

CODELCO-Chile's El Teniente Div.'s smelter at Caletones had an annual capacity of about 340,000 tons of blister copper from two reverberatory furnaces and two Teniente converters. The only modernization projects at the Caletones smelter were the addition of converter hoods and improvement of casting facilities. The new fire-refining furnace at the Caletones smelter had production problems upon startup in February. The company's Potrerillos smelter was about 50 kilometers from the El Salvador Mine and was equipped with one reverberatory furnace, four Peirce-Smith converters, two cylindrical refining furnaces, and one anode casting wheel. The plant's capacity was estimated to be about 100,000 tons of blister per year.

ENAMI's Ventanas smelter, which had an annual blister capacity of about 110,000 tons per year, was damaged in the March earthquake, but was functioning again within 30 days. ENAMI buys raw materials for the Ventanas smelter from the small-mine sector as well as from CODELCO-Chile. ENAMI was spending $4.5 million on the Ventanas complex to increase its refining capacity to 195,000 tons per year, which would be realized by January 1986. An investment of $30 million was planned to build a sulfuric acid plant that would produce 525 tons of sulfuric acid per day.

Considerable expansion of the Chuquicamata refinery was under way, and production was expected to reach 475,000 tons per year by yearend 1986. In 1985, electrorefining capacity in two existing tankhouses was about 400,000 tons per year. Refinery No. 1 was designed for electrowinning copper from leach solutions and would be completely replaced by the $70 million expansion. In 1985, CODELCO-Chile's only oxide treatment was done at Chuquicamata in the electrowinning facilities of refinery No. 1. About 40,000 tons of electrowon cathode per year was being produced through this method, but was expected to be doubled over the next 4 years using oxide ores at Mina Sur, low-grade ore dumps from the Chuquicamata Mine, and waste dumps at both Mina Sur and Chuquicamata. This expanded leaching was expected to be in operation by 1988, followed by cessation of vat leaching. The Potrerillos refinery at El Salvador also was originally designed for electrowinning and later converted to electrorefining. Expansion to 96,500 tons of copper cathode per year was completed in 1984, raising the capacity to equal the smelter. CODELCO-Chile postponed indefinitely the construction of a new 100,000-ton-per-year copper refinery 50 miles from Santiago, originally planned to treat blister copper from the El Teniente and Andina Mines. The refinery was to come on-stream in 1987. The existing El Teniente refinery had a capacity of about 155,000 tons of copper cathode in 1985.

CODELCO-Chile's Chuquicamata Div. held a near monopoly in Chile as a supplier of wirebar, and domestic fabricators claimed that they paid more for this wirebar than fabricators in other countries, including those in the United States. CODELCO-Chile owned equity in copper fabrication plants in Europe and was considering a joint-venture in China for a wire and cable plant. Prospects for downstream expansion of fabrication plants in Chile were limited because of the country's small domestic market and higher tariffs in export markets on fabricated products compared with tariffs on refined copper. Total output of fabricated copper products in Chile was about 35,000 tons per year, of which about 60% was exported, chiefly to other South American countries.

China.—Copper imports totaled 356,000 tons valued at $480 million in 1985, while domestic mine production was only about 185,000 tons. China's trade of all nonferrous metals was to be handled exclusively by the new CNNMIEC, the trading arm of China National Nonferrous Metals Industry Corp. (CNNMIC), beginning in 1986. The responsibility had previously been held by China National Metals & Minerals Import-Export

Corp.

CNNMIC was seeking technology and investments from foreign interests for 18 nonferrous metals joint venture projects, including a 5,000-ton-per-year copper tubing and a 1,000-ton-per-year copper sheet and strip plant in Beijing; a high-accuracy copper alloy strip processing line, with a capacity of 4,000 tons of brass strip per year and 3,000 tons of radiator and cable strip per year; and a copper foil plant, with a capacity of 1,000 tons per year at the Shanghai copper smelter complex; a beryllium bronze processing line with annual capacity of 2,000 metric tons at the Northwest copper fabricating plant; a mill to treat 1.5 million of ore per year at Huili Lala copper mine, Sichuan Province; and construction of a mine and a concentrator in the Jiangxi copper complex at the Chengmenshan copper mine.

Continuus-Properzi Corp. signed a sales contract with Wuhu Smelter, a copper refining and fabricating company of Wuhu City, Anhui Province, for the supply of a Properzi continuous cast copper rod line to be operating by the end of 1986. This was the third Properzi copper rod line recently sold to China. China planned to have at least 12 continuous cast copper rod mills in operation by 1987. Total capacity of the mills was estimated at about 390,000 tons of rod per year, with much of the output destined for use in telecommunications and magnet wire applications. CODELCO-Chile held discussions with representatives of CNNMIC for a possible joint venture to build an $8 million copper cable and wire plant near Beijing.

China's 5-year plan projected copper production at 150,000 tons per year in Jiangxi Province by 1990 and 200,000 tons per year by 1995. Production at Jiangxi's copper mines was 70,000 tons in 1985. The producing mines were in the northeast region of Jiangxi Province and included the Chengmenshan, Dexing, Dongfang, Wushan, Yinshan, and Yongping copper mines near Poyang Hu. This area accounted for nearly one-third of the national production. The Yongping open pit, which started in 1984, was producing 500 tons of concentrates per day. Reserves were estimated to be more than 74 million tons.

A joint Yugoslav-Chinese agreement for exploitation of a copper mine in the Province of Sichuan was reactived. The Yugoslav company, Bor Mining and Metallurgical Works Co., was to construct an open pit mine with a capacity of about 2.5 million tons of ore per year.

China has copper resources at more than 800 sites, including nearly 30 large copper deposits. The ores are mostly low-grade with an average copper content of 0.6% to 1.0% and many with less than 0.5%. There were no extremely large deposits; most have resources of less than 5 million tons and many lie at such depths and in such remote places as to be impractical to develop at present. Skarn copper deposits were China's main potentially commercial copper ores and occur in the middle and lower Changjiang Basin, the eastern section of northeast China, the Yanshan and Nanling mountain areas, and the southwest. Porphyry copper ore types made up about 45% of available resources and associated skarn deposits about 28%.[59]

New refining equipment was installed at the No. 2 refinery of the Tongling Nonferrous Metal Co. The annual capacity at the refinery was to be increased from 30,000 tons to 45,000 tons of copper cathode through the new addition.

China's Tianjin Nonferrous Metals Co. and Noranda were to undertake a feasibility study that could lead to the construction of a 100,000-ton-per-year copper complex at Tianjin in northeastern China by the early 1990's. Noranda would provide technology for a smelter, refinery, acid plant, and oxygen plant. The complex was estimated to cost about $200 million and would process foreign copper concentrates. The study would be funded largely by the Canadian International Development Agency's Industrial Development Div. and would be completed by 1987. Noranda would hold a minority share in the project.

Jiangxi Copper Corp.'s Guixi smelter was completed in December after more than 5 years of construction. The initial production was to be at a rate of about 90,000 tons of copper blister per year and about 340,000 to 360,000 tons of sulfuric acid per year. When fully complete, the smelter's annual capacity was planned for 200,000 tons of copper and 860,000 tons of sulfuric acid per year. Most of the equipment and technology used for the smelter was purchased from Sumitomo of Japan and Outokumpu Oy of Finland.

Colombia.—Nittetsu Mining Co. Ltd. of Japan formed a joint venture with Minas del Cobre Ltda. to develop the El Cobre copper mine in Colombia. Starting in 1986, the mine and infrastructure development would start production for 2 years at a rate of 4,000 tons of copper in concentrate per year. The mine, 80 kilometers southwest of Medellin, had reserves of 1 million tons with an average grade of 4% copper and 3 grams of gold per ton.

Indonesia.—Freeport Indonesia Inc., an 81% owned subsidiary of Freeport-McMoRan Inc., produced copper concentrates from two mines in Irian Jaya. Copper production set a new record high in 1985 at 88,700 tons of copper in concentrates produced. The Ertsberg East Mine accounted for most of it. Copper reserves at yearend 1985 were 846,000 tons in ore, according to the company's annual report, compared with 993,500 tons at the end of 1984. Work continued on evaluation of deep reserves at Ertsberg East.

Japan.—Electrolytic copper production was almost the same as in 1984 while consumption of refined copper was down to about 1.2 million tons during 1985 from the 1984 record high of 1.37 million tons. Communication cable shipments in Japan were 21% below 1984 levels and exports were halved. Electrical power cable shipments increased and were 14% above 1984 levels as a result of increased public housing and power generation investments. Production of copper pipe and tubing was down by about 4.6% in the second half of 1985, compared with the first half, as a result of a drop in exports and a sharp production fall of air conditioners; both were presumed to be the result of the increasing value of the yen. Imports of refined copper cathode were 351,000 tons in 1985, down sharply from 463,000 tons in 1984. The decline was explained in terms of reduced economic expansion and an accompanying fall in demand for finished products.[60] Exports of 51,000 tons of refined copper in 1985, on the other hand, were higher than the rather low figure of 18,400 tons reported for 1984. Alloy ingots and scrap exports were also much higher than in 1984. Although wire rod exports to China were down, exports of cathodes to China in 1985 jumped to 39,102 tons and accounted for 77% of Japan's total cathode exports, compared with only 378 tons in 1984. Imports of concentrates were at an increased level of 812,600 tons contained copper in 1985, compared with 785,000 tons in 1984 when concentrate market tightness forced a cutback on imports.

Nineteen Japanese zinc and copper producers made applications for assistance from the Ministry for International Trade and Industry's (MITI) emergency loan fund in 1985. MITI announced it would lend $12.5 million at an interest rate of 3% to 16 domestic copper and zinc mines in fiscal year 1986-87. The loan arrangement was set up in 1978 to help the mines maintain production while nonferrous metal prices remained low. The changing picture in 1985 was blamed on the strengthening yen against the dollar.

Japanese smelters continued to operate at a reduced output in 1985. Japanese smelters had begun to reduce operating capacity to about 1,348,000 tons of metal per year 2 years ago with the closure of the Hitachi, Ibargi (84,000 tons), and Okayama (7,200 tons), smelters. Mitsui Mining & Smelting Co. Ltd. was to stop smelting at its Hibi, Okayama, smelter (39,600 tons) in 1986 and planned to toll process at the larger Tamano, Okayama, smelter (164,000 tons), which was a joint venture with Mitsui (25%), Nittetsu Mining (20%), and Furukawa Mining Co. Ltd. Godo Shigen Sangyo Co. intended to stop blister copper production at its Miyako, Iwate, smelter at the end of May 1986. Although the smelter had two furnaces with a combined blister capacity of 36,000 tons per year, only one furnace was utilized, producing about 2,000 tons of blister per month for export only. Dowa Mining Co. Ltd. completed the installation of new oxygen blowing facilities at its Kosaka smelter. This will increase capacity to 66,000 tons of blister per year. Nippon Mining decided to shut down the Sagnoseki flash furnace for 6 months. Nippon said that this did not affect electrolytic output during the year because the company was able to process from blister copper stocks. The Saganoseki flash furnace was producing about 19,100 tons of cathode copper per year, about 15% below previous levels.

Furutobe Mining Co. Ltd. expected to close its copper-lead-zinc mine in the Akita Prefecture by the end of January 1986 because of ore reserve exhaustion. In 1985, Furutobe produced 10,000 tons of copper concentrates.

Mexico.—Domestic demand for refined copper was about 118,000 tons in 1985, nearly double that of 1984. Smelter expansions were well under way at Mexicana de Cobre S.A. (44% state-owned) and Cía. Minera de Cananea S.A. (92% state-owned). When completed, the two smelters would raise Mexico's total smelter capacity to about 362,000 tons of blister per year, reducing Mexico's role as a major exporter of concentrates. Mexicana de Cobre was completing a $400 million smelter that would have an annual capacity of about 180,000 tons of blister per year. The company also planned to complete a $250 million concentrator expansion at La Caridad to 150,000 tons per year by early 1986. Cananea, Mexico's leading blister producer, completed its $250 million expansion program to raise concentrate capacity from 40,000 to 150,000 tons of 26% concentrate per year. Cananea's blister capacity was to be increased to 125,000 tons per year by 1986. The company expected to export about 95,000 tons of the added concentrate production per year. About 40% of the concentrates were to be sold to Japan on a long-term basis, with the rest going to the Republic of Korea, Taiwan, China, and Europe, in order of volume. Cananea was also to install a 22,000-ton-per-year SX-EW plant at its mine in 1986, using refining technology from M.I.M. Holdings Ltd. of Australia.

The United States and Mexico negotiated a three-part environmental agreement that included a commitment by both countries to control sulfur emissions from the two Mexican smelters and the Phelps Dodge Douglas smelter in Arizona by January 2, 1988. The Mexican Government pledged to stop uncontrolled emissions from the Cananea and Nacozari smelters. Both smelters were expected to be operational by 1986. Nacozari, alone, was expected to emit about 400,000 tons of sulfur per year. Since the plant is only 55 miles south of the Arizona border, U.S. officials were concerned about the risk of acid rain damage. Plans to bring the two Mexican smelters into environmental compliance by 1988 may be delayed because of repair costs from the destruction from the September earthquakes.

Papua New Guinea.—Bougainville Copper Ltd. plans to alter its copper concentrate marketing plan when sale contracts expire in 1987. Contracts with the Federal Republic of Germany, Japan, and Spain accounted for most of the shipments under contracts initiated in 1972. However, since the mine opened, the company expanded sales to China and the Republic of Korea and was beginning to view the Asia-Pacific region as its prime market. Bougainville Copper produced 175,000 tons of copper in concentrates during 1985, up from 164,500 tons in 1984, according to the company's annual report. The increase was due to an increase in ore milled to 50 million tons from 47 million tons, while the grade remained unchanged at 0.42% copper. A new ball mill came on-stream in late 1985.

In early 1985, the $1,400 million Ok Tedi gold-copper project was the subject of a major dispute between the Government and its foreign partners. The Government was concerned that its partners might abandon the project once the gold-rich cap had been mined, while the partners were not prepared to commit themselves to a firm timetable for developing the copper deposit in view of the depressed market. The Government gave the operating company, Ok Tedi, a formal notice to close down the mine, but after lengthy negotiations, the Government endorsed a revised agreement allowing for variations in the mining plan and transfer of some of the debt from the operating company to the shareholders. Construction of a permanent tailings dam was to be deferred by 4 years, but copper mining was to start 2 years earlier than the initial date. The Government was to restore its stake in Ok Tedi to 20%. Shareholders in Ok Tedi were BHP with 30%; Standard Oil of Indiana (Amoco Minerals), 30%; Metallgesellschaft AG and Degussa AG, each with 7.5%; and the state-owned West German development company, Deutsche Gesellschaft Fuer Wirtschaftliche Zusammenarbeir (Entwicklungsgessellschaft) mbH, 5%. Copper production was scheduled to begin by yearend 1986 at about 30,000 tons of copper in concentrate per year, rising to 60,000 tons per year by mid-1988. A feasibility study completed in 1979 revealed minable ore reserves of 410 million tons, comprised of 351 million tons of porphyry copper ore that averaged 0.7% copper and 0.6 gram of gold per ton at a cutoff of 0.4% copper, and 25 million tons of skarn copper ore averaging 1.17% copper and 1.6 grams of gold per ton. Ok Tedi purchased Anaconda Minerals' Carr Fork, UT, concentrator for $7 million and was expected to have it shipped to Papua New Guinea and have it installed by August 1986 as part of its long-term plan to increase production. By buying secondhand equipment, costs of the copper milling expansion project could be contained to about one-half the cost of new equipment. Ok Tedi was projecting a break-even point of 42 cents per pound for the mine at peak copper output.

Peru.—The mining sector contributed about 50% to Peru's total export revenue in 1985. Copper exports from Peru increased in 1985 reaching a total of 350,800 tons (copper content of ores, blister, and refined copper) compared with 1984 exports of about 290,500 tons.[61]

Almost all large-scale mining operations in Peru were owned and operated by state-owned Empresa Minera del Perú (Minero Perú), Empresa Minera del Centro del Perú (Centromín Perú), and Empresa Minera del Hierro del Perú. Southern Peru Copper Corp. (SPCC), which operated two open pits, Cuajone and Toquepala, and Cía. Minera Pativilca S.A., which operated the Raul deposit, were Peru's largest private copper producers. When the new Peruvian Government took office on July 28, 1985, one of its priorities included the reorganization of state mining companies on a regional basis. According to the Government's plan, Minero Perú in its present form would disappear. Centromín Perú would remain essentially a central Peruvian company, and new companies would run operations in the south and the north. Several projects were to be given priority, including development of the Antamina copper-zinc project, a milling operation of about 3,000 tons per day using surplus equipment from the Cobriza copper mine. A mixed private and Government company would fund the project. A scaled-down version of the Cerro Verde II project would be financed at $40 million. Foreign investment in the Tintaya copper mine was also to be encouraged. Subsidies and financing would be provided to keep small- and medium-sized mines in operation when necessary.

Peru broke off negotiations with Japan's Marubeni Corp. and Mitsui for the $130 million financing package for the Cerro Verde II copper project near Arequipa. Nevertheless, Minero Perú hoped to keep the Cerro Verde Mine going through two smaller projects after production from the oxide ores ceases in late 1986. One plan involved recovering copper from the oxide ores at the Tintaya Mine, which started production in early 1985. The second plan would process the higher grade sulfide ores at Cerro Verde by construction of a smaller concentrator. The scaled-down production plan would require an investment of about $22 million versus $278 million estimated for the original Verde II plan and would use crushing machinery already at the mine. Cerro Verde I copper oxide reserves were expected to be depleted by October 1986. Production was down to 28,000 tons of electrowon copper cathode per year from 33,000 tons per year because of declining oxide reserves.

Financing for an expansion project at Centromín Perú's Cobriza Mine was supported through loans from the Inter-American Development Bank ($63.4 million), Wells Fargo Bank ($55.1 million), Peruvian Government ($37 million), World Bank ($36.4 million), Corporación Financiera Desarrollo (Cofide) ($33.8 million), Centromín Perú ($29.9 million), U.S. Export-Import Bank ($3.1 million), and the Sweden Export Bank ($2.5 million). In 1985, 528 people were employed at Cobriza, 126 at the concentrator, and 402 at the mine. The underground mine and 2,360-ton-per-day concentrator were 160 kilometers from the smelter at La Oroya.

Cía. Minera Condestable S.A., one of Peru's medium-sized mines, increased capacity from 1,100 tons of ore per day to 1,300 tons per day. Condestable handled about 400,000 tons of ore in 1985, producing 18,000 tons of concentrates containing 26% copper, plus gold and silver. The mine reportedly had a production cost level of about 55 cents per pound. A further expansion to 1,600 tons of ore per day was planned for 1986.

SPCC's Cuajone and Toquepala Mines were Peru's most prolific copper producers, recovering a combined total of 272,000 tons of contained copper in 1985, 3,800 tons of molybdenum in concentrate, and 2.8 million ounces of silver in blister copper.[62] Estimated ore reserves at the Cuajone Mine at yearend were 300 million tons averaging 0.88% copper and an average of 0.02% molybdenite. The grade of ore had fallen from 0.92% in 1980 to about 0.89% in 1985, a trend that was likely to continue. To maintain production levels, SPCC expanded concentrator throughput from 41,000 tons per day to 50,000 tons per day by installation of improved monitoring equipment and other efficiency improvements. SPCC's Toquepala Mine had a capacity to produce about 50,000 tons of ore and 45,000 tons of waste, based on a 6-day workweek. As of January 1986, a total of 109 million tons of sulfide ore grading 0.81% copper and 0.023% molybdenite remained in the pit. About 27 million tons of low-grade sulfides were stockpiled for future heap leaching recovery.

Empresa Minera Especial Tintaya S.A., a state-owned company formed by Minero Perú (45%), Centromín Perú (45%), and Cofide (10%), started shipments of copper concentrates from the Tintaya open pit mine in August. The $326 million Tintaya copper project was expected to reach capacity in 1986 of 170,000 tons of 33% copper concentrates per year containing 4 ounces of silver per ton and 0.14 ounce of gold per ton. Based on proven reserves of 34 million tons of ore grading 2.12%, the life of the mine was estimated at 13 years. There was also 8 million tons of 2.75% copper in oxide ore that was to be stockpiled for future recovery. A Tucson, AZ, company was doing metallurgical studies to determine the best method to recover this copper, including the possibility of making copper sulfate and shipping it to Minero Perú's Cerro Verde Mine for conversion to refined copper in its SX-EW plant. Financing was provided by $100 million from the Canadian Export Development Corp. and $115 million from the Bank of Nova Scotia and the Toronto Dominion Bank.

Centromín Perú's La Oroya reverberatory smelter treated combined copper, lead, and zinc concentrates. About 80% of the feed was from Centromín Perú's operations. The total labor force at La Oroya was 5,500. Two reverberatory furnaces and six converters were used for copper. Blister copper was fire-refined to 98% copper anodes containing some gold, silver, and 0.3% lead, which were sent to Centromín Perú's La Oroya electrolytic refinery at Huaymanta. In 1983, the refinery produced about 47,000 tons of refined copper, of which 24,000 tons was marketed as 250-pound wirebars, 21,000 tons as copper rod, and 2,500 tons as cathodes.

Private investors in Peru, Spain, and Venezuela opened a brass mill in Trujillo, northern Peru. The new 5,000-ton-per-year brass operation was named Peru Venezuela España S.A. (Pvesa) and made its first shipment of free-cutting brass rod and forging brass to the United States in early July. Minpeco USA Inc., a subsidiary of the state-owned marketing company Minero Perú Comercial, was the U.S. marketing agency for the mill. About 25% to 30% of the plant's production was to be consumed by Industrious Reunidas S.A., a Lima-based brass fabricator that owned 80% of the Pvesa stock. The primary product was copper brass bar and alloy 260 strip.

Philippines.—The Philippine Government accepted bids for the 100,000-ton-per-year ASEAN Copper Products Inc. copper semifabrication plant in 1985. The project owners, the Association of Southeast Asian Nations (ASEAN), were owned 60% by the Philippine Government and 40% by the Governments of Indonesia, Malaysia, Singapore, and Thailand. The Government also offered the Philippines Associated Smelting and Refining Corp. (PASAR) smelter for privatization during the year. Three Japanese companies already held 30% of the preferred shares. About 44% of its output went to Japan, 19% to Taiwan, and the rest to China, the Republic of Korea, and various traders. Exports of copper concentrates fell from 462,549 tons in 1984 to 376,674 tons in 1985. Copper cathode exports were 136,495 tons in 1985. Mine production fell as a result of the closure of two mines by Atlas Consolidated Mining and Development Corp. However, the Japanese company Marubeni provided $12 million to assist in reopening of the Sipalay Mine in return for 90% of the concentrates. The state-owned Maricalum Mining Corp., which was created out of the bankrupt Marinduque Mining and Industrial Corp. group of companies in July 1985, planned to increase the daily ore milling rate at the Sipalay Mine to 40,000 tons per day by early 1986.

Poland.—Refined copper production amounted to an estimated 387,000 tons in 1985, 70% of which was sold as cathode and 30% as semifabricates (rod). About 180,000 tons of unwrought copper was exported. Principal export destinations were the Federal Republic of Germany, Romania, and the United Kingdom. The Polish copper industry was managed by Kombinat Gorniczo-Hutniczy Miedzi and employed about 43,000 workers. There was a labor shortage in 1985, reportedly because of low pay in the copper mines. About 10% to 20% of future copper industry investment budgets were related to environmental costs and called for emphasis on finished products. About 75% of the concentrates mined were treated in shaft furnaces at Legnica and Glogow with the remainder treated by a modified Outokumpu flash smelter at Glogow II.

Portugal.—A 49% interest in Sociedade Mineira de Neves-Corvo S.A.R.L. (Somincor) of Portugal, which was previously held by Penarroya S.A. and Compagnie Française des Mines S.A. of France, was sold to Rio Tinto Zinc in mid-1985. The other 51% of Somincor was state-owned. The $200 million Neves-Corvo copper project was expected to produce about 65,000 tons of copper in concentrates by yearend 1988 from a 25-million-ton ore body having an average grade of about 3.2% copper. In addition to the main ore body, there were 40 million tons of copper-lead-silver-zinc reserves. In

November, Quimica de Portugal E.P., a state-owned company, invited tenders for design and construction of a 100,000-ton-per-year smelter, refinery, acid plant, and associated infrastructure estimated to cost $300 million.

U.S.S.R.—Based on a detailed study of U.S.S.R. copper mine, smelter, and refinery trends that was completed by the U.S. Bureau of Mines in 1984,[63] capacity and production figures for the Soviet Union were significantly reduced from previous estimates by the Bureau. The growth of the U.S.S.R. copper industry during the past 65 years was analyzed in some detail on a mine-by-mine and plant-by-plant basis and, when compared with the last known published official figures, indicated an overall lower growth in Soviet copper production and capacity than had been previously estimated. The principal geological features of the deposits and an analysis of ore reserves were described by the report as well as historical trends in mining, beneficiation, metallurgy, and supply-demand relationships. Copper production capacity for the U.S.S.R. was estimated to be, in thousand tons of copper content, as follows for 1985: mine, 680; smelter, 980; and refinery, 1,100 tons per year.

Zaire.—La Générale des Carrières et des Mines du Zaire (Gécamines) began a 5-year, $750 million investment program to stabilize copper production through the rehabilitation and modernization of the mining, concentrating, smelting, and refining operations. Of the total, $500 million was to be financed through retained earnings with the remainder financed by multilateral development banks with bilateral cofinancing. The goal was to renew aging plants and to increase the in-country value added through additional refining. Almost one-half of Zaire's production was either blister or standard-grade cathode, both of which required further refining in Europe. The plan called for the construction of a 100,000-ton-per-year copper smelter and refinery complex at Luilu in Kolwesi.

In July, the direct marketing control of all copper and cobalt was taken over by Gécamines Commerciale from the Belgian company SGM-Afrimet. This followed a major corporate restructuring last year involving the formation of Gécamines Holdings to oversee the activities of three separate operating subsidiaries responsible for mining, development, and marketing.

Gécamines was under pressure from the Government to use the state-owned railway, Voie Nationale, in a bid to increase revenues for the railway. The railway was to handle 60% of material shipped in 1986 with only 30% to be sent through South African ports. Gécamines was countering transportation problems between Lubumbashi and the Port of Matadi in early 1985 and turned to increasing shipments via the quicker southern route, with about 43% of Gécamines output exported via the Republic of South Africa and Zambia; about 11% was being sent through the Port of Dar es Salaam in Tanzania.

Zambia.—For the year to March 31, 1985, Zambia Consolidated Copper Mines Ltd. (ZCCM), which was 60.3% Government-owned, reported a pretax profit of $62 million. This was achieved against a background of rising costs, lower copper prices, and continued deterioration of production owing to poor plant and equipment availability. Following this achievement, however, ZCCM incurred a net loss of $15 million in the 9 months to December 1985. In addition to hard currency shortages, ZCCM was also plagued by railroad shipping problems, although new locomotives had been introduced on the Tanzanian Railway. Shortages of spare parts and diesel fuel, coupled with a strike in June by 8,000 workers, resulted in a drop in annual mine production to about 483,000 tons. Some material was imported during the year from Zaire to be smelted and refined in Zambia. Since 1984, ZCCM had been undertaking an export, rehabilitation, and diversification program where the main objective was to enhance corporate viability by improving productivity and efficiency. It was being funded by the World Bank, the EEC, and the African Development Bank, together with funds from ZCCM's own sources. The European Commission announced approval in October of a $23.2 million loan to Zambia. The Italian Government was also to make a grant to help complete ZCCM's rehabilitation program and cover the purchase of equipment for mining and processing. ZCCM was to embark on a recruitment campaign for qualified and experienced specialists both locally and overseas. As of November, about 1,633 expatriates were employed at the mines, or about 2.7% of the work force.

Zambia, started a major reorganization of its copper industry at yearend 1985, which, while initially trimming about 50,000 tons of annual production, was ultimately designed to restore the health of the industry. The 5-year plan, which was to start in January 1986, called for the closure of the Kansanshi (6,000 tons per year) and Chambishi (26,000 tons per year) Mines and the No. 3 shaft at the Konkola Div. (output 20,000 tons for year ending March 1985). The mines were to close as soon as developed ore reserves were exhausted. The mines have been beset by Zambia's acute economic problems. A severe shortage of trucks reduced Kansanshi Mine's effectiveness. In 1985, about 162,000 tons of ore was brought to the surface, but only 77,000 tons was moved from the minesite. As of March 31, 1985, undeveloped reserves at Kansanshi stood at 3.4 million tons grading 2.75% copper, while those at Chambishi totaled 20.9 million tons grading 2.78% copper, and at Konkola, 45.1 million tons grading 3.84% copper. Also included would be the shutdown of the Chambishi concentrator, Luanshya smelter, Ndola copper refinery, and the Nkana oxide concentrator. About 3,000 workers will lose their jobs. The Konkola Div. and Nchanga Div. would be merged, leaving ZCCM with four mining divisions: Luanshya, Nchanga, Nkana, and Mufulira.

The $250 million Stage II Nchanga tailings leach project started treating tailings in mid-December, and at full capacity, which was to occur in August 1986, was expected to recover about 50,000 tons of lower cost copper per year that will help to offset production loss from planned closures. The Kafironda explosives factory in Zambia, the sole supplier of industrial explosives to ZCCM, was to resume full production in early 1986.

Zimbabwe.—The former South African-owned Messina (Transvaal) Development subsidiary, M.T.D. (Mangula) Ltd., which produced about 90% of Zimbabwe's copper, changed its corporate name during the year to Mhangura Copper Mines Ltd. and changed the brand name of its standard copper cathode produced at its refinery to Mhangura from Mangula. This followed the sale of Messina's assets (55% of Mangula and 65% of Lomagundi Smelting and Mining Co.) to the Government-owned Zimbabwe Mining Development Corp. (ZMDC) in September 1984. In addition to the equity in Mangula and Lomagundi, ZMDC also acquired M.T.D. Management Services Ltd., which controlled Bar 20 Mines (Pvt.) Ltd., 85% of Sabi Consolidated Gold Mines, 50% of Jena Mines, and M.T.D. Sanyati (Pvt.) Ltd. Mhangura was to push ahead with development of the Copper Queen and Copper King deposits at Sanyati that had been delayed by former owners because of low copper prices and high electricity costs. Messina already had invested $1 million in developing the Copper Queen deposits when operations were postponed. Ore production at Mhangura's Messina Mine cost $343 per ton of recovered copper in December 1984; at Harper, the cost was $211 per ton, and at Campbell, the cost was $369 per ton of recovered copper. The average production cost for all mines was $257 per ton of recovered copper. The average loss per ton was $134 cumulative through December 1984 for all three mines.

Rio Tinto (Zimbabwe) Ltd.'s Eiffel Flats base metal refinery (56.1% owned by Rio Tinto Zinc) was producing at its targeted operating level of 360 tons of nickel per month and 400 tons of copper per month after it was recommissioned in August. Zimbabwe's two copper refineries, Corsyn Consolidated Mines Ltd.'s Inyati refinery and Mhangura's Alaska refinery, had a combined cathode production capacity of about 25,000 tons per year.

Table 4.—Estimated production costs at producing copper mines

(January 1985 U.S. dollars per pound of refined copper)

Country	Number of mines	Mine operating cost	Mill operating cost	Smelter-refinery cost[1]	(Less) byproduct credit	Net operating cost	Taxes[2]	Cash costs	Recovery of capital	Production cost[2]
Australia	3	$0.19	$0.10	$0.32	$0.07	$0.55	$0.01	$0.56	$0.08	$0.64
Canada	14	.27	.35	.45	.32	.76	.01	.77	.12	.89
Chile	9	.30	.17	.11	.05	.53	.02	.55	.05	.60
India	5	.34	.21	.42	.03	.93	.05	.98	.12	1.10
Peru	6	.19	.20	.32	.05	.65	.02	.67	.14	.81
Philippines	7	.31	.27	.22	.21	.58	.05	.63	.07	.70
South Africa, Republic of	4	.41	.25	.50	.49	.67	--	.67	.13	.80
United States	13	.23	.20	.23	.09	.56	.02	.58	.12	.70
Zaire	7	.39	.19	.25	.41	.42	.08	.50	.07	.57
Zambia	8	.31	.14	.05	.09	.42	.06	.48	.12	.60
Other	34	.25	.27	.29	.30	.51	.05	.56	.10	.66
Total or average	110	.28	.21	.22	.16	.55	.03	.58	.09	.67

[1]Includes cost of transportation.
[2]Taxes and production cost are at a zero percent rate of return.

Source: Bureau of Mines, Minerals Availability System (MAS) cost analysis.

Table 5.—Average ore feed grade and recoverable copper from market economy countries' copper deposits representing nearly 80% of the world reserve base in 1985, by region and country[1]

Region and country	Number of deposits	Producing: Average feed grade[2] (percent)	Producing: Recoverable copper[3] (million metric tons)	Nonproducing: Average feed grade[2] (percent)	Nonproducing: Recoverable copper[3] (million metric tons)	Total: Average feed grade[2] (percent)	Total: Recoverable copper[3] (million metric tons)
North America:							
Canada	35	0.55	9.2	0.47	8.3	0.51	17.6
Mexico	6	.70	15.3	.60	5.2	.67	20.5
United States	62	.65	27.4	.60	30.0	.62	57.4
Total or average	103	.64	51.9	.57	43.5	.61	95.5
Central and South America:							
Argentina	3	--	--	.55	6.6	.55	6.6
Chile	16	1.02	85.3	1.04	26.9	1.03	112.2
Peru	12	.82	10.2	.82	11.1	.82	21.2
Other	5	1.03	1.4	.72	9.3	.75	10.7
Total[4] or average	36	1.00	96.8	.84	53.9	.93	150.7
Europe	12	.58	4.0	W	W	W	5.5
Middle East	10	1.17	4.8	1.88	1.5	1.30	6.3
Asia:							
India	6	1.24	4.6	W	W	W	4.7
Philippines	22	.44	4.0	.50	6.4	.47	10.4
Other	6	1.21	1.9	W	W	W	2.9
Total[4] or average	34	.72	10.5	.47	7.5	.59	18.0
Africa:							
South Africa, Republic of	5	.62	1.7	W	W	W	W
Zaire	8	3.93	17.8	W	W	W	W
Zambia	9	2.31	10.0	W	W	W	W
Other	10	1.62	.8	2.21	.9	1.87	1.7
Total[4] or average	32	2.51	30.3	2.57	4.4	2.51	34.7
Oceania:							
Australia	9	2.82	3.9	1.59	21.7	1.69	25.5
Other	5	.47	6.5	.47	5.9	.47	12.4
Total[4] or average	14	.67	10.5	1.05	27.5	.91	37.9
Grand total[4] or average	241	.91	208.7	.75	139.9	.87	[5]348.6

W Withheld to avoid disclosing company proprietary data; included in "Total or average."
[1]Based on Jan. 1985 resource estimates for 110 producing and 131 idle, developing, or explored deposits in market economy countries. Excludes copper available from byproduct mines. Total world reserve base is estimated at 566 million tons contained copper in ore.
[2]Feed grade to concentrator, averaged over the life of the mine. Does not include leach material.
[3]Includes recoverable copper from leach operations.
[4]Data may not add to totals shown because of independent rounding.
[5]Recoverable total corresponds to 465 million tons contained copper in ore, or 78.8% of the world reserve base for copper.

Source: Bureau of Mines, Minerals Availability System (MAS).

TECHNOLOGY

A copper-tungsten composite substrate for microcircuits, which combined copper's good thermal conductivity and tungsten's low thermal expansion, was developed and marketed by Sumitomo Electric Industries Ltd. The new composite was produced by sintering a mixture of copper and tungsten powder. Beryllium copper was used in similar applications, but presented a problem of toxicity.[64]

Electromagnetic forces that result when eddy currents are induced in a molten metal load were used to contain and shape molten metal during copper alloy casting in place of the conventional chilled metal mold. The development of this technology, undertaken by Olin Corp., was described in a paper highlighting the commercial benefits.[65] This casting technique eliminated the mold-related defects normally encountered in direct chill mold-casting, and provided copper alloy castings with greatly improved hot workability.

Bureau of Mines studies of the flotation behavior of a series of minerals containing varying amounts of copper and iron illustrated that the percentage of iron in the mineral significantly affected both the potential at which the mineral floats and the mechanism by which the collector, ethylxanthate, interacted with the mineral. Current research in froth flotation research was being directed toward gaining a fundamental understanding of sulfide flotation chemistry to improve existing flotation methods, devise new methods, and help in the selection of control parameters for computerized process control of flotation circuits.[66]

Mineral liberation research at the Bureau of Mines was directed toward devising methods for optimizing and predicting liberation of mineral phases during the grinding of complex ores. The cobalt mineral siegenite is closely associated with the copper mineral chalcopyrite in ores of the Missouri Lead Belt. Liberation of the two minerals required to recover a cobalt product and the influence of an organic polymer in ball-mill grinding of copper, dolomite, and quartz ore was the subject of a Bureau of Mines report.[67] The degree of mineral liberation and the particle size distribution of ground products were measured using optical and scanning electron microscopy in conjunction with computerized image analysis techniques.

Heap and dump leaching are among the simplest and least expensive methods for leaching metal values from ores containing copper, gold, silver, or uranium. However, the reactions may be slow and metal recoveries can be low. Bureau of Mines research was being directed toward gaining a fundamental understanding of leaching chemistry, both to improve existing methods and to devise new methods for faster, more complete extraction. Several Bureau papers were published during the year on various aspects of this research.[68]

Magma reached an agreement with M.I.M. Holdings to utilize copper refinery technology developed by the Australian company, known as the "Isa Process," at the new oxide copper plant under construction at the San Manuel copper property. The key feature of the process is the use of permanent stainless steel cathode plates. The process gives substantial energy savings and other operational advantages over the older conventional technology. This would be the first time it was tried in an electrowinning process, however. Magma was also instituting its own patented process to retain tankhouse fumes during the refining process.

An in situ bioleach pilot operation to recover copper from an abandoned underground mine in northern Italy was started up at the beginning of the year by the University of Cagliari, with funding from the Italian National Research Council and the Ministry of Public Education. Indigenous bacteria in acidic mine waters were being used to leach copper from the mixed pyrite-chalcopyrite ore, then the copper was recovered from solution by conventional cementation. Copper production from the ore containing 1% to 2% copper was about 3 kilograms per hour. Filamentous fungi were also being used to recover copper in work done in the United Kingdom. *Penicillium spinulosum, Aspergillus niger,* and *Trichoderma viride* were being used to remove copper and gold from aqueous effluents.[69] Research was being done at Michigan Technical Institute on the use of the bacteria *Thiobacillus ferrooxidans* in extracting copper from the White Pine copper ores.[70]

Direct smelting of partially roasted copper concentrates to blister copper by using residual sulfide as a reductant was reviewed.[71] Roasting and smelting chemistries were discussed in light of experimental results and commercial process control requirements. Until now, significant copper losses to the slag, as well as intolerably high antimony, arsenic, and bismuth impurity levels in the copper, have impeded the progress of direct smelting. Effective solutions to these problems were outlined that could result in elimination of the converter vessel from the process.

A new continuous process for conversion of copper mattes to blister copper was successfully pilot-tested and was ready for commercial application. The process, known as "Kennecott-Outokumpu Flash Converting," involved reaction of solidified matte particles with industrial-grade oxygen in a flash furnace to produce blister copper and a small quantity of slag that could be recycled to the primary smelting furnace. Reduced smelter capital and operating costs were major benefits of the process.[72]

The economics of the Oxygen Sprinkle Smelting (OSS) process were examined, and its capital and operating costs were compared with the Outokumpu and Inco processes for the retrofitting of conventional reverberatory smelters to modern oxygen flash smelting. The current economic return on investment makes it difficult to justify building new greenfield smelters. On the other hand, it was reported that much can be gained by modernizing existing plants such as retrofitting conventional reverberatory/Peirce-Smith converter-type smelters. Benefits, such as increased throughput, lower energy consumption, higher metal recovery, and a viable means for environmental control were said to be realized with less capital outlay.[73]

The simultaneous recovery of various metals from complex sulfide ores accomplished in a single smelting process was being developed at the University of Birmingham, England, and supported by five multinational companies through the Mineral Industry Research Organization and the British Technology Group of London.[74] The technique promised to be an economical way to deal with ores that are difficult and expensive to process by conventional methods. A 5-ton-per-day demonstration unit was expected to start in 1986. In the process, a bulk concentrate was prepared and fed into a two-stage smelter. The concentrates were melted under nonoxidizing conditions in the first furnace. At slightly higher temperatures, oxygen was added in the second furnace to react with sulfur in the matte, forming sulfur dioxide and freeing the metals. Most of the copper settled to the bottom where at this point it was removed. Unreacted matte was recirculated in a continuous closed loop from the second hearth to the first.

EPA research indicated a less costly approach for sulfur removal from stack gases. The method, dubbed "E-SOx," was said to be 20% cheaper than current methods per ton of sulfur removed.[75] Developed by EPA's Air and Energy Engineering Research Laboratory, E-SOx substitutes multistage electrostatic precipitators (ESP) for single-stage units in retrofits. ESP's take up about one-third less space and the reclaimed space can then be used for scrubbing or spray-drying operations to remove sulfur from the flue gas, eliminating the need for a separate processing unit.

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Table 6.—Percentage of copper ore and recoverable copper extracted from open pit and underground mines in the United States

Year	Open pit		Underground	
	Ore	Copper[1]	Ore	Copper[2]
1981	89	84	11	16
1982	88	82	12	18
1983	89	85	11	15
1984	92	87	8	13
1985	88	89	12	11

[1]Includes copper from dump leaching.
[2]Includes copper from in-place leaching and copper recovered from tailings and as a byproduct from other sources.

Table 7.—Mine production of recoverable copper in the United States, by month and by State

(Metric tons)

	1981	1982	1983	1984[r]	1985
Month:					
January	123,244	113,150	90,025	92,971	92,699
February	117,620	108,134	77,664	87,863	87,089
March	127,559	120,578	89,274	96,124	100,170
April	127,251	112,662	84,646	91,250	93,641
May	130,953	97,628	92,170	95,045	96,834
June	127,188	90,614	89,717	98,000	90,225
July	123,726	85,179	76,323	88,235	90,711
August	136,221	81,574	79,211	89,032	87,446
September	134,731	78,585	86,704	88,074	81,898
October	140,771	87,071	89,608	94,382	94,222
November	134,944	90,285	93,706	92,507	91,870
December	113,952	81,515	89,050	89,130	98,953
Total	1,538,160	1,146,975	1,038,098	1,102,613	1,105,758
State:					
Alaska	--	W	W	--	--
Arizona	1,040,813	769,521	678,216	746,453	796,556
California	W	W	W	W	W
Colorado	W	575	W	W	W
Idaho	4,245	3,074	3,556	3,701	3,551
Illinois	--	--	--	--	W
Michigan	W	W	--	--	W
Missouri	8,411	7,941	7,725	5,818	13,410
Montana	62,485	64,951	33,337	W	15,092

See footnotes at end of table.

Table 7.—Mine production of recoverable copper in the United States, by month and by State —Continued

(Metric tons)

	1981	1982	1983	1984[r]	1985
State —Continued					
Nevada	W	W	W	W	W
New Mexico	154,114	W	W	W	W
Oregon	W	--	W	--	--
South Carolina	W	--	--	--	--
Tennessee	W	W	W	W	W
Utah	211,276	189,090	169,751	W	W
Washington	W	W	--	--	--
Total	1,538,160	1,146,975	1,038,098	1,102,613	1,105,758

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 8.—Twenty-five leading copper-producing mines in the United States in 1985, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Morenci	Greenlee, AZ	Phelps Dodge Corp	Copper-molybdenum ore, concentrated and leached.
2	Tyrone	Grant, NM	Phelps Dodge Corp. and Burro Chief Copper Co.	Copper ore, concentrated and leached.
3	Chino	do	Chino Mines Co	Copper-molybdenum ore, concentrated and leached.
4	Sierrita	Pima, AZ	Duval Corp	Copper molybdenum ore, concentrated.
5	San Manuel	Pinal, AZ	Magma Copper Co	Copper-molybdenum ore and retreated slag, concentrated.
6	Ray	do	Kennecott	Copper ore, concentrated and leached.
7	Bagdad	Yavapai, AZ	Cyprus Bagdad Copper Co	Copper-molybdenum ore, concentrated and leached.
8	Pinto Valley	Gila, AZ	Pinto Valley Copper Corp	Do.
9	Inspiration	do	Inspiration Consolidated Copper Co.	Do.
10	Eisenhower	Pima, AZ	ASARCO Incorporated	Copper ore, concentrated.
11	Bingham Canyon	Salt Lake, UT	Kennecott	Copper-molybdenum ore, concentrated and leached.
12	Troy	Lincoln, MT	ASARCO Incorporated	Silver-copper ore, concentrated.
13	Twin Buttes	Pima, AZ	Anamax Mining Co	Copper ore, leached.
14	Copperhill	Polk, TN	Tennessee Chemical Co	Copper-zinc-iron sulfide ore, concentrated.
15	Lakeshore	Pinal, AZ	Noranda Lakeshore Mines Inc	Copper ore, leached.
16	Casteel	Iron, MO	St. Joe Minerals Corp	Lead-copper ore, concentrated.
17	San Xavier	Pima, AZ	ASARCO Incorporated	Copper ore, concentrated.
18	Esperanza	do	Duval Corp	Copper ore, leached.
19	Silver Bell	do	ASARCO Incorporated	Do.
20	Miami	Gila, AZ	Pinto Valley Copper Corp	Do.
21	Mission	Pima, AZ	ASARCO Incorporated	Copper ore, concentrated.
22	Battle Mountain	Lander, NV	Battle Mountain Gold Co	Copper ore, leached.
23	Johnson	Cochise, AZ	Cyprus Johnson Copper Co	Do.
24	Buick	Iron, MO	AMAX Lead Co. of Missouri	Lead-zinc ore, concentrated.
25	Copper Queen	Cochise, AZ	Phelps Dodge Corp	Copper ore, leached.

Table 9.—Mine production of copper-bearing ores and recoverable copper content of ores produced in the United States, by source and treatment process

(Metric tons)

Source and treatment process	1981		1982		1983		1984		1985	
	Gross weight	Recoverable copper	Gross weight	Recoverable copper	Gross weight	Recoverable copper	Gross weight	Recoverable copper	Gross weight	Recoverable copper
Mined copper ore:										
Concentrated[1]	263,144,000	1,275,999	174,537,000	883,153	171,776,000	810,090	168,226,000	883,338	160,258,000	906,438
Leached[2]	14,372,000	[3]131,400	7,289,000	123,848	6,154,000	104,991	3,588,000	106,597	1,952,000	98,453
Total	277,516,000	1,407,399	181,826,000	1,007,001	177,930,000	915,081	171,814,000	[r]989,935	162,210,000	1,004,891
Copper precipitates shipped; leached from tailings, dump, and in-place material	170,604	113,991	147,701	104,791	130,857	89,274	120,437	80,845	118,096	82,948
Miscellaneous:										
Silver ore	1,713,000	6,258	3,652,000	20,616	4,483,000	19,384	4,487,000	22,334	1,041,000	3,745
Lead ore	7,729,000	8,411	8,531,000	7,941	7,303,000	7,725	4,748,000	5,818	6,433,000	13,410
Other copper-bearing ores[4]	3,946,000	2,101	6,535,000	6,626	9,970,000	6,634	22,821,000	3,681	8,898,000	764
Grand total	XX	1,538,160	XX	1,146,975	XX	1,038,098	XX	[r]1,102,613	XX	1,105,758

[r]Revised. XX Not applicable.
[1]Includes the following methods of concentration: dual process (concentration followed by leaching), leach-precipitation-flotation, and froth flotation.
[2]At least 85% of leached ore processed by electrowinning.
[3]Includes some copper electrowon from in-place leaching.
[4]Includes gold ore, gold-silver ore, lead-zinc ore, molybdenum ore, tungsten ore, flux ores, cleanup, and tailings.

Table 10.—Recoverable copper, gold, and silver content of concentrated copper ore in 1985

State	Ore concentrated (thousand metric tons)	Recoverable metal content: Copper, Metric tons	Copper, Percent	Gold (troy ounces)	Silver (troy ounces)	Value of gold and silver per metric ton of ore
Arizona	124,889	678,937	0.54	46,056	4,382,491	$0.33
Michigan	W	W	W	--	W	W
Montana	2,579	14,936	.57	W	3,565,927	W
New Mexico	W	W	W	W	W	W
Tennessee	W	W	W	--	W	W
Utah	W	W	W	W	W	W
Total or average	160,258	906,438	.56	74,633	9,658,981	.51

W Withheld to avoid disclosing company proprietary data; included in "Total or average."

Table 11.—Blister and anode copper produced in the United States, by source of material

(Metric tons)

Source	1981	1982	1983	1984[r]	1985
Ores and concentrates:					
Domestic	1,294,962	940,547	888,130	989,924	941,575
Foreign	21,794	35,148	39,609	24,200	1,882
Secondary materials[1]	60,882	45,105	59,276	169,296	249,890
Total	1,377,638	1,020,800	987,015	1,183,420	1,193,347

[r]Revised.
[1]Production from secondary sources prior to 1984 excludes data for those plants that were not associated with refineries processing primary materials.

Table 12.—Primary and secondary copper produced by refineries and electrowinning plants in the United States

(Metric tons)

	1981	1982	1983	1984[r]	1985
PRIMARY					
Electrolytic	[r]1,297,353	[r]1,039,772	[r]959,801	978,999	[1]947,559
Electrowon	161,083	131,858	[r]126,659	127,286	109,606
Fire-refined	[r]85,581	[r]55,148	[r]95,630	58,315	W
Total	1,544,017	1,226,778	1,182,090	1,164,600	1,057,165
SECONDARY					
Electrolytic	[2]303,338	[2]268,952	[r] [2]224,761	186,712	264,834
Fire-refined	[3]179,499	[3]198,597	[3]176,907	138,237	114,347
Total	[r]482,837	[r]467,549	[r]401,668	324,949	379,181
Grand total	[r]2,026,854	[r]1,694,327	[r]1,583,758	1,489,549	1,436,346
Primary domestic materials[4]	[r]1,419,189	[r]1,050,445	[r]1,028,423	1,089,584	1,003,636
Primary foreign materials[4]	[r]124,828	[r]176,333	[r]153,667	75,016	53,529
Secondary materials	[r]482,837	[r]467,549	[r]401,668	324,949	379,181
Total	[r]2,026,854	[r]1,694,327	[r]1,583,758	1,489,549	1,436,346

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Electrolytic."
[1]Includes fire-refined copper amounting to less than 2% of total primary production.
[2]Includes some copper fire-refined at plants processing primary materials.
[3]Includes some copper electrolytically refined at plants processing secondary materials only.
[4]The separation of refined copper into metal of domestic and foreign origins can only be approximated at this stage of processing.

Table 13.—Copper cast in forms at refineries in the United States

(Thousand metric tons)

	1984[r]	1985
Billets	94	94
Cakes	15	7
Cathodes	1,276	1,280
Ingots and ingot bars	52	--
Wirebars	38	50
Other forms	15	5
Total	1,490	1,436

[r]Revised.

Table 14.—Production, shipments, and stocks of copper sulfate in the United States

(Metric tons)

Year	Production		Shipments[1]	Stocks, Dec. 31
	Quantity	Copper content		
1981	35,636	9,413	36,103	5,269
1982	32,227	8,385	33,355	4,142
1983	37,500	9,789	36,614	5,029
1984[r]	34,859	8,862	37,006	3,564
1985	32,740	8,265	31,952	4,353

[r]Revised.
[1]Includes consumption by producing companies.

Table 15.—Byproduct sulfuric acid[1] (100% basis) produced in the United States

(Metric tons)

Plant type	1981	1982	1983	1984	1985
Copper[2]	2,593,762	1,879,983	1,837,827	2,251,312	2,230,257
Lead[3]	405,974	310,606	319,137	248,474	267,159
Zinc[4]	545,890	341,728	384,529	442,517	430,946
Total	3,545,626	2,532,317	2,541,493	2,942,303	2,928,362

[1]Includes acid from foreign materials.
[2]Excludes acid made from pyrite concentrates.
[3]Includes acid processed at molybdenum plants to avoid disclosing company proprietary data.
[4]Excludes acid made from native sulfur.

Table 16.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1981	1982	1983	1984	1985
KIND OF SCRAP					
New scrap:					
Copper-base	r793,115	649,406	611,890	r637,201	633,924
Aluminum-base	22,281	20,192	21,926	21,919	13,330
Nickel-base	162	122	254	68	321
Zinc-base	34	20	31	31	35
Total	r815,592	669,740	634,101	r659,219	647,610
Old scrap:					
Copper-base	r576,497	501,576	431,243	r443,585	486,500
Aluminum-base	15,043	16,047	18,015	16,929	15,459
Nickel-base	123	76	158	102	676
Zinc-base	142	27	62	79	60
Total	r591,805	517,726	449,478	r460,695	502,695
Grand total	r1,407,397	1,187,466	1,083,579	r1,119,914	1,150,305
FORM OF RECOVERY					
As unalloyed copper:					
At electrolytic plants	r303,338	268,952	224,761	r186,712	264,834
At other plants	200,465	212,613	194,093	r151,477	124,488
Total	r503,803	481,565	418,854	r338,189	389,322
In brass and bronze	850,546	660,152	625,349	r735,154	724,273
In alloy iron and steel	1,876	1,492	1,434	r1,705	1,336
In aluminum alloys	47,728	41,930	36,704	r43,511	33,398
In other alloys	217	77	162	r307	1,118
In chemical compounds	3,227	2,250	1,076	1,048	858
Total	903,594	705,901	664,725	r781,725	760,983
Grand total	r1,407,397	1,187,466	1,083,579	r1,119,914	1,150,305

rRevised.

Table 17.—Copper recovered as refined copper and in alloys and other forms from copper-base scrap processed in the United States, by type of operation

(Metric tons)

Type of operation	From new scrap		From old scrap		Total	
	1984r	1985	1984	1985	1984r	1985
Ingot makers and secondary smelters	72,910	65,823	r258,583	248,948	331,493	314,771
Electrolytic-refiners	30,276	75,979	r130,926	188,855	161,202	264,834
Brass mills	513,801	477,517	15,790	16,121	529,591	493,638
Foundries and manufacturers	19,867	13,750	r37,585	32,573	57,452	46,323
Chemical plants	347	855	r701	3	1,048	858
Total	637,201	633,924	r443,585	486,500	1,080,786	1,120,424

rRevised.

Table 18.—Production of secondary copper and copper-alloy products in the United States, by item produced from scrap

(Metric tons)

Item produced from scrap	1984[r]	1985
UNALLOYED COPPER PRODUCTS		
Electrolytically refined copper	186,712	264,834
Fire-refined copper	138,237	114,347
Copper powder	12,783	9,776
Copper castings	457	365
Total	338,189	389,322
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronzes	16,075	17,907
Leaded red brass and semired brass	116,569	106,877
High-leaded tin bronze	12,716	8,335
Yellow brass	11,004	8,575
Manganese bronze	8,062	8,069
Aluminum bronze	8,331	7,523
Nickel silver	3,514	2,931
Silicon bronze and brass	4,526	4,276
Copper-base hardeners and master alloys	15,931	13,274
Miscellaneous	313	2,898
Total	197,041	180,665
Brass-mill products	666,640	562,324
Brass and bronze castings	41,977	31,332
Brass powder	879	396
Copper in chemical products	1,048	858
Grand total	1,245,774	1,164,897

[r]Revised.

Table 19.—Composition of secondary copper-alloy production in the United States

(Metric tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze ingot production:[1]							
1984[r]	156,476	7,560	12,294	20,456	236	19	197,041
1985	148,204	6,585	9,997	15,681	183	15	180,665
Secondary metal content of brass mill products:							
1984[r]	531,765	456	3,733	127,847	2,823	16	666,640
1985	454,853	220	2,712	102,580	1,944	15	562,324
Secondary metal content of brass and bronze castings:							
1984[r]	34,541	1,115	2,181	4,069	16	55	41,977
1985	26,408	784	1,448	2,614	22	56	31,332

[r]Revised.
[1]About 94% from scrap and 6% from other than scrap in 1984 (revised) and in 1985.

Table 20.—Stocks and consumption of purchased copper scrap in the United States in 1985, by class of consumer and type of scrap

(Metric tons, gross weight)

Class of consumer and type of scrap	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
SECONDARY SMELTERS-REFINERS						
No. 1 wire and heavy	6,597	134,853	31,307	97,670	128,977	12,473
No. 2 wire, mixed heavy and light	14,897	223,999	41,615	167,025	208,640	30,256
Composition or soft red brass	2,797	42,208	8,517	33,989	42,506	2,499
Railroad-car boxes	253	1,123	--	1,249	1,249	127
Yellow brass	5,810	58,835	30,889	29,369	60,258	4,387
Cartridge cases	12	245	--	237	237	20
Automobile radiators (unsweated)	4,396	72,248	2,606	70,959	73,565	3,079
Bronze	1,745	15,620	2,418	13,405	15,823	1,542
Nickel silver and cupronickel	796	1,701	707	1,375	2,082	415
Low brass	640	1,734	571	828	1,399	975
Aluminum bronze	94	168	94	65	159	103
Refinery brass	14,660	86,568	25,080	64,819	89,899	11,329
Low-grade scrap and residues	21,001	108,184	75,896	35,344	111,240	17,945
Total	73,698	747,486	219,700	516,334	736,034	85,150
BRASS MILLS[1]						
No. 1 wire and heavy	8,508	193,265	180,439	12,826	193,265	9,124
No. 2 wire, mixed heavy and light	3,591	65,311	63,971	1,340	65,311	1,047
Yellow brass	18,730	265,820	263,678	2,142	265,820	10,849
Cartridge cases and brass	9,802	66,984	66,338	646	66,984	7,184
Bronze	1,248	3,517	3,517	--	3,517	2,277
Nickel silver and cupronickel	4,214	13,565	13,254	311	13,565	4,155
Low brass	2,813	12,524	12,431	93	12,524	1,945
Aluminum bronze	--	37	37	--	37	--
Total	48,906	621,023	603,665	17,358	621,023	36,581
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy	1,935	25,984	6,582	19,263	25,845	2,074
No. 2 wire, mixed heavy and light	608	3,820	1,143	2,953	4,096	332
Composition or soft red brass	406	8,939	4,715	4,202	8,917	428
Railroad-car boxes	1,507	2,502	--	3,524	3,524	485
Yellow brass	595	5,965	4,044	2,021	6,065	495
Automobile radiators (unsweated)	933	3,689	56	3,609	3,665	957
Bronze	851	636	207	447	654	833
Nickel silver and cupronickel	27	162	67	105	172	17
Low brass	50	995	666	342	1,008	37
Aluminum bronze	103	707	11	762	773	37
Low-grade scrap and residues	--	3	--	3	3	--
Total[2]	7,015	53,402	17,491	37,231	54,722	5,695
GRAND TOTAL						
No. 1 wire and heavy	17,040	354,102	218,328	129,759	348,087	23,671
No. 2 wire, mixed heavy and light	19,096	293,130	106,729	171,318	278,047	31,635
Composition or soft red brass	3,203	51,147	13,232	38,191	51,423	2,927
Railroad-car boxes	1,760	3,625	--	4,773	4,773	612
Yellow brass	25,135	330,620	298,611	33,532	332,143	15,731
Cartridge cases	9,814	67,229	66,338	883	67,221	7,204
Automobile radiators (unsweated)	5,329	75,937	2,662	74,568	77,230	4,036
Bronze	3,844	19,773	6,142	13,852	19,994	4,652
Nickel silver and cupronickel	5,037	15,428	14,028	1,791	15,819	4,587
Low brass	3,503	15,253	13,668	1,263	14,931	2,957
Aluminum bronze	197	912	142	827	969	140
Low-grade scrap and residues[3]	35,661	194,755	100,976	100,166	201,142	29,274
Total	129,619	1,421,911	840,856	570,923	1,411,779	127,426

[1]Brass-mill stocks include home scrap; purchased scrap consumption is assumed equal to receipts, so lines in "BRASS MILLS" and "GRAND TOTAL" sections do not balance.
[2]Of the totals shown, chemical plants reported the following: unalloyed copper scrap, 891 tons new and 3 tons old.
[3]Includes refinery brass.

Table 21.—Consumption of copper and brass materials in the United States, by item

(Metric tons)

Item	Brass mills	Wire rod mills	Foundries, chemical plants, miscellaneous users	Secondary smelters-refiners	Total
1984:					
Copper scrap	675,472	--	r69,484	r758,107	r1,503,063
Refined copper[r] [1]	576,160	1,504,694	34,981	6,897	2,122,732
Brass ingot	16,553	--	r135,364	--	r151,917
Slab zinc[r]	116,392	--	3,689	5,268	125,349
Miscellaneous	--	--	--	r3,365	r3,365
1985:					
Copper scrap	621,023	--	54,722	736,034	1,411,779
Refined copper[1]	485,343	1,378,586	36,406	5,299	1,905,634
Brass ingot	13,289	--	131,186	--	144,475
Slab zinc	69,052	--	4,693	4,175	77,920
Miscellaneous	--	--	--	6,090	6,090

[r]Revised.
[1]Detailed information on consumption of refined copper can be found in table 24.

Table 22.—Apparent consumption of copper in the United States

(Metric tons)

Period	Refined copper production	Total old scrap	Net refined imports	Stock change during period	Apparent consumption
1981	1,544,017	r591,805	306,228	171,000	r2,271,050
1982	1,226,778	517,726	227,881	211,000	r1,761,385
1983	1,182,090	449,478	378,171	-4,000	r2,013,739
1984	r1,164,600	r460,695	353,285	-128,000	r2,106,580
1985:					
January	96,071	38,936	40,288	-35,000	210,295
February	82,603	41,006	15,824	-52,000	191,433
March	94,878	50,093	23,719	-24,000	192,690
April	95,411	43,882	19,383	-39,000	197,676
May	101,555	46,112	16,944	-48,000	212,611
June	77,170	43,979	38,856	-1,000	161,005
July	90,880	38,964	22,627	12,000	140,471
August	84,716	38,270	20,039	-12,000	155,025
September	81,873	45,146	32,793	-10,000	169,812
October	84,901	40,367	18,509	-25,000	168,777
November	79,490	39,132	42,224	-14,000	174,846
December	87,617	36,808	48,582	-5,000	178,007
Total	1,057,165	502,695	339,788	-253,000	2,152,648

[r]Revised.

Table 23.—Foundries and miscellaneous manufacturers consumption of brass ingot and refined copper and copper scrap in the United States, by geographic division and State

(Metric tons)

Geographic division and State	Tin bronzes	Leaded red brass and semi-red brass	Yellow brass	Man-ganese bronze	Hardeners and master alloys	Nickel silver	Alumi-num bronze	Total brass ingot	Refined copper con-sumed	Copper scrap con-sumed
1981	28,885	94,142	19,659	6,270	4,411	2,030	6,853	162,250	33,533	73,038
1982	24,577	75,402	12,584	5,220	2,499	1,619	5,038	126,939	r28,812	r57,992
1983	r24,448	r80,741	r11,155	5,423	r2,511	r1,612	5,675	r131,565	r30,050	r60,366
1984	r24,660	r89,341	r6,143	r4,907	2,430	1,457	r6,426	r135,364	r34,424	r68,386
1985:										
New England:										
Connecticut	392	1,187	543	79			272	2,550	53	160
Maine, New Hampshire, Rhode Island, Vermont	110	1,889	122	108	11	381				
Massachusetts	339	1,940	14	172			58	5,067	836	445
Total	841	5,016	679	359	11	381	330	7,617	889	605
Middle Atlantic:										
New Jersey	374	778	39	64			109	1,370		
New York	470	6,160	207	500	185	205	59	7,461	929	5,106
Pennsylvania	4,424	5,982	399	418			1,097	12,639	3,866	5,061
Total	5,268	12,920	645	982	185	205	1,265	21,470	4,795	10,167
East North Central:										
Illinois		6,377	16	457			1,292	9,263	1,288	
Indiana	2,512	11,083	329	150	1,221	519	28	13,153	482	8,334
Michigan		5,887	153	978			556	9,141	7,832	4,228
Ohio		7,419	116	343			335	14,773		7,458
Wisconsin	5,347	7,890	1,957	396	2,181	112	74	11,398	6,591	3,147
Total	7,859	38,656	2,571	2,324	3,402	631	2,285	57,728	16,193	23,167
West North Central:										
Iowa, Kansas, Minnesota	148	4,020	76	307			173	4,776		
Missouri, Nebraska, South Dakota	32	1,397	213	135	61	5	451	2,242	2,044	2,737
Total	180	5,417	289	442	61	5	624	7,018	2,044	2,737

South Atlantic:										
Delaware, District of Columbia, Florida, Georgia, Maryland	238	353	346	45	1	308	32	966	1,710	4,785
North Carolina, South Carolina, Virginia, West Virginia	86	8,784		74			215	9,516		
Total	324	9,137	346	119	1	308	247	10,482	1,710	4,785
East South Central:										
Alabama, Kentucky, Mississippi, Tennessee	1,310	3,446	1	375				5,495		3,953
West South Central:										
Arkansas, Louisiana, Oklahoma, Texas	2,659	6,004	155	78	149	121	1,051	9,839	9,242	270
Mountain:										
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	262	493	119	6			18	913		272
Total	4,231	9,943	275	459	149	121	1,069	16,247	9,242	4,495
Pacific:										
California	1,279	6,797	903	524	59	22	929	9,490	795	7,076
Oregon and Washington	54	57						1,134		795
Total	1,333	6,854	903	524	59	22	929	10,624	795	7,871
Grand total	20,036	87,943	5,708	5,209	3,868	1,673	6,749	131,186	35,668	53,827

[r]Revised.

Table 24.—Refined copper consumed in the United States, by class of consumer

(Metric tons)

Class of consumer	Cathodes	Wirebars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1984:							
Wire rod mills	r1,447,925	56,246	W	W	--	523	r1,504,694
Brass mills	r261,622	13,268	58,480	127,448	115,191	151	r576,160
Chemical plants	W	--	--	--	--	r557	r557
Ingot makers	2,657	--	4,240	--	--	([1])	r6,897
Foundries	762	2,548	8,456	--	3,314	938	16,018
Miscellaneous[2]	r8,917	W	r3,218	r195	W	r6,076	r18,406
Total	r1,721,883	72,062	r74,394	r127,643	118,505	r8,245	r2,122,732
1985:							
Wire rod mills	1,322,216	55,706	W	W	--	664	1,378,586
Brass mills	197,228	13,723	43,346	114,360	116,628	58	485,343
Chemical plants	W	--	--	--	--	738	738
Ingot makers	1,054	--	4,243	--	--	2	5,299
Foundries	969	904	9,048	--	3,298	226	14,445
Miscellaneous[2]	10,920	W	3,217	1,412	W	5,674	21,223
Total	1,532,387	70,333	59,854	115,772	119,926	7,362	1,905,634

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Revised to zero.
[2]Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and other manufacturers.

Table 25.—Stocks of copper in the United States, December 31

(Thousand metric tons)

Period	Blister and materials in process of refining[1]	Refined copper					
		Electrolytic refiners	Wire rod mills	Brass mills	Other[2]	New York Commodity Exchange	Total
1981	277	151	109	26	r29	170	r485
1982	233	268	125	25	r29	249	r696
1983	174	154	116	26	r25	371	r692
1984	r245	r125	r134	27	r27	251	r564
1985:							
January	240	122	124	22	27	234	529
February	225	94	114	24	27	218	477
March	230	80	119	22	27	205	453
April	222	70	102	20	27	195	414
May	172	70	65	22	27	182	366
June	171	80	68	21	27	169	365
July	168	94	82	22	27	152	377
August	121	95	83	19	27	141	365
September	150	84	83	27	27	134	355
October	140	62	100	17	27	124	330
November	142	62	94	19	27	114	316
December	146	66	94	20	22	109	311

rRevised.
[1]Includes copper in transit from smelters in the United States to refineries therein.
[2]Includes secondary smelters, chemical plants, foundries, and miscellaneous plants; includes 20,000 tons in the National Defense Stockpile.

Table 26.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York, by type

(Cents per pound)

Year and month	Scrap: No. 2 heavy copper	Scrap: No. 1 composition (red brass)	Ingot: No. 115 brass (85-5-5-5)	Ingot: Yellow brass (405)
1984:				
January	41.17	42.83	84.00	69.75
February	40.60	42.60	85.25	71.93
March	43.59	45.05	87.36	74.61
April	44.50	45.50	88.50	75.75
May	43.30	45.50	87.23	74.48
June	42.21	44.60	86.50	73.75
July	39.36	42.50	86.50	73.75
August	38.50	42.50	86.50	73.75
September	38.08	42.08	86.50	73.75
October	36.20	41.07	86.50	73.75
November	34.50	40.50	84.50	71.75
December	35.67	40.50	81.58	69.81
Average	39.81	42.94	85.91	73.07
1985:				
January	37.50	40.50	81.50	70.75
February	37.50	40.50	81.50	70.75
March	37.50	40.50	81.50	70.75
April	37.50	40.50	81.50	70.75
May	37.50	39.50	81.50	70.75
June	37.50	39.50	81.50	70.75
July	37.50	39.50	81.50	70.75
August	37.50	39.50	81.50	70.75
September	37.50	39.50	81.50	70.75
October	37.50	39.50	81.50	70.75
November	37.50	39.50	81.50	70.75
December	37.50	39.50	81.50	70.75
Average	37.50	39.83	81.50	70.75

Source: American Metal Market.

Table 27.—Average monthly prices for electrolytic copper in the United States and on the London Metal Exchange

(Cents per pound)

Month	1984					1985				
	U.S. producers delivered price		COMEX first position	LME cash price[r 1]		U.S. producers delivered price		COMEX first position	LME cash price[1]	
	Cathode[2]	Wirebar[3]		Cathode	High grade[4]	Cathode[2]	Wirebar[3]		Cathode	High grade[4]
January	66.10	68.79	62.30	61.65	62.38	64.49	64.49	59.15	61.19	61.63
February	68.35	70.75	64.22	64.09	64.84	66.45	66.45	60.57	62.79	62.96
March	72.71	75.31	67.91	67.79	68.07	65.55	65.55	60.09	62.91	63.02
April	74.67	77.39	68.46	69.36	69.50	70.32	70.32	63.62	67.11	68.08
May	69.55	72.23	63.40	64.49	64.43	69.86	69.86	62.95	67.67	69.38
June	67.29	69.85	61.04	62.10	61.91	67.09	67.09	60.15	64.31	64.95
July	64.40	64.40	58.60	60.64	60.35	66.77	66.77	60.78	64.73	66.86
August	64.54	64.54	59.35	61.14	60.65	66.35	66.35	60.19	62.40	64.39
September	63.41	63.41	57.06	58.94	58.66	65.72	65.72	59.57	60.74	61.96
October	62.04	62.04	56.34	57.87	57.73	66.68	66.68	60.97	61.57	62.79
November	65.65	65.65	59.63	61.43	60.99	66.29	66.29	60.64	60.70	62.10
December	63.54	63.54	57.54	60.30	59.91	68.03	68.03	63.18	62.13	63.07
Average	66.85	68.16	61.32	62.48	62.45	66.97	66.97	60.99	63.19	64.27

[r]Revised.
[1]Based on average monthly rates of exchange.
[2]Listed as "U.S. producer cathode."
[3]Listed as "U.S. producer delivered."
[4]Includes both cathode and wirebar.

Source: Metals Week.

Table 28.—U.S. exports of copper, by country

Country	Ore and concentrate (copper content)		Ashes and residues[1] (copper content)		Refined		Scrap		Blister and precipitates	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1984	60,999	$69,085	5,150	$11,911	91,414	$138,834	80,810	$96,266	8,379	$10,562
1985:										
Belgium-Luxembourg	91	130	718	5,744	536	696	9,418	12,535	--	--
Canada	2,767	8,202	1,687	1,695	3,540	4,988	16,582	20,989	815	686
China	--	--	8,205	9,097	--	--	--	--	--	--
France	--	--	--	--	323	631	166	196	--	--
Germany, Federal Republic of	--	--	409	5,300	1,270	2,018	16,924	18,574	200	107
Hong Kong	--	--	--	--	971	1,514	1,442	776	71	62
India	--	--	744	677	--	--	999	859	40	29
Italy	--	--	--	--	--	--	6,854	6,625	--	--
Japan	102,833	108,932	97	381	5,002	7,708	13,451	15,803	--	--
Korea, Republic of	6,920	8,757	--	--	869	1,247	13,865	10,459	32,354	16,220
Mexico	--	--	73	186	4,229	2,956	12,254	13,774	5,610	3,220
Netherlands	--	--	11	13	17,324	25,207	3,986	4,081	--	--
Spain	--	--	--	--	2	4	4,802	4,715	--	--
Sweden	--	--	18	8	69	143	211	228	--	--
Switzerland	--	--	--	--	36	89	441	530	1	2
Taiwan	3,697	5,100	--	--	1,471	1,804	25,084	14,691	186	220
United Kingdom	--	--	102	86	671	1,351	3,904	4,988	99	93
Yugoslavia	--	--	--	--	1,512	1,899	--	--	--	--
Other	([2])	2	20	13	112	209	3,917	2,563	256	345
Total	116,308	131,123	12,084	23,200	37,937	52,464	134,300	132,386	39,632	20,984

See footnotes at end of table.

Table 28.—U.S. exports of copper, by country—Continued

Country	Pipes and tubing		Plates and sheets		Wire and cable, bare		Wire and cable, insulated		Other copper manufactures[3]	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1984	4,304	$13,541	4,647	$10,387	7,379	$22,023	28,141	$167,214	13,817	$30,438
1985:										
Belgium-Luxembourg	--	--	2	13	(2)	2	215	5,137	6	63
Canada	1,788	5,080	373	1,403	983	3,549	14,090	68,706	1,277	2,854
China	(2)	2	--	--	--	--	1,244	10,096	103	264
Egypt	15	56	--	--	--	--	1,285	5,863	469	933
France	3	79	(2)	1	7	268	741	26,012	2	24
Germany, Federal Republic of	8	32	--	--	30	235	1,827	27,677	10	129
Haiti	2	12	--	--	38	95	629	3,528	111	312
Israel	26	65	169	442	9	78	182	3,332	15	273
Italy	11	19	4	18	14	78	185	3,936	6	78
Japan	--	--	13	50	5	98	584	17,693	36	159
Korea, Republic of	1	34	3	126	12	81	1,380	8,308	262	404
Mexico	586	1,794	45	212	5,130	13,968	15,470	56,771	3,398	5,712
Netherlands	100	387	(2)	3	1	6	373	6,853	9	62
Saudi Arabia	594	1,924	24	200	127	472	2,529	11,707	110	466
Spain	166	423	22	87	10	33	85	7,358	--	--
Sweden	--	--	--	--	--	--	92	4,383	12	58
Taiwan	89	217	5	30	2	49	242	3,475	38	216
United Kingdom	181	497	27	80	43	396	2,390	33,832	33	199
Other	972	2,831	99	571	372	1,780	7,530	53,220	1,986	5,316
Total	4,542	13,452	786	3,236	6,783	21,188	51,073	357,887	7,883	17,522

[1]Includes matte.
[2]Less than 1/2 unit.
[3]Excludes copper wire cloth.

Source: Bureau of the Census.

Table 29.—U.S. exports of copper scrap, by country

Country	Unalloyed copper scrap				Copper-alloy scrap			
	1984		1985		1984		1985	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium-Luxembourg	2,005	$5,174	9,418	$12,535	3,112	$7,027	6,314	$6,875
Canada	11,249	14,630	16,582	20,989	30,895	37,715	23,968	35,329
France	52	76	166	196	205	523	205	230
Germany, Federal Republic of	2,968	2,488	16,924	18,574	3,732	3,496	17,067	18,435
Hong Kong	405	570	1,442	776	239	268	1,165	603
India	--	--	999	859	8,278	8,476	13,822	15,078
Italy	762	766	6,854	6,625	2,449	2,400	8,893	8,610
Japan	15,311	18,285	13,451	15,803	28,072	31,652	24,791	27,023
Korea, Republic of	13,278	15,678	13,865	10,459	7,614	8,735	12,422	13,498
Mexico	13,533	17,683	12,254	13,774	2,416	2,013	3,845	4,307
Netherlands	984	921	3,986	4,081	603	717	3,915	4,078
Spain	1,867	1,927	4,802	4,715	1,263	1,250	6,928	7,382
Sweden	441	559	211	228	2,556	3,414	1,808	2,520
Switzerland	--	--	441	530	471	307	646	633
Taiwan	15,813	14,090	25,084	14,691	14,642	13,959	14,724	10,635
United Kingdom	517	1,770	3,904	4,988	594	1,732	2,081	2,366
Other	1,625	1,649	3,917	2,563	1,190	1,263	3,265	2,277
Total	80,810	96,266	134,300	132,386	108,331	124,947	145,859	159,879

Source: Bureau of the Census.

Table 30.—U.S. imports for consumption of unmanufactured copper (copper content), by country

Country	Ore and concentrate		Matte		Blister and anode		Refined		Unalloyed scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1984	11,056	$9,863	2,094	$2,586	38,949	$52,950	444,699	$620,674	23,005	$28,925	519,803	$714,998
1985:												
Australia	1,112	641	--	--	--	--	8	36	--	--	1,120	677
Belgium-Luxembourg	--	--	--	--	10	28	5,321	7,060	--	--	5,331	7,088
Canada	396	404	2,170	1,397	--	--	127,990	172,823	18,278	20,664	148,834	195,288
Chile	16	22	178	1,663	8,119	9,465	155,686	198,484	--	--	163,999	209,634
Costa Rica	--	--	--	--	--	--	--	--	113	114	113	114
Dominican Republic	--	--	--	--	--	--	--	--	86	72	86	72
France	--	--	--	--	--	--	39	74	45	197	84	271
Germany, Federal Republic of	--	--	--	--	65	155	1,097	1,393	46	18	1,208	1,566
Guatemala	--	--	--	--	--	--	--	--	39	30	39	30
Honduras	75	89	--	--	--	--	--	--	44	34	119	123
Jamaica	--	--	--	--	--	--	--	--	145	122	145	122
Japan	476	115	--	--	982	1,415	509	1,110	--	--	1,967	2,640
Korea, Republic of	--	--	--	--	--	--	2,160	2,924	260	329	2,420	3,253
Mexico	--	--	15	27	2,041	2,187	2,289	3,320	3,149	3,346	7,494	8,880
Netherlands	--	--	823	901	--	--	--	--	--	--	823	901
Norway	--	--	--	--	--	--	940	1,309	--	--	940	1,309
Panama	--	--	--	--	--	--	--	--	389	400	389	400
Peru	794	468	110	2,580	1,549	1,994	32,562	40,685	--	--	35,015	45,727
South Africa, Republic of	--	--	99	54	--	--	5,854	7,698	--	--	5,953	7,752
Switzerland	--	--	--	--	--	--	--	--	13	15	13	15
Taiwan	--	--	--	--	--	--	--	--	1	3	1	3
Trinidad	--	--	--	--	--	--	--	--	88	43	88	43
United Kingdom	--	--	--	--	--	--	3,213	4,664	63	16	3,276	4,680
Venezuela	--	--	602	375	--	--	--	--	149	160	751	535
Zaire	--	--	--	--	--	--	28,502	34,694	--	--	28,502	34,694
Zambia	--	--	--	--	139	180	11,429	15,323	--	--	11,568	15,503
Other	--	--	--	--	74	105	126	201	106	117	306	423
Total	2,869	1,739	3,997	6,997	12,979	15,529	377,725	491,798	23,014	25,680	420,584	541,743

Source: Bureau of the Census.

Table 31.—U.S. imports for consumption of copper scrap, by country

Country	Unalloyed copper scrap: Quantity (metric tons)	Unalloyed copper scrap: Value (thousands)	Copper-alloy scrap: Gross weight (metric tons)	Copper-alloy scrap: Copper content (metric tons)	Copper-alloy scrap: Value (thousands)
1978	r15,436	r$16,583	19,018	13,199	$18,044
1979	r14,652	r21,483	21,624	14,983	25,796
1980	r16,053	r28,540	19,162	13,704	26,806
1981	r17,640	r25,328	24,101	17,539	30,562
1982	r16,459	r20,550	25,449	18,844	24,247
1983	23,086	32,183	42,006	31,832	48,597
1984	23,005	28,925	42,357	31,999	47,333
1985:					
Canada	18,278	20,664	20,557	15,624	21,287
Chile	--	--	90	51	143
Costa Rica	113	114	76	59	72
Dominican Republic	86	72	418	369	398
France	45	197	54	47	66
Germany, Federal Republic of	46	18	121	88	165
Guatemala	39	30	45	39	21
Honduras	44	34	26	22	19
Jamaica	145	122	127	110	78
Japan	--	--	38	27	101
Korea, Republic of	260	329	7	7	16
Mexico	3,149	3,346	8,873	5,757	9,134
Panama	389	400	469	354	387
Philippines	--	--	125	109	126
Switzerland	13	15	31	29	70
Taiwan	1	3	150	117	231
Trinidad	88	43	40	25	17
United Kingdom	63	16	278	200	429
Venezuela	149	160	233	186	241
Other	106	117	176	128	202
Total	23,014	25,680	31,934	23,348	33,203

r Revised.

Source: Bureau of the Census.

Table 32.—Copper: World mine production,[1] by country

(Thousand metric tons)

Country	1981	1982	1983	1984p	1985e
Albania e	r12.0	r13.2	r14.3	r16.1	16.2
Algeria	.2	.1	.1	.1	.1
Argentina	.1	(2)	.3	.3	.3
Australia	231.3	245.3	261.5	236.0	258.0
Bolivia	2.6	2.3	2.0	1.6	1.5
Botswana[3]	17.8	18.4	20.3	21.5	22.0
Brazil	11.8	24.4	40.0	44.4	32.0
Bulgaria	62.0	70.0	80.0	e80.0	80.0
Burma	(2 3)	(2 3)	4.2	e12.0	4 16.7
Canada[5]	691.3	612.4	653.0	712.8	724.4
Chile[6]	1,081.1	1,242.2	1,257.5	1,290.7	4 1,356.4
China e	170.0	175.0	175.0	180.0	185.0
Colombia	r.5	r.5	.4	.8	.8
Congo (Brazzaville)	.2	.1	.1	(2)	(2)
Cuba	2.9	2.6	2.7	2.7	3.1
Cyprus[7]	--	.8	1.2	(2)	(2)
Czechoslovakia	r9.2	r9.3	9.8	10.0	10.3
Ecuador	.8	r(2)	(2)	e.2	.1
Finland	r38.5	37.8	39.3	31.3	30.0
France	.1	.2	.1	.1	.1
German Democratic Republic e	12.0	13.0	12.0	12.0	10.0
Germany, Federal Republic of[5]	1.4	1.3	1.2	e1.0	4 .9
Greece	.1	--	--	--	--
Guatemala	.7	e.7	(8)	(8)	--
Honduras	.5	.5	.6	e.7	.8
India	25.2	e24.0	37.8	44.1	4 42.8
Indonesia	62.5	r75.1	78.6	82.5	4 88.7
Iran[9]	2.0	43.0	65.0	60.0	60.0
Ireland	3.5	1.6	--	--	--
Israel	NA	r3.5	3.5	r e2.9	--

See footnotes at end of table.

Table 32.—Copper: World mine production,[1] by country —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Italy	.8	[r].1	1.5	.9	.1
Japan	51.5	50.7	46.0	43.3	[4]43.2
Korea, North[e]	15.0	15.0	15.0	15.0	15.0
Korea, Republic of	.5	[e].3	.4	.3	.3
Malaysia	28.6	[r]30.1	29.0	28.9	[4]30.5
Mexico	232.9	229.2	196.0	303.5	290.0
Mongolia[e]	71.8	90.0	104.0	118.0	128.0
Morocco	[r]8.3	[r]22.7	23.8	22.1	22.0
Mozambique[e]	.2	[r].3	.2	[r].3	.3
Namibia	46.1	49.8	50.4	47.4	[4]48.0
Nepal	(2)	(2)	(2)	(2)	(2)
Norway	[r]28.1	[r]27.6	22.6	22.3	[4]19.0
Oman	--	--	11.3	16.2	18.0
Papua New Guinea	165.4	170.0	201.9	164.5	[4]175.0
Peru[6]	342.1	356.6	322.2	375.1	[4]397.2
Philippines	302.3	292.1	271.4	233.4	[4]226.2
Poland	[r]294.6	[r]376.0	402.3	431.0	431.3
Portugal[e,10]	[r].6	[r].4	.4	.4	[4].3
Romania[e,5]	27.0	26.0	27.0	25.0	26.0
South Africa, Republic of[6]	[r]199.4	188.7	205.0	198.2	[4]202.3
Spain	50.9	47.6	50.0	63.1	[4]56.4
Sweden	[r]50.7	[r]55.4	74.6	85.8	[4]91.8
Taiwan[e]	.5	--	--	(8)	--
Turkey[11]	31.9	34.4	25.0	32.1	32.5
U.S.S.R.[e,5]	570.0	560.0	570.0	590.0	600.0
United Kingdom	[r].6	.6	.7	.7	.7
United States:[5]					
By concentration or leaching	[r]1,406.8	[r]1,023.2	933.1	996.0	[4]1,007.3
Leaching (electrowon)	[r]131.4	[r]123.8	105.0	106.6	[4]98.5
Yugoslavia[11]	[r]111.0	119.3	129.8	137.6	150.0
Zaire	555.1	519.0	536.5	520.0	560.0
Zambia:[12]					
By concentration or leaching	465.8	436.9	455.6	406.6	363.0
Leaching (electrowon)	122.2	130.9	118.9	134.4	120.0
Zimbabwe	24.6	24.7	21.6	23.6	21.0
Total	[r]7,777.0	[r]7,618.7	7,711.7	7,986.1	8,114.1

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Data represent copper content by analysis of concentrates produced except where otherwise specified. Table includes data available through July 8, 1986.

[2]Less than 50 tons.

[3]Copper content of matte produced.

[4]Reported figure.

[5]Recoverable content.

[6]Copper content by analysis of concentrates for export plus nonduplicative total of copper content of all metal and metal products produced indigenously from domestic ores and concentrates. Includes leach production for electrowinning.

[7]Includes copper content of cupriferous pyrite.

[8]Revised to zero.

[9]Data are for years beginning Mar. 21 of that stated.

[10]Calculated from gross weight of ore using 21.6% copper content.

[11]Copper content by analysis of ore mined.

[12]Data are for fiscal years ending Mar. 31 of year stated.

Table 33.—Copper: World smelter production,[1] by country

(Thousand metric tons)

Country[2] and metal origin	1981	1982	1983	1984[p]	1985[e]
Albania, primary	[r]9.1	[r]10.2	11.0	12.6	12.6
Australia:					
Primary	172.2	175.5	173.6	179.8	167.0
Secondary	5.0	4.8	[e]5.0	[e]5.0	4.7
Total	177.2	180.3	[e]178.6	[r][e]184.8	171.7
Austria, secondary	27.1	30.0	30.0	30.0	36.0
Belgium:[e]					
Primary	3.1	2.5	2.8	[r].5	.5
Secondary	47.5	47.5	47.5	[r]10.0	10.0
Total	50.6	50.0	50.3	[r]10.5	10.5
Brazil, primary	--	[r]4.8	63.1	61.3	60.0
Bulgaria:[e]					
Primary	[r]59.0	[r]59.0	[r]57.0	[r]57.0	87.0
Secondary	3.0	3.0	3.0	3.0	3.0
Total	[r]62.0	[r]62.0	[r]60.0	[r]60.0	90.0
Canada:					
Primary	450.1	394.3	499.7	504.3	488.0
Secondary[e]	15.0	10.0	11.0	11.0	17.0
Total[e]	465.1	404.3	510.7	[r]515.3	505.0
Chile, primary[3]	953.8	1,046.8	1,058.9	1,098.3	[4]1,088.5
China, primary[e]	190.0	205.0	195.0	210.0	225.0
Czechoslovakia:					
Primary	8.0	10.8	10.0	10.0	[4]10.2
Secondary	2.4	2.4	2.4	2.4	2.4
Total[e]	[r]10.4	[r]13.2	[r]12.4	[r]12.4	12.6
Finland:					
Primary	54.7	66.3	74.5	71.2	71.0
Secondary	13.0	19.1	12.6	12.1	12.0
Total	67.7	85.4	87.1	83.3	83.0
France, secondary	6.5	[r]8.1	7.2	6.8	7.0
German Democratic Republic, primary[e]	16.0	17.0	17.0	[r]14.0	11.0
Germany, Federal Republic of:					
Primary	163.1	161.8	159.1	148.8	160.0
Secondary	88.3	78.2	94.5	76.7	80.0
Total	251.4	240.0	253.6	225.5	240.0
Hungary, secondary[e]	.1	.1	.1	.1	.1
India, primary	25.7	32.6	35.5	40.5	34.0
Iran, primary[e]	.8	[r]18.0	[r]18.0	[r]50.0	40.0
Japan:					
Primary	930.0	948.2	944.6	821.1	[4]802.3
Secondary	50.1	98.1	117.3	107.9	[4]130.3
Total	980.1	1,046.3	1,061.9	929.0	[4]932.6
Korea, North:[e]					
Primary	15.0	15.0	15.0	15.0	15.0
Secondary	3.0	3.0	3.0	3.0	3.0
Total	18.0	18.0	18.0	18.0	18.0
Korea, Republic of, primary and secondary	101.2	119.4	124.0	100.2	106.9
Mexico, primary	[r]69.2	[r]77.5	92.0	80.3	80.0
Namibia, primary	39.7	49.8	54.2	46.4	[4]43.3
Norway, primary (including electrowon)	32.0	24.4	27.2	37.0	38.2
Oman, primary	--	--	7.6	21.3	15.0
Peru, primary	279.3	294.4	258.3	298.8	326.6
Philippines, primary	--	--	57.6	109.2	[4]125.0
Poland:[e]					
Primary	315.0	338.0	349.0	360.0	370.0
Secondary	15.8	13.0	13.0	15.0	20.0
Total	[4]330.8	351.0	362.0	375.0	390.0

See footnotes at end of table.

Table 33.—Copper: World smelter production,[1] by country —Continued

(Thousand metric tons)

Country[2] and metal origin	1981	1982	1983	1984[p]	1985[e]
Portugal:					
Primary[e]	[r]2.8	1.1	[r]3.2	[r]2.5	3.0
Secondary[e]	.4	.4	3.0	[r]1.0	2.0
Total	[r]3.2	1.5	6.2	3.5	5.0
Romania:[e]					
Primary	[4]39.4	35.0	34.0	32.0	32.0
Secondary	4.0	4.0	[r]6.0	6.0	6.0
Total	43.4	39.0	[r]40.0	38.0	38.0
South Africa, Republic of, primary	185.4	[r]191.8	192.3	178.7	[4]159.7
Spain:					
Primary	87.9	105.0	100.0	97.0	100.0
Secondary	20.0	30.0	18.0	30.0	25.0
Total	107.9	135.0	118.0	127.0	125.0
Sweden:					
Primary	60.6	72.5	78.7	79.8	[4]56.1
Secondary	13.2	17.4	23.1	22.9	[4]18.4
Total	73.8	89.9	101.8	102.7	[4]74.5
Taiwan, primary	53.1	47.3	37.9	48.4	47.0
Turkey:					
Primary	[r]27.0	[r]25.5	18.8	31.8	31.8
Secondary	[r].3	[r].2	.3	.2	.2
Total	27.3	[r]25.7	19.1	32.0	32.0
U.S.S.R.:[e]					
Primary	673.0	680.0	700.0	734.0	750.0
Secondary	137.0	138.0	139.0	141.0	143.0
Total	810.0	818.0	839.0	875.0	893.0
United States:					
Primary[5]	1,316.8	975.7	927.7	1,014.1	[4]943.5
Secondary	60.9	45.1	59.3	169.3	[4]249.9
Total[6]	1,377.6	1,020.8	987.0	1,183.4	[4]1,193.4
Yugoslavia, primary	92.5	94.0	86.8	[r e]90.0	100.0
Zaire, primary:					
Electrowon	301.9	302.4	304.1	309.1	310.0
Other	178.5	171.1	175.0	171.5	170.0
Total	480.4	473.5	479.1	480.6	480.0
Zambia, primary	560.6	584.7	562.7	531.8	508.2
Zimbabwe, primary	[e]23.0	[e]23.2	21.6	22.7	28.0
Grand total	[r]8,002.1	[r]7,933.0	8,142.8	8,344.4	8,386.4
Of which:					
Primary:					
Electrowon	301.9	302.4	304.1	309.1	310.0
Other	[r]7,086.4	[r]6,958.8	7,119.4	7,281.7	7,199.5
Secondary	[r]512.6	[r]552.4	595.3	653.4	770.0
Undifferentiated	101.2	119.4	124.0	100.2	106.9

[e]Estimated. [p]Preliminary. [r]Revised.

[1]This table includes total production of copper metal at the unrefined stage, including low-grade cathode produced by electrowinning methods. The smelter feed may be derived from ore, concentrates, copper precipitate or matte (primary), and/or scrap (secondary). To the extent possible, primary and secondary output of each country is shown separately. In some cases, total smelter production is officially reported, but the distribution between primary and secondary has been estimated. Table includes data available through July 8, 1986.

[2]Argentina presumably produces some smelter copper utilizing its own small mine output together with domestically produced cement copper, and possibly using other raw materials including scrap, but the levels of such output cannot be reliably estimated.

[3]Data include electrowon production; estimated to be 35,000 to 45,000 tons per year that is fire-refined and cast into wirebars; detailed data are not available.

[4]Reported figure.

[5]Figures for U.S. primary smelter production may include a small amount of copper derived from precipitates shipped directly to the smelter for further processing; production derived from electrowinning and fire-refining is not included. Copper content of precipitates shipped directly to smelter are as follows, in metric tons: 1981—113,991; 1982—104,791; 1983—89,274; 1984—80,845; and 1985—82,948. Production from scrap prior to 1984 excludes data from secondary smelters processing only scrap.

[6]Data may not add to totals shown because of independent rounding.

Table 34.—Copper: World refinery production,[1] by country

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Albania, primary[e]	9.0	r9.5	r10.5	r11.5	11.5
Australia:					
Primary	164.2	160.2	168.5	171.7	2163.7
Secondary	r26.8	17.9	34.1	e35.0	35.0
Total	r191.0	178.1	202.6	e206.7	198.7
Austria:					
Primary	8.8	8.8	8.8	9.6	9.0
Secondary	30.3	32.8	33.1	34.2	34.0
Total	39.1	41.6	41.9	43.8	43.0
Belgium:					
Primary	r378.6	r420.6	360.3	351.7	320.0
Secondary	58.0	81.0	71.0	76.0	80.0
Total	r436.6	r501.6	431.3	427.7	400.0
Brazil:					
Primary	--	r4.8	63.1	61.3	70.0
Secondary	45.0	r52.0	39.3	36.0	40.0
Total	45.0	r56.8	102.4	97.3	110.0
Bulgaria, primary and secondary[e]	62.0	65.0	62.0	62.0	93.0
Canada:					
Primary	476.7	337.8	464.3	504.3	488.0
Secondary[e]	31.9	16.5	33.0	35.0	34.0
Total[e]	508.6	354.3	497.3	r539.3	522.0
Chile, primary	775.6	852.5	834.2	879.7	2884.3
China, primary and secondary[e]	295.0	300.0	310.0	310.0	400.0
Czechoslovakia, primary and secondary	25.5	25.6	25.7	26.1	26.5
Egypt, secondary	2.0	2.4	2.4	e2.6	1.6
Finland:					
Primary	23.8	38.0	45.4	47.3	46.5
Secondary[e]	10.0	10.0	10.0	10.0	12.0
Total	33.8	48.0	55.4	57.3	58.5
France:					
Primary[e]	23.0	24.0	r23.0	r30.0	23.5
Secondary[e]	23.0	23.1	r22.1	r20.0	21.0
Total[3]	46.0	47.1	45.1	49.9	44.5
German Democratic Republic, primary and secondary[e]	54.0	51.0	50.0	r55.5	55.0
Germany, Federal Republic of:					
Primary	304.1	313.7	332.8	297.9	2330.0
Secondary	83.4	80.4	87.9	81.1	284.3
Total[3]	387.4	394.1	420.8	379.0	2414.3
Hungary, primary and secondary[e]	12.0	212.2	12.5	12.8	12.8
India:					
Primary:					
Electrolytic	24.0	25.6	28.4	32.6	27.0
Fire refined	1.2	1.2	1.0	1.0	1.0
Secondary	(4)	(4)	(4)	(4)	--
Total	25.2	r26.8	29.4	33.6	28.0
Iran, primary[5]	.8	1.0	10.0	r e10.0	12.0
Italy:					
Primary[e]	1.0	--	--	--	--
Secondary[e]	22.7	19.6	r31.2	r40.0	35.0
Total	23.7	19.6	31.2	40.0	35.0
Japan:					
Primary	930.0	948.2	944.6	821.1	2802.3
Secondary	120.2	126.8	147.4	114.1	2133.6
Total[3]	1,050.1	1,075.0	1,091.9	935.2	2936.0

See footnotes at end of table.

Table 34.—Copper: World refinery production,[1] by country —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Korea, North, primary and secondary[e]	22.0	22.0	22.0	22.0	22.0
Korea, Republic of:					
Primary	108.0	110.8	123.3	129.1	140.0
Secondary[e]	5.0	5.0	11.5	7.9	10.0
Total[e]	113.0	115.8	134.8	137.0	150.0
Mexico:					
Primary	61.3	61.4	80.9	69.8	76.8
Secondary[e]	10.0	14.0	15.0	[2]13.8	14.0
Total[e]	71.3	75.4	95.9	[2]83.6	90.8
Norway:					
Primary (electrowon)[6]	26.1	18.0	22.7	30.3	[2]31.1
Secondary[e]	6.0	6.0	[2]2.0	[r]2.0	2.0
Total[e]	32.1	24.0	[2]24.7	[r]32.3	33.1
Oman, primary	--	--	3.8	15.1	16.0
Peru, primary:					
Electrowon	33.8	33.9	33.0	30.8	[2]27.4
Other	175.6	194.4	158.1	188.6	[2]200.6
Total	209.4	228.3	191.1	219.4	[2]228.0
Philippines, primary	--	--	38.8	99.2	[2]130.3
Poland, primary[7]	327.2	348.0	360.0	372.3	[2]387.0
Portugal, primary	4.8	4.6	[e]4.6	[e]4.6	4.5
Romania:[e]					
Primary	39.4	38.0	35.0	33.0	33.0
Secondary	20.6	12.0	12.0	12.0	12.0
Total	60.0	50.0	47.0	45.0	45.0
South Africa, Republic of, primary[8]	144.1	142.8	157.7	155.7	[2]161.5
Spain:					
Primary	137.1	[e]151.3	141.5	118.1	125.0
Secondary	15.0	[e]20.6	17.1	38.3	30.0
Total	152.1	171.9	158.6	156.4	155.0
Sweden:					
Primary	[r]58.7	58.1	59.0	[r] [e]59.4	60.2
Secondary	[r]3.2	4.2	4.3	[r] [e]4.5	4.5
Total[3]	61.9	62.3	63.4	63.9	[2]64.7
Taiwan:					
Primary[e]	45.2	39.4	30.0	40.4	39.0
Secondary[e]	8.0	8.0	8.0	8.0	8.0
Total	53.2	47.4	38.0	48.4	47.0
Turkey, primary	[r]22.4	32.2	31.8	39.0	30.0
U.S.S.R.:[e]					
Primary	730.0	759.0	776.0	798.0	810.0
Secondary	137.0	138.0	139.0	141.0	143.0
Total	867.0	897.0	915.0	939.0	953.0
United Kingdom:					
Primary	59.8	63.2	67.5	69.5	64.0
Secondary	76.3	71.0	76.8	67.4	62.0
Total[3]	136.2	[r]134.1	144.4	136.8	126.0
United States:					
Primary:					
Electrowon	161.1	131.9	126.7	127.3	109.6
Other	1,382.9	1,094.9	1,055.4	1,037.3	947.6
Secondary	[r]482.8	467.5	401.7	324.9	379.2
Total[3]	[r]2,026.9	1,694.3	1,583.8	1,489.5	1,436.3

See footnotes at end of table.

Table 34.—Copper: World refinery production,[1] by country —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Yugoslavia:					
Primary	90.7	82.5	82.9	[r] [e]94.0	100.0
Secondary	41.9	44.4	40.8	33.6	35.4
Total	132.6	126.9	123.7	127.6	[2]135.4
Zaire, primary	151.3	175.0	227.2	224.8	[2]226.8
Zambia, primary:					
Electrowon	122.2	130.9	119.0	134.4	120.0
Other	438.2	453.7	456.4	387.5	360.0
Total	560.4	584.6	575.4	521.9	480.0
Zimbabwe, primary	8.0	23.0	21.6	[r] [e]22.7	20.4
Grand total[3]	[r]9,178.3	[r]9,021.8	9,229.9	9,136.2	9,229.5
Of which:					
Primary	[r]7,448.7	[r]7,292.9	7,507.8	7,510.6	7,409.6
Secondary	[r]1,259.1	[r]1,253.2	1,239.7	1,137.4	1,210.6
Primary and secondary, undifferentiated	470.5	475.8	482.2	488.4	609.3

[e]Estimated. [p]Preliminary. [r]Revised.

[1]This table includes total production of refined copper, whether produced by pyrometallurgical or electrolytic refining methods, and whether derived from primary unrefined copper or from scrap. Copper cathode derived from electrowinning processing is also included. To the extent possible, primary and secondary output of each country is shown separately. In most cases, total refinery production is officially reported, and in some, the distribution between primary and secondary has been estimated. Table includes data available through July 8, 1986.

[2]Reported figure.

[3]Data may not add to totals shown because of independent rounding.

[4]Revised to zero.

[5]Data are for years beginning Mar. 21 of that stated.

[6]Includes electrowon cathode produced from imported matte.

[7]May include small quantities of secondary.

[8]Although only primary production is reported, an unknown but small additional output of secondary refined copper may have been produced.

Diatomite

By A. C. Meisinger[1]

The quantity of processed diatomite produced in 1985 was 635,000 short tons, a slight increase over that of 1984. Of the four Western States with reported production, California continued to be the leading producing State.

Diatomite exports declined 6% to 120,000 tons and comprised 19% of domestic production. World production was estimated to be nearly 2 million tons.

Domestic Data Coverage.—Domestic production data for diatomite are developed by the Bureau of Mines from one voluntary survey of U.S. plant operations. Of the nine operations to which a survey request was sent, 100% responded, representing 100% of the total production shown in tables 1 and 5.

Table 1.—Diatomite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
Domestic production (sales)	687	613	619	627	635
Total value of sales	$113,010	$107,619	$114,279	$120,926	$127,030

DOMESTIC PRODUCTION

Output of diatomite by domestic producers was 635,000 tons valued at $127 million, a slight increase over 1984 output. Diatomite was processed by seven companies in nine plants in four States. California continued to be the leading producing State, followed by Nevada, Washington, and Oregon.

The major diatomite producers continued to be Manville Products Corp., with operations at Lompoc, CA; Grefco Inc., Dicalite Div., at Lompoc, CA, and Mina, NV; Eagle-Picher Industries Inc. at Sparks and Lovelock, NV; and Witco Corp. (formerly Witco Chemical Corp.), Inorganic Specialties Div., at Quincy, WA. Other producers were Lassenite Industries Inc. in Herlong, CA; Cyprus Minerals Co. (formerly Cyprus Diatomite Co., a division of Amoco Minerals Co.) in Fernley, NV; and Oil-Dri Production Co. in Christmas Valley, OR.

Eagle-Picher, Reno, NV, began development of its open pit diatomite operation near Drewsey, Harney County, OR, in late 1985. Mining and processing was expected to be on-stream in mid-1986. The processing plant is near Vale in Malheur County, OR.

Grefco, Torrance, CA, began construction of a plant near Burney to process diatomite from the company's Shasta County, CA, freshwater deposits. The plant is expected to be completed by mid-1986. Initial plant capacity will be about 50,000 tons per year.

Whitecliff Industries was reported to have begun mining and shipping diatomite at Mammoth (near Tucson), AZ, in late 1985.

CONSUMPTION AND USES

Apparent domestic consumption of processed diatomite increased slightly to 520,000 tons. Domestic and export sales of filter-grade diatomite were 417,000 tons, compared with 418,000 tons in 1984. Sales of filler-grade diatomite were 137,500 tons, slightly above that of 1984. Diatomite used as additives and absorbents increased 10,000 tons to 76,000 tons. Insulation use decreased 35% to 4,200 tons in 1985, the second straight year of decline.

Table 2.—Diatomite sold or used,[1] by principal use

(Percent of U.S. production)

Use	1981	1982	1983	1984	1985
Fillers	23	19	21	22	21
Filtration	64	68	66	67	66
Insulation	2	1	3	1	1
Other[2]	11	12	10	10	12

[1]Includes exports.
[2]Includes abrasives (1981-82), absorbents, additives, and silicate admixtures.

PRICES

The average unit value of sales for processed diatomite increased $7 per ton to $200.

Table 3.—Average annual value per ton[1] of diatomite, by use

Use	1983	1984	1985
Fillers	$176.77	$175.10	$184.49
Filtration	200.16	210.60	220.80
Insulation	119.26	136.98	110.95
Other[2]	116.05	120.85	118.39
Weighted average	184.58	192.62	199.93

[1]Based on unrounded data.
[2]Includes absorbents, additives, and silicate admixtures.

FOREIGN TRADE

U.S. exports of processed diatomite declined 6% from that of 1984. Average unit value of exports, however, increased slightly from $232 per ton to $238 per ton. Diatomite was exported to 77 countries, and the quantity represented 19% of domestic production. The following six countries received 61% of the total: Canada, 25,500 tons; Japan, 14,000 tons; Australia, 13,000 tons; the United Kingdom, 8,700 tons; the Republic of South Africa, 6,100 tons; and the Federal Republic of Germany, 5,900 tons.

Diatomite imports totaled 4,950 tons, of which nearly 95% originated from Taiwan, compared with 338 tons in 1984, of which Mexico supplied 75%.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value[1]
1982	141	29,863
1983	146	31,569
1984	127	29,461
1985	120	28,519

[1]U.S. Customs.

WORLD REVIEW

World production of diatomite was estimated to be nearly 2 million tons, of which the United States produced one-third, followed by Romania, France, and the U.S.S.R. New data available in recent years show that Romania has emerged as a major world producer. The principal Romanian deposit areas are at Adamclisi, Partirlapele-Buzau, and Minis-Arad. Diatomite consumption in Romania has been oriented toward the building construction industry.

[1]Industry economist, Division of Industrial Minerals.

Table 5.—Diatomite: World production, by country[1]

(Thousand short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	5	5	5	2	2
Argentina	5	7	12	[e]11	12
Australia	2	2	[e]9	[e]9	9
Brazil (marketable)	10	14	[e]18	[e]18	18
Canada[e]	4	2	2	2	2
Chile	(2)	(2)	1	2	2
Colombia[e]	1	1	1	1	1
Costa Rica	1	1	[e]1	[e]1	1
Denmark:[3]					
Diatomite	4	[r]4	7	13	6
Moler	70	78	[r] [e]72	70	83
Egypt	--	--	(2)	[e](2)	(2)
France	[r] [e]231	269	244	273	276
Germany, Federal Republic of	47	47	49	49	50
Iceland	22	28	28	30	33
Italy[e]	28	22	28	[r]31	33
Kenya	2	2	2	2	2
Korea, Republic of	46	61	62	53	55
Mexico	62	62	48	49	50
Peru[e]	8	8	8	8	8
Portugal	3	[e]3	2	2	2
Romania[e]	[r]320	[r]320	[r]320	[r]331	331
South Africa, Republic of	1	1	1	(2)	(2)
Spain	42	70	61	80	66
Thailand	(2)	(2)	(2)	1	1
Turkey[e]	11	11	11	[r]3	3
U.S.S.R.[e]	[r]254	260	260	265	270
United Kingdom	[e]1	[e]1	(2)	(2)	(2)
United States	687	613	619	627	[4]635
Total	[r]1,867	[r]1,892	1,871	1,933	1,951

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 22, 1986.
[2]Less than 1/2 unit.
[3]Data represent sales.
[4]Reported figure.

Feldspar, Nepheline Syenite, and Aplite

By Michael J. Potter[1]

Total U.S. feldspar output in 1985, including soda, potash, or mixed feldspar, and feldspar-silica mixtures, was 700,000 short tons with a value of $22.8 million. Housing and commercial construction activity remained relatively high resulting in continued strong demand for plumbing fixtures, tile, and glass fiber insulation in which feldspar is used. Imports of crude and ground nepheline syenite decreased 12% to about 333,000 tons with a total value of $11.4 million.

Domestic Data Coverage.—Domestic production data for feldspar are developed by the Bureau of Mines by means of a voluntary survey. Of the 15 active mines, 12, or 80%, responded, representing an estimated 81% of the total production data for feldspar shown in table 1. The remaining 19% was estimated from prior years' data adjusted to current industry levels.

Legislation and Government Programs.—According to provisions of the Tax Reform Act of 1969, which continued in force throughout 1985, the depletion rate allowed on domestic and foreign feldspar production was 14%.

Table 1.—Salient feldspar and nepheline syenite statistics

	1981	1982	1983	1984	1985
United States:					
Feldspar:					
Produced[1] short tons	665,000	615,000	710,000	710,000	700,000
Value thousands	$21,000	$20,300	$22,500	$23,500	$22,800
Exports short tons	14,025	10,800	9,360	10,080	9,280
Value thousands	$1,110	$989	$856	$920	$680
Imports for consumption short tons	206	48	64	25	952
Value thousands	$61	$24	$31	$15	$1,150
Nepheline syenite:					
Imports for consumption short tons	506,100	455,596	407,351	377,945	332,604
Value thousands	$11,529	$13,751	$13,997	$14,218	$11,435
Consumption, apparent[2] (feldspar plus nepheline syenite) thousand short tons	1,157	1,060	1,108	1,078	1,024
World: Production (feldspar) do	[r]3,561	[r]3,835	4,003	[p]4,167	[e]4,294

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Includes hand-cobbed feldspar, flotation concentrate feldspar, and feldspar in feldspar-silica mixtures; includes potash feldspar (8% K_2O or higher).

[2]Production plus imports minus exports.

FELDSPAR

DOMESTIC PRODUCTION

Soda feldspar is defined commercially as containing 7% soda (Na_2O) or higher; potash feldspar contains 10% potash (K_2O) or higher. However, to publish information on potash feldspar without revealing company proprietary data in this report, feldspars containing 8% K_2O or more are defined as potash feldspars. Hand-cobbed or hand-sorted feldspar is usually obtained from pegmatites and is relatively high in K_2O

compared with Na_2O. Hand cobbing continued to be a minor fraction of total production. Feldspar flotation concentrates, most of the U.S. output, are classified as either soda, potash, or mixed feldspar, depending on the relative amounts of Na_2O and K_2O present. Feldspar-silica mixtures, feldspathic sand, can either be naturally occurring or a flotation product. Total feldspar content of this mixture was 28% of total feldspar output during 1985.

Feldspar was mined in six States, led by North Carolina and followed in descending order by Connecticut, Georgia, California, Oklahoma, and South Dakota. North Carolina accounted for 70% of the total. Eleven U.S. companies operating 15 mines and 13 plants produced feldspar or feldspar-silica mixtures for shipment to more than 31 States and foreign countries, primarily Canada and Mexico. Of the 11 companies, 3 produced potash feldspar, and the remainder produced mixed feldspar or feldspathic sand mixtures. North Carolina had five plants, California had three, and Connecticut, Georgia, South Carolina, and South Dakota each had one.

The data for potash feldspar were collected from the three U.S. producers of this material; some of this feldspar contained less than 10% K_2O (8% to 10% K_2O).

Lithium Corp. of America (Lithco), a wholly owned subsidiary of Gulf Resources & Chemical Corp., was sold to FMC Corp.[2] Lithco's domestic facilities are located near Bessemer City, NC. Ore from the company's open pit mine was milled to produce lithium-bearing spodumene concentrates, byproduct mica, and feldspar-silica mixtures.

Table 2.—Feldspar[1] produced in the United States

(Thousand short tons and thousand dollars)

Year	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures[2]		Total[3]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1981	11	194	504	16,850	149	4,000	665	21,000
1982	10	172	457	16,090	147	4,040	615	20,300
1983	7	107	525	17,128	178	5,265	710	22,500
1984	7	124	502	17,874	201	5,503	710	23,500
1985	14	W	487	16,781	197	W	700	22,800

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes potash feldspar (8% K_2O or higher).
[2]Feldspar content.
[3]Data may not add to totals shown because of independent rounding.

Table 3.—Producers of feldspar in 1985

Company	Plant location	Product
Arkhola Sand & Gravel Co	Muskogee, OK	Feldspar-silica mixture.
California Silica Products Co	San Juan Capistrano, CA.	Do.
Calspar Inc	Santa Fe Springs, CA	Soda feldspar.
Crystal Silica Co	Oceanside, CA	Feldspar-silica mixture.
The Feldspar Corp	Middletown, CT	Soda feldspar.
Do	Monticello, GA	Potash feldspar.
Do	Spruce Pine, NC	Soda feldspar.
Do	Montpelier, VA	Aplite.
Foote Mineral Co	Kings Mountain, NC	Feldspar-silica mixture.
Indusmin Inc	Spruce Pine, NC	Soda feldspar.
International Minerals & Chemical Corp	do	Do.
Kings Mountain Mica Co. Inc	Kings Mountain, NC	Potash feldspar.
Lithium Corp. of America	Bessemer City, NC	Feldspar-silica mixture.
Pacer Corp	Custer, SD	Potash feldspar.
Spartan Minerals Corp	Pacolet, SC	Feldspar-silica mixture.

CONSUMPTION AND USES

The majority of users acquired their supplies already ground and sized by feldspar producers, although some manufacturers of pottery, soaps, and enamels continued to purchase feldspar for grinding to their preferred specifications in their own mills. A substantial portion of the material classified as feldspar-silica mixtures served in glassmaking without additional processing.

Of the total feldspar consumed in the United States, 55% was used in glassmaking, including container glass and glass fiber; 45% was used in pottery; and less than 1% was used in enamels, electrical insulators, etc.

The use of feldspar in pottery articles such as plumbing fixtures and tile increased by 9% compared with that of 1984. This was apparently because of the continued good demand for plumbing fixtures and tile in the housing market.

Table 4.—Destination of shipments of feldspar[1] sold or used by producers in the United States, by State

(Short tons)

State	1981	1982	1983	1984	1985
Alabama	19,600	16,500	14,600	15,100	W
California[e] [2]	35,000	30,000	45,000	45,000	50,000
Connecticut	17,800	18,800	W	W	W
Florida	25,700	21,000	22,700	20,300	16,900
Georgia	68,300	74,600	96,900	96,000	95,300
Illinois	31,100	26,900	46,600	38,000	37,000
Indiana	22,700	20,200	37,200	[r]35,700	W
Kentucky	11,700	13,400	11,400	13,300	16,200
Louisiana	13,900	12,200	17,400	21,300	12,200
Maryland	4,300	4,600	4,500	7,400	7,400
Massachusetts	8,800	9,300	1,200	[r]10,800	W
Michigan	W	2,000	W	W	W
Mississippi	13,000	15,800	15,900	12,000	W
Missouri	4,300	4,100	5,000	4,400	4,700
New Jersey	63,400	51,700	56,600	53,200	W
New York	19,400	17,800	18,300	[r]10,800	W
North Carolina	17,000	16,500	20,100	16,400	17,000
Ohio	52,800	51,600	53,600	[r]64,900	65,800
Oklahoma	34,700	31,900	W	W	W
Pennsylvania	42,900	28,800	33,200	[r]37,200	31,100
South Carolina	16,400	14,900	18,400	17,400	W
Tennessee	16,100	15,300	W	W	W
Texas	39,400	36,700	41,900	[r]41,400	42,000
West Virginia	36,100	31,600	38,100	[r]28,500	27,000
Wisconsin	W	W	9,400	11,100	W
Other destinations[3]	40,600	43,800	102,000	[r]99,800	277,400
Total	655,000	610,000	710,000	[r]700,000	700,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other destinations."

[1]Includes potash feldspar (8% K_2O or higher).

[2]Data are incomplete, and estimates are very rough.

[3]Includes Arkansas, Colorado, Kansas, Minnesota, Rhode Island, Virginia, States indicated by symbol W, and unspecified States. Also includes exports to Canada, Mexico, and other foreign countries.

Table 5.—Destination of shipments of potash feldspar[1] sold or used by producers in the United States

(Short tons)

Destination	1981	1982	1983	1984[r]	1985
Illinois, Indiana, Wisconsin	11,300	8,000	6,000	5,800	5,800
Maryland, New York, West Virginia	24,800	21,600	25,300	21,800	28,000
Ohio	9,800	8,100	8,100	9,000	8,200
Pennsylvania	9,100	6,400	7,100	13,500	8,200
Texas	200	200	300	200	200
Canada	4,900	3,200	4,300	4,600	5,200
Mexico	2,800	2,400	W	W	W
Other[2]	17,500	16,300	14,100	16,400	21,400
Total	80,400	66,200	65,200	71,300	77,000

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]K_2O content of 8% or higher.
[2]Includes Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Kansas, Kentucky, Michigan, Massachusetts, Minnesota, Missouri, New Jersey, North Carolina, South Carolina, Tennessee, States indicated by symbol W, and other unspecified States. May also include foreign countries.

Table 6.—Feldspar[1] sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1984		1985	
	Quantity	Value	Quantity	Value
Hand-cobbed:				
Pottery	6	487	12	W
Other	1	51	1	W
Total	7	538	13	W
Flotation concentrate:				
Glass	229	7,063	216	7,207
Pottery	[r]253	[r]12,100	276	14,135
Other	W	W	--	--
Total	W	W	492	21,342
Feldspar-silica mixtures:[2]				
Glass	153	7,468	173	8,351
Pottery	28	1,367	25	W
Other	W	W	--	--
Total	W	W	198	W
Total:[3]				
Glass[4]	382	14,531	389	15,558
Pottery	[r]287	[r]13,954	313	W
Other[5]	[r]28	[r]1,568	1	W
Total	[r]700	[r]30,100	700	32,000

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes potash feldspar (8% K_2O or higher).
[2]Feldspar content.
[3]Data may not add to totals shown because of independent rounding.
[4]Includes container glass and glass fiber.
[5]Includes enamel, filler, etc., and unknown.

Table 7.—Potash feldspar[1] sold or used by producers in the United States, by use

Use	1984[r]		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Pottery	52,200	$3,790	59,300	W
Other[2]	19,100	990	17,700	W
Total	71,300	4,780	77,000	W

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]K_2O content of 8% or higher.
[2]Includes glass, enamel, etc.

PRICES

Most feldspar prices increased compared with those of 1984. Engineering and Mining Journal, December 1985, listed the following prices for feldspar, per short ton, f.o.b. mine or mill, carload lots, bulk, depending on grade:

	1984	1985
Connecticut:		
20 mesh, granular	$39.00	$41.35
200 mesh	53.25	56.50
Georgia:		
40 mesh, granular	54.00	57.25
200 mesh	73.50	76.50
North Carolina:		
20 mesh, flotation	29.25	29.25
40 mesh, flotation	54.00	57.25
200 mesh, flotation	NA	76.50

NA Not available.

Source: Engineering and Mining Journal, v. 186, No. 12, Dec. 1985, p. 11.

FOREIGN TRADE

U.S. exports classified as feldspar, leucite, and nepheline syenite, but presumably mostly feldspar, decreased 8% to 9,280 tons valued at $680,000. Chief recipients were Canada, 51%; the Dominican Republic, 18%; Mexico, 11%; and Taiwan, 6%. The remaining 14% was shared among eight other countries.

In addition to feldspar and nepheline syenite, the United States imported 580 tons of "Other mineral fluxes, crushed" with a value of $323,000. This represented a 59% decrease in tonnage compared with that of 1984. Also, 60,400 tons of "Other crude natural mineral fluxes" was imported with a value of about $3.0 million. This was a 39% decrease in tonnage compared with that of 1984.

The tariff schedule in force throughout 1985 for most favored nations provided for a 3.0% ad valorem duty on ground feldspar; imports of unground feldspar were admitted duty free.

Table 8.—U.S. exports of feldspar, by country

Country	1984		1985	
	Short tons	Value	Short tons	Value
Canada	6,040	$378,100	4,700	$290,100
Dominican Republic	1,020	107,400	1,640	100,300
Mexico	1,180	179,400	1,000	54,800
Philippines	270	27,100	--	--
Taiwan	600	112,000	560	100,400
Venezuela	490	38,300	270	60,000
Other	480	77,400	1,110	74,100
Total	10,080	919,700	9,280	679,700

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of feldspar, by type and country

Type and country	1984 Short tons	1984 Value	1985 Short tons	1985 Value
Crude:				
Canada	--	--	20	$9,000
Germany, Federal Republic of	1	$361	--	--
Mexico	--	--	214	19,328
United Kingdom	1	561	--	--
Venezuela	--	--	702	1,097,600
Ground, crushed, or pulverized:				
France	11	9,800	--	--
Germany, Federal Republic of	2	227	--	--
Netherlands	--	--	9	19,116
Switzerland	--	--	1	2,428
United Kingdom	10	3,595	6	2,991
Total	25	14,544	952	1,150,463

Source: Bureau of the Census.

WORLD REVIEW

Germany, Federal Republic of.—Although a major producer of feldspar, the country relied on imports of feldspar and nepheline syenite from the Scandinavian countries. The majority of feldspar was used as a flux in the ceramics industry, of which the Federal Republic of Germany was a leading producer. The most important feldspar producing region contained feldspar-quartz-pegmatites and their derived pegmatite sands, which were mined and beneficiated in conjunction with kaolin and silica sand. Amberger Kaolinwerke GmbH was Western Europe's largest producer of potassium feldspar with about 130,000 tons per year. Gebruder Dorfner OHG had an output of about 28,000 tons per year of feldspar. The ceramic manufacturer Hutschenreuther AG also worked pegmatite sands and had an annual capacity of 44,000 tons of feldspar. Saarfeldspatwerke H. Huppert GmbH & Co. KG of Saarbrucken was mining 55,000 to 66,000 tons per year of feldspar. The country's largest tile manufacturer and major whiteware ceramic producer, Villeroy and Boch Keramisch Werke KG, worked partly kaolinized, feldspar-rich rhyolites and was producing about 55,000 tons per year of feldspar for its own consumption. Rhyolites are fine-grained igneous rocks having a chemical composition similar to that of granite. A final source of feldspathic material was phonolite, which is an igneous rock containing feldspar. The major producer of phonolite was the Brenk Mine at Eifel, operated by Kali Chemie AG. Annual production was approximately 140,000 tons, which was primarily for the manufacture of colored glass.[3]

Greece.—The Hellenic Industrial Development Bank reportedly began work on its feldspar mine at Paranesti near Drama. In the first stage, production was planned at a rate of 31,000 tons per year at an estimated cost of $2.7 million. Upon completion of the facility, annual output was projected to rise to 86,000 tons. Greece imported up to 15,000 tons per year of feldspar during the previous decade.[4]

The final stage of construction for a plant owned by Dr. Georgiadis to process quartz and feldspar, and potentially other minerals, continued in 1985 at Assiros in northern Greece, approximately 15 miles north of Thessalonike. The feldspar was a soda feldspar occurring in pegmatite veins. Processing steps would be employed to remove mica and iron oxide. Quartz and feldspar would be sold for use in ceramics and paint. Feldspar sales would be directed at eastern and central Mediterranean countries and the Middle East, after satisfying local demand.[5]

Spain.—Industrias del Cuarzo S.A. continued mining operations at a large feldspathic sand deposit at Carrascal del Río in Segovia Province. The processing plant produced silica, feldspathic sand, and feldspar.

Llansa S.A. worked five quarries near Llansa in Gerona Province. The deposit was in the form of pegmatite veins, with three of the quarries containing soda feldspar and two containing mixed soda-potash feldspar. Proven reserves were in excess of 5 million tons. Processing steps included crushing, washing to separate clays, and air separation. Plant capacity was 44,000 tons per year. A second milling plant, which would include magnetic separation and air separators of a new design and would double capacity to 88,000 tons per year, was targeted to come on-stream at yearend 1985.[6]

United Kingdom.—Feldspar imports in 1984 were 60,000 tons. Principal countries of origin and the share supplied were Finland, 43%; Norway, 26%; and Sweden, 20%.[7]

Table 10.—Feldspar: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina	29	17	22	[e]22	22
Australia	4	5	4	[e]4	4
Austria	11	3	1	3	3
Brazil[3]	131	145	136	116	132
Burma	5	3	3	7	7
Chile	3	1	3	3	3
Colombia	30	33	35	36	35
Egypt	4	9	7	[e]6	6
Finland	70	77	57	62	61
France	211	191	193	230	231
Germany, Federal Republic of	377	365	364	[r e]287	309
Guatemala[e]	[4]11	13	7	[r]6	6
Hong Kong	4	36	62	127	83
India	65	49	46	44	44
Iran[e]	2	3	3	3	3
Italy	472	864	951	1,086	[4]1,231
Japan[5]	28	33	34	39	34
Kenya	([6])	--	1	1	1
Korea, Republic of	114	94	121	140	110
Mexico	144	127	130	93	110
Morocco	2	1	[e]1	[e]1	1
Mozambique	1	1	1	[e]1	1
Nigeria[e]	6	6	6	6	6
Norway[7]	[r]64	[r]69	64	[r e]66	66
Pakistan	12	[r]9	6	6	6
Peru[e]	[4]24	28	28	28	28
Philippines	18	17	7	13	13
Poland[e]	90	88	88	88	88
Portugal[e]	[4]49	47	46	44	39
Romania[e]	[r]93	[r]93	[r]94	[r]94	95
South Africa, Republic of	63	53	50	43	35
Spain[8]	143	144	128	[e]127	132
Sri Lanka	[e]4	3	3	6	6
Sweden	44	60	58	[e]61	61
Taiwan	19	12	13	17	17
Thailand	27	21	53	82	83
Turkey[e]	77	77	[4]10	11	22
U.S.S.R.[e]	350	360	360	360	370
United Kingdom (china stone)	[r]6	[r]6	7	7	7
United States	665	615	710	710	[4]700
Uruguay	3	1	1	[e]1	1
Venezuela	24	[e]8	41	[r e]32	31
Yugoslavia	59	47	46	[e]46	50
Zambia	([6])	([6])	([6])	([6])	([6])
Zimbabwe	3	1	2	2	1
Total	[r]3,561	[r]3,835	4,003	4,167	4,294

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through May 6, 1986.

[2]In addition to the countries listed, Czechoslovakia, Madagascar, and Namibia produce feldspar, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.

[3]Series excludes production of leucite and sodalite; data consist only of that material reported by Brazil under the heading of "Feldspar." Data represent the sum of (1) run-of-mine production for direct sale and (2) salable beneficiated product; total run-of-mine feldspar production was as follows, in thousand short tons: 1981—121 (revised); 1982—87; 1983—71 (revised); 1984—93; and 1985—100 (estimated).

[4]Reported figure.

[5]In addition, the following quantities of aplite were produced, in thousand short tons: 1981—386; 1982—385; 1983—442 (revised); 1984—486; and 1985—515 (estimated).

[6]Less than 1/2 unit.

[7]Excludes nepheline syenite.

[8]Includes pegmatite.

NEPHELINE SYENITE

Nepheline syenite is a quartz-free, light-colored rock that, although resembling medium-grained granite in texture, consists principally of nepheline and alkali feldspars, usually in association with minor amounts of other minerals. Large quantities of nepheline syenite, after processing to remove contaminants, especially iron-bearing minerals, were consumed in making glass and ceramics. There was no domestic production of nepheline syenite in grades suitable for these purposes, and U.S. needs were wholly supplied by imports.

With the purchase of IMC Industry

Group (Canada) Ltd. in 1985, Falconbridge Ltd. became owner of both nepheline syenite operations in Canada. The two operations, IMC and Indusmin Ltd., a division of Falconbridge, were mined at different points on the Nephton nepheline syenite deposit in the Blue Mountain District of Ontario, Canada.[8]

In Norway, nepheline syenite was produced at the Norsk Nefelin underground mining operation on the Arctic island of Stjernoy. Sales were mostly to markets in Western Europe.

About two-thirds of the output from Canada and Norway was consumed in insulation fiberglass and container glass manufacture. The second largest outlet was in ceramics, especially porcelain, tile, and whitewares. Nepheline syenite also was used in fine-grind applications as an extender in paint and an inert filler in plastics.[9]

In the U.S.S.R., development of the mineral resource known as synnyrite was being considered. The mineral, which has been identified in only two locations in Siberia, is similar to nepheline syenite and is made up essentially of the potassium analog of nepheline-kalsilite, $K_2O \cdot Al_2O_3 \cdot 2SiO_2$; and potassium feldspar, $K_2O \cdot Al_2O_3 \cdot 6SiO_2$. Synnyrite is a potential raw material for the production of alumina for reduction to aluminum and nonchlorine-containing potassium fertilizers. The typical composition of synnyrite is SiO_2, 54%; Al_2O_3, 22%; and K_2O, 19%. Various technologies for processing the mineral were being tested, including one that uses sulfuric acid to decompose the synnyrite into alum, $KAl(SO_4)_2$, and silica, SiO_2.[10]

The price for Canadian nepheline syenite, glass grade, bulk, 30 mesh, carlots or trucklots, was $20 to $28 per ton, depending on iron content, according to Industrial Minerals (London), December 1985.

Table 11.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983	212	$13	407,139	$13,984
1984	410	17	377,535	14,201
1985	920	62	331,684	11,373

Source: Bureau of the Census.

APLITE

Aplite is a feldspar mineral that has more than one geological definition. However, aplite from the only active U.S. operation contains primarily lime-soda feldspar. Aplite, usually unsuitable for use in ceramics, has been used in the manufacture of glass, especially container glass, when it is sufficiently low in iron. Japan, with an annual production of approximately 450,000 tons, has been the world's foremost producer of aplite.

Aplite of glassmaking quality was produced in the United States from one surface mine. The Feldspar Corp. mined aplite near Montpelier, Hanover County, VA, and treated the material by wet grinding, classification, and spiraling to remove biotite, ilmenite, and rutile, followed by dewatering and high-intensity magnetic separation to eliminate iron-bearing minerals.

Domestic output of aplite increased over that of 1984. The data are company proprietary and cannot be released for publication. Aplite traditionally has a somewhat lower price than feldspar. Industrial Minerals (London), December 1985, gave a value of $25.75 per ton for glass grade, bulk, 100% plus 200 mesh, f.o.b. Montpelier, VA.

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[1]Physical scientist, Division of Industrial Minerals.
[2]Chemical & Engineering News. Gulf Resources To Sell Lithium Unit to FMC. V. 63, No. 22, June 3, 1985, p. 10.
[3]Robbins, J. The Industrial Minerals of West Germany. Ind. Miner. (London), No. 219, Dec. 1985, p. 39.
[4]Mining Journal (London). Paranesti Feldspar for Greece. V. 304, No. 7795, Jan. 11, 1985, p. 26.
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[6]———. Spain's Industrial Minerals. Ind. Miner. (London), No. 217, Oct. 1985, p. 46.
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[9]Ash, D. R. Nepheline Syenite. Min. Eng., v. 37, No. 5, May 1985, p. 477.
[10]Soviet Geography. Potential Uses of Synnyrite Being Studied. V. 26, Jan. 1985, p. 64.

Ferroalloys

By Raymond E. Brown[1]

World demand for ferroalloys in 1985 was little changed from that of 1984. As a result, prices for most ferroalloys remained depressed. Brazil planned to triple its ferroalloy production capacity despite world overcapacity and oversupply conditions. The expansion in Brazil is being offset to some extent by reductions in the United States and Japan. The European Economic Community's (EEC) Executive Commission voted against allowing the official formation of Euromang, a cartel consisting of EEC ferromanganese producers. The EEC also increased tariff quotas on certain duty-free ferroalloy imports and approved a plan to support research on ways to make its mining and materials industries more competitive. Although France, the United Kingdom, and the United States reduced or planned to reduce the size of their stockpiles, Japan planned to increase its stockpile, and the Republic of Korea planned to initiate a stockpiling program. The Government of Japan agreed to provide tax credits for expenditures by its ferrochromium producers for modernization or research and development. The Government of the Republic of South Africa was considering withholding exports of chromium in retaliation for tougher U.S. sanctions. The high value of the U.S. dollar relative to other currencies continued to make the United States an attractive market for exporters throughout the world. However, the administration took steps to weaken the U.S. dollar.

Domestic Data Coverage.—Domestic production data for ferroalloys are developed by the Bureau of Mines by means of monthly and annual voluntary domestic surveys. Typical of these surveys are the three separate monthly surveys for chromium alloys and metal, manganese alloys and metal, and silicon alloys and metal, and the annual survey for ferroalloys. Of the 51 operations to which a survey was sent, 44 responded, representing an estimated 90% of the total production and/or shipments shown in table 2. Production and shipments for the remaining seven nonrespondents were estimated using reported prior year production and shipment levels adjusted by trends in employment and other guidelines.

Legislation and Government Programs.—There were a number of significant Government actions that impacted the ferroalloys industry in 1985. For the third consecutive year, to begin in 1986, the General Services Administration awarded contracts to Macalloy Inc., Charleston, SC, and Elkem Metals Co., Pittsburgh, PA, for upgrading chromium ore and manganese ore, respectively, in the National Defense Stockpile to the ferroalloy form. Macalloy's contracts amounted to $22.7 million in 1984 to convert 125,628 short tons of chromite ore into 50,254 tons of high-carbon ferrochromium (H-C FeCr), $26.0 million in 1985 to convert 141,601 tons of ore into 56,640 tons of H-C FeCr, and $19.3 million in 1986 to convert 92,184 tons of ore into 38,200 tons of H-C FeCr. Elkem Metal's contracts amounted to $10.1 million in 1984 to convert 47,951 tons of manganese ore into 24,332 tons of high-carbon ferromanganese (H-C FeMn), $19.3 million in 1985 to convert 88,329 tons of ore into 46,620 tons of H-C FeMn, and $15.3 million in 1986 to convert 58,557 tons of ore into 34,200 tons of H-C FeMn. The 10-year upgrading program was designed to reduce the quantity of ore needing conversion to ferroalloy form during a national emergency and to help maintain an adequate level of U.S. ferroalloy furnace and processing capacity.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines for the chemical and metallurgical group, chromium would be categorized in tiers I and II, and the goals would be 199,300 tons and 594,123 tons, respectively, of chromium metal equivalent. Manganese would be categorized in tier II only, and the goal would be 869,667 tons of manganese metal equivalent. The reader is referred to the respective commodity chapters for more details on chromium and manganese and for information on other elements such as vanadium that are contained in the National Defense Stockpile. At yearend, this proposal was under consideration by the U.S. Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

Companion bills S. 262 and H.R. 976 entitled "Fair Trade in Ferroalloys Act" were introduced in the U.S. Senate on January 24 and in the U.S. House of Representatives on February 6. The bills, designed to preserve the domestic ferroalloy industry, would establish a tariff mechanism whereby certain ferroalloy imports entering the United States below an established fair market price would be automatically assessed a tariff. By yearend, the bills still were under consideration. On May 21, the U.S. Senate adopted an amendment (No. 168) to the U.S. Department of Defense (DOD) fiscal year 1986 authorization bill (S. 1160) that requires DOD to conduct a study to determine what impact the loss of all domestic ferroalloy production capacity would have on the U.S. industrial base and military preparedness.

Economic sanctions were proposed by members of the U.S. Congress against the Republic of South Africa in 1985 to protest that country's apartheid policy. Some of the proposed bills would have a direct impact on a wide range of minerals for which the Republic of South Africa is a leading supplier to the United States. For instance, H.R. 997, introduced in the U.S. House of Representatives on February 6, would prohibit U.S. citizens from making or holding any investments in the Republic of South Africa and would prohibit imports of materials such as ferrochromium, ferromanganese, and their respective ores from that country. H.R. 3481, introduced on October 2, would ban the importation of H-C FeCr from the Republic of South Africa into the customs territory of the United States. Although the bill would prohibit imports of South African H-C FeCr, it would not ban imports of chromite, the ore from which ferrochromium is smelted. The United States has no domestic reserves of chromite but has underutilized furnace processing capacity for conversion of ore to ferroalloy form.

Bill S. 1533, "National Security Trade Act of 1985," was introduced in the U.S. Senate on July 31 to amend section 232 of the 1962 Trade Expansion Act. The U.S. Trade Representative would have final responsibility for decisions on trade relief cases and setting time limits. On October 9, bill S. 1753 was introduced in the U.S. Senate to amend title II of the Trade Act of 1974 to eliminate the discretion of the President to grant import relief and for other purposes. The Administration has outlined a group of six top administration officials that would monitor other countries' export barriers to U.S. goods and unfair subsidies of foreign goods that compete in the U.S. market. The Administration also announced an agreement by the United States with four other leading industrial nations (France, the Federal Republic of Germany, Japan, and the United Kingdom) on a joint action to weaken the U.S. dollar in an attempt to slow the protectionist pressures on Congress to curb imports and to promote U.S. exports.

A "Buy America" clause in the Federal Government's procurement code, requiring that all purchases of chromium metal for stockpile purposes be made from the domestic industry, is under review by the office of the U.S. Trade Representative to determine if it can be instituted in the face of U.S. obligations under international Government procurement agreements. The Federal Emergency Management Agency requested the clause in an effort to maintain the domestic industry for defense purposes. Elkem Metals is the sole domestic producer of the vacuum-grade electrolytic chromium metal required for the stockpile. A review of defense-related ferrochromium procurement policy, instituted in 1984, and action to enforce the policy was called for by a member of the Senate Armed Services Committee.

The new National Critical Materials Council, consisting of three members nominated by the President, was sworn in on November 8. The Council will coordinate Government policies toward the mining and mineral processing industries.

Both the U.S. House of Representatives and the U.S. Senate passed Comprehensive Environmental Response, Compensation, and Liability Act (Superfund) reauthorization bills but, by yearend, were unable to reconcile their differences. The House version would provide $10 billion for the program, while the Senate's measure would provide $7.5 billion. The legislative authority for taxes to pay for the cleanup of abandoned toxic chemical dumps expired on September 30, 1985. The Environmental Protection Agency (EPA) announced its intention to list chromium as a hazardous air pollutant for purposes of regulation under section 112 of the Clear Air Act. EPA is considering regulating some metal wastes that previously were excluded from regulation under the Resource Conservation and Recovery Act. Metal waste controls of this type are expected to impact domestic ferroalloy producers, among others.

The Congressional Research Service of the Library of Congress released a report that examines key changes in the structure of the U.S. ferroalloys industry since the early 1970's. The main focus is on the changing competitive posture of domestic producers of ferrochromium, ferromanganese, and ferrosilicon, the so-called tonnage alloys.[2] The Bureau of Mines released a report that reviews technological alternatives for the conservation of strategic and critical materials. The review focuses on the extent to which technologically and economically feasible programs in substitution, improved processing practices, recycling, and design can achieve conservation of chromium, manganese, and other critical and strategic materials, and thus reduce U.S. vulnerability to interruptions of supply. In addition, supply-side options—domestic and foreign resources, ocean minerals, and stockpiles—are identified.[3]

Table 1.—Government inventory of ferroalloys, December 31, 1985

(Thousand short tons)

Alloy	Stockpile grade	Nonstockpile grade	Total
Ferrochromium:			
High-carbon	[1]452	1	453
Low-carbon	300	19	319
Ferrochromium-silicon	57	1	58
Ferrocolumbium (contained columbium)	.3	.2	.5
Ferromanganese:			
High-carbon	[2]624	--	624
Medium-carbon	29	--	29
Ferrotungsten (contained tungsten)	.4	.6	1
Silicomanganese	24	--	24

[1]This figure includes the estimated 50,000 tons of high-carbon ferrochromium produced under the National Defense Stockpile chromium ore conversion program in 1984, but does not reflect the estimated 57,000 tons produced in 1985.

[2]This figure includes the estimated 24,000 tons of high-carbon ferromanganese produced under the National Defense Stockpile manganese ore conversion program in 1984, but does not reflect the estimated 47,000 tons produced in 1985.

DOMESTIC PRODUCTION

Domestic production and shipments of ferroalloys declined in 1985 because of weak demand by major consuming industries and continued competition from low-priced imports. Producers of the bulk ferroalloys of chromium, manganese, and silicon, and their respective metals operated their plants at about two-fifths of capacity, down slightly from that of 1984. The long-term trend continued toward greater reliance on imported ferroalloys, especially for ferrochromium and ferromanganese. The number of active domestic producers of ferroalloys was again reduced.

A. Johnson Metals Corp., Lionville, PA, began marketing electrolytic manganese metal produced in the Republic of South Africa by Manganese Metal Co. (Pty.) Ltd. (MMC). MMC was formed by the merger between Delta Manganese (Pty.) Ltd. (Deltamang) and Electrolytic Metal Corp. Pty. Ltd. (Emcor). A. Johnson is the sole European sales agent for MMC and is one of MMC's three U.S. agents. Demolition of one of Bethlehem Steel Corp.'s old "L" blast furnaces in Johnstown, PA, in October represents a potential loss of 240,000 tons of H-C FeMn capacity. The Johnstown blast furnace was the last of its kind dedicated to the production of H-C FeMn until it was idled in 1977 because of flood damage. An important aspect of emergency plans for ferroalloy production in a national crisis has been reactivation of old blast furnaces for H-C FeMn production to free up submerged arc electric-furnace (SAEF) capacity for H-C FeCr production. Demolition of the Johnstown blast furnace eliminates the option of freeing up 240,000 tons of H-C FeMn SAEF capacity to produce approximately 140,000 tons of H-C FeCr. Cabot Corp., Boston, MA, announced a major restructuring program on October 16. The divestiture includes the sale of most of the company's metals businesses with the exception of its columbium and tantalum KBI Div. Bomar Resources Inc., New York, NY, was named the exclusive U.S. agent for Hellenic Ferroalloys S.A. (HFA).

Elkem A/S, Norway, increased to 100% its ownership of both Elkem Metals in the United States and Elkem Metals Canada Inc. in Canada. This completed the takeover begun in 1983 of bulk ferroalloy businesses in North America formerly owned by Union Carbide Corp. In August, hourly workers struck Elkem Metals' ferroalloy plant in Marietta, OH, for 1 month before an agreement was reached on a new contract. The Marietta plant produces high-purity chromium metal, manganese metal, manganese ferroalloys, and some vanadium products. A Government-funded retraining program in progress at Elkem Metals' Alloy, WV, plant was anticipated to give the ferroalloys producer an edge on foreign competition. Foote Mineral Co., Exton, PA, closed its Graham, WV, plant on December 31, putting nearly 300 people out of work. The workers had given concessions to the company in 1983 to help keep the plant operating. The company attributed the decision to close the plant to competition from large volumes of imported ferroalloys and to the higher production costs at Graham compared with its other plants. Sale of its specialty foundry product lines including proprietary technology, trade names, and patents to SKW Alloys Inc., Niagara Falls, NY, was to be effective on January 3, 1986. As compensation, Foote will participate in the profits obtained by SKW Alloys in the manufacture and sales of the specialty product lines over the next 6 years. Foote also was aiming to negotiate favorable labor and power contracts at its Keokuk, IA, plant by mid-1986. The company warned that failure to lower both labor and power costs would likely lead to closure of that plant.

Globe Metallurgical Inc., a subsidiary of Moore McCormack Resources Inc., reportedly was considering ending ferrochromium production at its Beverly, OH, plant. M. A. Hanna Co. obtained a 5-year extension of its current offpeak power rate from the Bonneville Power Administration for its Riddle, OR, ferronickel operation. Hanna also obtained a new 5-year labor contract. Subsequently, the Riddle facility was shut down for about 6 months for capital improvements that included a wet-screening system to upgrade the ore. Exports to Europe and Japan could account for up to 40% of Hanna's sales from its Riddle, OR, ferronickel plant. International Minerals & Chemical Corp., Northbrook, IL, completed an expansion that tripled production of high-purity quartz at its feldspar beneficiation complex in Spruce Pine, NC.

In February 1985, Ohio Ferro-Alloys Corp., Dayton, OH, closed its Powhatan Point silicon metal plant for the balance of the year. The company subsequently concentrated all of its silicon metal production at its Montgomery, AL, facility. The company's third plant in Philo, OH, which produced ferrosilicon, was shut down in September 1984. Ohio Ferro-Alloys also obtained a 5-year agreement to sell silicon metal from its Montgomery, AL, plant to General Electric Co.'s (GE) Silicones Product Div. and concluded a $3 million loan agreement with GE's Credit Corp.

Satra Concentrates Inc. was processing ferrochrome slags at its Steubenville, OH, plant. The company bought the slags and the equipment for treating them from Satralloy Inc., Steubenville, OH, a division of Satra Corp., New York, NY. Satralloy has not operated its six ferrochrome furnaces since November 1982. The furnaces had a combined annual capacity of 96,000 tons consisting of 36,000 tons of charge chrome, 36,000 tons of low-carbon ferrochromium, and 24,000 tons of ferrochromium-silicon. Satra Concentrates' water concentrator recovers about 80% of the charge chrome (60% to 65% chromium) from its first slag pile that originally contained about 5% charge chrome. Its magnetic reclamation system gets back approximately 70% of the low-carbon ferrochromium from its second slag pile that originally contained about 3% low-carbon ferrochromium (67% to 75% chromium). Satra Concentrates expects to be active over the next 5 years processing an estimated 175,000 tons of charge chrome slags and about 1 million tons of low-carbon ferrochromium slags. This is equivalent to an annual recovery from the slag piles of 1,400 tons of charge chrome and 4,000 tons of low-carbon ferrochromium.

SKW Alloys announced that it would cease production, but not marketing, of manganese ferroalloys at its Calvert City, KY, plant after current ore stocks are consumed. Trans World Metals Inc., New York, NY, was phasing out its ferroalloys trading business only about 1 year after it created a new division from the former ferroalloy division of Clarendon Ltd. Reportedly, the reason for withdrawing from the ferroalloys trading business was that the company considered itself an arbitrage trader and would need a whole new network to be an effective trader of ferroalloys.

After 2 years of attempting to sell Umetco Minerals Corp.'s metals mining and processing operations as an intact unit, Union Carbide, the parent company, announced that it will sell the operations piecemeal. The corporation agreed to sell the South African chromium assets of Umetco to General Mining Union Corp. Ltd. (Gencor) of the Republic of South Africa, Union Carbide's joint venture partner in Tubatse Ferrochrome (Pty.) Ltd. Gencor agreed to buy Umetco's 49% interest in Tubatse Ferrochrome, as well as all of Union Carbide's interests in Jagdlust Chrome Co. Pty. Ltd., Chrometco Minerals Pty. Ltd., and Chrome Corp. (South Africa) (Pty.) Ltd. With these purchases, Gencor would become a major force in the worldwide ferroalloys industry, rivaling Middleburg Steel & Alloys Holdings (Pty.) Ltd., Republic of South Africa, as one of the world's major ferrochrome producers. Employees of Umetco planned to acquire the company's U.S. tungsten and vanadium assets, which consist of tungsten mines at Bishop, CA, and Tempiute, NV, a vanadium mill and mine at Hot Springs, AR, and the tungsten and vanadium processing facilities at Niagara Falls, NY. They also planned to acquire the vanadium mine and mill at Brits in the Republic of South Africa. Union Carbide continued to negotiate with other organizations for the purchase of Umetco's major tungsten mine in Brazil and its significant interest in a major tungsten mine in Portugal, as well as its chromium mines and smelter in Zimbabwe.

Estimated ferrous scrap consumption by the domestic ferroalloys industry was 310,000 tons in 1985, down from 340,000 tons in 1984.

The Ferroalloys Association reported that its member companies consumed 4.5 billion kilowatt hours (kW•h) of electricity in 1985, down from 5.3 billion kW•h in 1984. Additionally, its member companies employed 4,100 workers and reported losses, before taxes, amounting to $16 million in 1985, compared with 4,800 (revised) workers and a reported profit amounting to $1 million in 1984.

Table 2.—Ferroalloys[1] produced and shipped from furnaces in the United States

	1984				1985			
	Net production		Net shipments		Net production		Net shipments	
	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)
Ferromanganese[2]	171,129	77	185,499	$106,282	153,550	77	156,582	$100,903
Silicomanganese	(3)	66	(3)	(3)	(3)	66	(3)	(3)
Manganese metal	(3)	100	(3)	(3)	(3)	100	(3)	(3)
Ferrosilicon[4]	490,370	55	498,067	259,407	441,673	53	404,733	190,392
Silicon metal	140,866	98	139,393	171,814	120,965	99	121,640	157,231
Chromium alloys:								
Ferrochromium	95,400	62	120,772	102,101	109,563	62	108,472	97,723
Other[5]	(6)	--	(6)	(6)	(6)	--	(6)	(6)
Total	95,400	62	120,772	102,101	109,563	62	108,472	97,723
Ferrocolumbium	W	65	W	9,809	W	65	W	8,843
Ferrophosphorus	91,117	24	113,504	18,123	61,962	24	54,912	7,921
Other[7]	99,010	XX	96,683	92,959	89,469	XX	95,360	136,179
Grand total[8]	1,087,892	XX	1,153,918	760,495	977,182	XX	941,698	699,191

W Withheld to avoid disclosing company proprietary data; included with "Other." XX Not applicable.
[1]Does not include alloys consumed in the making of other ferroalloys.
[2]Includes fused-salt electrolytic low- and medium-carbon ferromanganese (massive manganese), and includes silicomanganese and manganese metal.
[3]Included with ferromanganese.
[4]Includes miscellaneous silicon alloys.
[5]Includes ferrochromium-silicon, chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.
[6]Included with ferrochromium.
[7]Includes ferroaluminum, ferroboron and other complex boron additive alloys, ferromolybdenum, ferronickel, ferrotitanium, ferrotungsten, ferrovanadium, ferrozirconium, silvery iron, and other miscellaneous alloys.
[8]Data may not add to totals shown because of independent rounding.

Table 3.—Producers of ferroalloys in the United States in 1985

Producer	Plant location	Products[1]	Type of furnace
FERROALLOYS (EXCEPT FERROPHOSPHORUS)			
Affiliated Metals and Minerals Inc	New Castle, PA	FeMo, FeV	Metallothermic.
Aluminum Co. of America, Northwest Alloys Inc.	Addy, WA	FeSi, Si	Electric.
Ashland Chemical Co	Columbus, OH	FeB, FeCb, FeMo, FeTi, FeW, NiCb.	Electric and metallothermic.
AMAX Inc., Climax Molybdenum Co. Div	Langeloth, PA	FeMo	Metallothermic.
Cabot Corp., KBI Div., Penn Rare Metal Div	Revere, PA	FeCb	Do.
Dow Corning Corp	Springfield, OR	Si	Electric.
Elkem A/S, Elkem Metals Co	Alloy, WV Ashtabula, OH Marietta, OH Niagara Falls, NY	Cr, FeB, FeCr, FeMn, FeSi, Mn, Si, SiMn, other.[2]	Electric and electrolytic.
Foote Mineral Co., Ferroalloys Div	Cambridge, OH Graham, WV Keokuk, IA	FeSi, FeV, silvery pig iron, other.[2]	Electric.
Hanna Mining Co., The:			
Hanna Nickel Smelting Co	Riddle, OR	FeNi, FeSi	Do.
Silicon Div	Wenatchee, WA	FeSi, Si	Do.
International Minerals & Chemical Corp., Industry Group, TAC Alloys Div.	Bridgeport, AL	FeSi	Do.
	Kimball, TN	FeSi, other[2]	Do.
Kerr-McGee Chemical Corp	Hamilton (Aberdeen), MS.	Mn	Electrolytic.
Macalloy Inc	Charleston, SC	FeCr	Electric.
Metallurg Inc., Shieldalloy Corp	Newfield, NJ	Cr, FeAl, FeB, FeCb, FeTi, FeV, other.[2]	Metallothermic.
Moore McCormack Resources Inc., Globe Metallurgical Inc.	Beverly, OH Selma, AL	FeCr, Fesi, Si	Electric.
Ohio Ferro-Alloys Corp	Montgomery, AL Powhatan Point, OH	FeSi, Si	Do.
Pennzoil Co., Duval Corp	Sahuarita, AZ	FeMo	Metallothermic.
Reactive Metals and Alloys Corp	West Pittsburg, PA	FeAl, FeB, FeTi, other[2]	Electric.
Reading Alloys Inc	Robesonia, PA	FeCb, FeV	Metallothermic.
Reynolds Metals Co	Sheffield, AL	Si	Electric.
SEDEMA S.A., Chemetals Corp	Kingwood, WV	FeMn	Fused-salt electrolytic.
SKW Alloys Inc	Calvert City, KY Niagara Falls, NY	FeCr, FeCrSi, FeSi	Electric.
Teledyne Inc., Teledyne Wah Chang, Albany Div.	Albany, OR	FeCb	Metallothermic.
Umetco Minerals Corp	Marietta, OH Niagara Falls, NY	FeV, FeW, other[2]	Electric.
Union Oil Co. of California, Molycorp Inc	Washington, PA	FeB, FeMo	Electric and metallothermic.
FERROPHOSPHORUS			
FMC Corp., Industrial Chemical Div	Pocatello, ID	FeP	Electric.
Monsanto Co., Monsanto Industrial Chemicals Co.	Columbia, TN Soda Springs, ID		
Occidental Petroleum Corp., Hooker Chemical Co., Industrial Chemicals Group.	Columbia, TN		
Stauffer Chemical Co., Industrial Chemical Div.	Mount Pleasant, TN Silver Bow, MT		

[1]Cr, chromium metal; FeAl, ferroaluminum; FeB, ferroboron; FeCb, ferrocolumbium; FeCr, ferrochromium; FeCrSi, ferrochromium-silicon; FeMn, ferromanganese; FeMo, ferromolybdenum; FeNi, ferronickel; FeP, ferrophosphorus; FeSi, ferrosilicon; FeTi, ferrotitanium; FeV, ferrovanadium; FeW, ferrotungsten; FeZr, ferrozirconium; Mn, manganese metal; Si, silicon metal; SiMn, silicomanganese.

[2]Includes specialty silicon alloys, zirconium alloys, and miscellaneous ferroalloys.

CONSUMPTION AND USES

Total domestic consumption of ferroalloys in 1985 was lower than that of 1984 owing to weaker demand by major consuming industries. Consumption patterns for ferroalloys followed the production patterns of the steel and ferrous casting industries, its major end-use markets, which each experienced production cutbacks of slightly more than 5%. However, overall consumption of silicon metal increased moderately, mainly the result of stronger demand by the chemical industry, one of its two major markets. Although the aluminum industry, the other major consumer of silicon metal, decreased production by 15%, this did not offset the gain in silicon metal consumption by the chemical industry.

Overall demand for bulk ferroalloys of chromium, manganese, and silicon and their respective metals was down by about one-tenth in 1985 compared with that of 1984. Demand for chromium ferroalloys and metal declined by a larger percentage than that for manganese- or silicon-ferroalloys and metal.

Market conditions for ferroalloys in the United States continued to be severely depressed, mainly the result of continuing weak demand by the U.S. steel industry, its major consumer. Most major domestic steel producers continued to operate at a loss for the fourth consecutive year, and one major producer, Wheeling-Pittsburgh Steel Corp., was forced to file for bankruptcy. Along with the domestic ferroalloys industry, the U.S. steel industry continues to operate at reduced rates because of weak demand and competition from low-priced imports.

Imports of bulk ferroalloys and their respective metals represented 59% of the domestic market in 1985, up from 55% in 1984. H-C FeCr and H-C FeMn produced under the National Defense Stockpile upgrading program were included in U.S. demand calculations.

Table 4.—U.S. consumption of ferroalloys as additives in 1985, by end use[1]

(Short tons of alloys unless otherwise specified)

End use	FeMn	SiMn	FeSi	FeTi	FeP	FeB
Steel:						
Carbon	360,733	76,343	[2]70,235	483	8,747	350
Stainless and heat-resisting	[2]14,026	3,228	[2]61,286	2,104	14	16
Other alloy	[2]70,119	[2]19,295	[2]29,781	491	1,167	227
Tool	376	([3])	1,683	([3])	([3])	--
Unspecified	753	660	28,350	18	1	--
Total	446,007	99,526	191,335	3,096	9,929	593
Cast irons	[4]16,318	2,583	207,741	23	2,216	W
Superalloys	326	W	570	657	--	W
Alloys (excluding alloy steels and superalloys)	18,576	W	122,120	357	78	32
Miscellaneous and unspecified	8,820	2,669	21,882	--	--	211
Total consumption	490,047	104,778	543,648	4,133	12,223	836
Percent of 1984	94	102	97	95	77	81

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]FeMn, ferromanganese including spiegeleisen and manganese metal; SiMn, silicomanganese; FeSi, ferrosilicon including silicon metal, silvery pig iron, and inoculant alloys; FeTi, ferrotitanium; FeP, ferrophosphorus; FeB, ferroboron including other boron materials.
[2]Part included with "Steel: Unspecified."
[3]Included with "Steel: Unspecified."
[4]Part included with "Miscellaneous and unspecified."

Table 5.—U.S. consumption of ferroalloys as alloying elements in 1985, by end use[1]

(Short tons of contained elements unless otherwise specified)

End use	FeCr	FeMo	FeW	FeV	FeCb	FeNi
Steel:						
Carbon	[2]4,573	69	--	1,135	860	--
Stainless and heat-resisting	156,277	314	37	35	468	15,847
Other alloy	[2]24,541	936	21	2,327	1,028	1,235
Tool	2,416	209	134	522	([3])	--
Unspecified	([4])	--	--	W	15	--
Total[2]	187,807	1,528	192	4,019	2,371	17,082
Cast irons	3,646	524	--	22	--	356
Superalloys	8,330	W	W	16	602	W
Alloys (excluding alloy steels and superalloys)	2,238	149	W	807	11	388
Miscellaneous and unspecified	4,840	74	5	19	--	167
Total consumption	206,861	2,275	197	4,883	2,984	17,993
Percent of 1984	89	104	64	127	111	97

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]FeCr, ferrochromium including other chromium ferroalloys and chromium metal; FeMo, ferromolybdenum including calcium molybdate; FeW, ferrotungsten; FeV, ferrovanadium including other vanadium-carbon-iron ferroalloys; FeCb, ferrocolumbium including nickel columbium; FeNi, ferronickel.
[2]Part included with "Miscellaneous and unspecified."
[3]Included with "Steel: Unspecified."
[4]Included with "Miscellaneous and unspecified."

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States at yearend

(Short tons)

	Producer		Consumer		Total	
	1984 (gross weight)	1985 (gross weight)	1984 (gross weight)	1985 (gross weight)	1984 (gross weight)	1985 (gross weight)
Manganese ferroalloys[1]	30,806	W	145,442	W	176,248	119,342
Silicon alloys[2]	91,110	120,017	27,261	25,399	118,371	145,416
Ferrochromium[3]	19,414	20,387	26,302	32,166	45,716	52,553
Ferroboron[4]	114	157	197	212	311	369
Ferrophosphorus	141,212	60,388	1,720	1,495	142,932	61,883
Ferrotitanium	W	W	548	667	548	667
Total	282,656	200,949	201,470	59,939	484,126	380,230
	1984 (contained element)	1985 (contained element)	1984 (contained element)	1985 (contained element)	1984 (contained element)	1985 (contained element)
Ferrocolumbium[5]	W	W	W	W	476	559
Ferromolybdenum[6]	1,226	1,257	361	298	1,587	1,555
Ferronickel	W	W	692	1,930	692	1,930
Ferrotungsten	W	W	41	40	41	40
Ferrovanadium[7]	946	W	334	360	1,280	360
Total	2,172	1,257	1,428	2,628	4,076	4,444

W Withheld to avoid disclosing company proprietary data.
[1]Includes ferromanganese, silicomanganese, and manganese metal.
[2]Includes ferrosilicon, miscellaneous silicon alloys, and silicon metal.
[3]Includes other chromium alloys and chromium metal.
[4]Consumer totals include other boron materials.
[5]Consumer totals include nickel columbium.
[6]Consumer totals include calcium molybdate.
[7]Includes other vanadium-iron-carbon ferroalloys.

PRICES

Published prices for imported ferrochromium products showed a firming trend during the first three quarters of the year, mainly the result of steady demand by stainless steel mills. However, an apparent oversupply of ferrochromium tended to push imported prices down in the fourth quarter by 1 to 3 cents per pound of contained chromium. Continued demand by stainless steel mills and the possibility of disruption of supplies from the Republic of South Africa, the major source of chromium materials, helped to prevent prices from falling further. With the exception of U.S. vacuum melted chromium metal pellets, which increased from $4.40 per pound to $4.62 per pound on October 11, posted prices for all other domestically produced chromium products in 1985 were unchanged or not listed.

Posted prices for most other ferroalloys began to weaken by the beginning of the second quarter owing to declining demand by major consuming industries and stronger competition among producers.

The average posted price of imported bulk ferroalloys increased for most chromium products in 1985 compared with that of 1984. For example, by 4% to $0.46 per pound of chromium for charge chrome containing 60% to 65% chromium and by 1% to $0.87 per pound of chromium for low-carbon ferrochromium containing up to 0.05% carbon. However, the average posted price for most major imported manganese and silicon bulk ferroalloy products declined compared with that of 1984. For example, by 5% to $0.32 per pound of manganese for medium-carbon ferromanganese, by 11% to $0.17 per pound for silicomanganese, by 10% to $0.37 per pound of silicon for 50% ferrosilicon, by 15% to $0.35 per pound of silicon for 75% ferrosilicon, and by 4% to $0.57 per pound of silicon for silicon metal containing up to 1% iron. Average listed prices for comparable domestically produced bulk ferroalloys were significantly higher than these seven imports by 18%, 9%, 27%, 39%, 22%, 32%, and 10%, respectively.

The average posted price of many specialty ferroalloys that compete as microalloying additives in the production of high-strength, low-alloy steels was lowered in 1985. For instance, the average posted price was lowered slightly to $5.66 per pound of columbium for regular-grade ferrocolumbium, by 11% to $5.78 per pound of vanadium for domestically produced ferrovanadium, and by 14% to $3.67 per pound of molybdenum for dealer exported ferromolybdenum.

Published prices were lowered from a range of $48-$52 to $40-$42 per metric ton for chromium ore from the Republic of South Africa on May 9 and from a range of $1.44-$1.47 to $1.40-$1.45 per long ton unit (22.4 avoirdupois pounds) of manganese content for manganese ore on March 21. In contrast, the posted price for chromium ore imported from Turkey was raised from $110 to $125 per metric ton on November 7.

Although published prices for domestically produced ferroalloys were generally much higher than those of imports, discounting by domestic producers was reported throughout the industry. Prices for selected domestically produced ferroalloys are shown in the following tabulation:

Alloy	Yearend price[1]	
	1984	1985
Charge chromium (66% to 70%)	$0.54	$0.54
Low-carbon ferrochromium, 0.02% maximum carbon (Simplex)	1.00	1.00
Standard 78% ferromanganese, per long ton of alloy[2]	325.00	320.00
Ferromolybdenum, dealer export	3.55	3.26
Ferronickel	3.16	3.16
Ferrosilicon, 50%	.45	.40
Ferrosilicon, 75%	.47	.40

[1]Per pound contained, except as noted otherwise. If range of prices was quoted, the lowest price is shown.
[2]Prices for imported material. List price for domestic material suspended on June 28, 1984.

Source: Metals Week.

FOREIGN TRADE

The trade deficit for ferroalloys declined from $470 million in 1984 to $425 million in 1985. However, a surplus of $6 million for ferroalloy metals in 1984 changed to a deficit of $40 million in 1985.

Both quantity, on a gross weight basis, and value of exported ferroalloys and ferroalloy metals declined in 1985, by 21% to 106,000 tons and 18% to $135 million, respectively. The quantity and value of exported ferroalloys and ferroalloy metals were 9% and 23% of the quantity and value of imports in 1985, respectively, compared with 11% and 26%, respectively, in 1984.

Total imports for consumption of ferroalloys and ferroalloy metals decreased 7% in quantity to 1.1 million tons and 5% in value to $600 million, compared with those of 1984. Of the imported bulk ferroalloys, the quantity of chromium ferroalloys and manganese ferroalloys declined by 23% and 3%, respectively, while that of silicon ferroalloys increased by 8%. Imports of chromium metal and manganese metal declined by 15% and 36%, respectively. However, imports of silicon metal were up by 105%. Imports declined by 15% for ferronickel and by 13% overall for all other ferroalloys. Ferroalloy and ferroalloy metal imports were equal to 72% of reported consumption in 1985, the same as in 1984.

Imports of ferroalloys and ferroalloy metals to the United States were supplied by 39 countries. The geographic sources were Africa, 41%; Europe, 28%; Western Hemisphere, 24%; Middle East, 3%; Oceania, 4%; and Asia, 1%. The four principal suppliers were the Republic of South Africa, 37%; France, 11%; Brazil, 8%; and Canada, 7%. Combined imports of chromium ferroalloys from the Republic of South Africa and Zimbabwe were 73% of total chromium ferroalloys, the same as in 1984. Of the total chromium ferroalloys, the Republic of South Africa supplied 61%. Turkey was the third leading supplier of chromium ferroalloys with 9% of the total. Major sources of imported manganese ferroalloys were the Republic of South Africa, 37%; France, 22%; Mexico, 9%; Canada, 7%; and Brazil, 6%. The principal sources of ferrosilicon imports were Brazil, 22%; Venezuela, 18%; Norway, 16%; Canada, 16%; and the U.S.S.R., 10%. The leading suppliers of ferronickel were the Dominican Republic, 54%; New Caledonia, 39%; and Colombia, 4%. The main suppliers of all other ferroalloys were Brazil, 52%; the United Kingdom, 12%; Australia, 10%; France, 9%; and Belgium, 5%. Major suppliers of ferroalloy metal imports were the United Kingdom, Japan, China, and France with 44%, 32%, 11%, and 10%, respectively, of the chromium metal; the Republic of South Africa with 98% of the manganese metal followed by Belgium with less than 2% of the total; and Brazil, Canada, Portugal, France, and the Republic of South Africa with 26%, 20%, 12%, 8%, and 8%, respectively, of the silicon metal. In 1984, the leading suppliers of silicon metal were Canada (33%), France (16%), Yugoslavia (13%), Brazil (11%), and the Republic of South Africa (8%).

Table 7.—U.S. exports of ferroalloys and ferroalloy metals

Alloy	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Ferroalloys:						
Ferrocerium and alloys	41	$372	29	$304	28	$314
Ferrochromium and ferrochromium-silicon	4,247	4,822	15,388	10,542	10,262	7,688
Ferromanganese	8,433	5,765	6,764	4,397	6,927	4,762
Silicomanganese	6,426	1,746	5,333	2,237	3,089	136
Ferromolybdenum	85	687	325	1,567	631	2,698
Ferrophosphorus	26,933	3,716	39,603	5,279	49,674	5,776
Ferrosilicon	13,338	10,712	29,364	21,185	12,970	12,671
Ferrovanadium	775	6,144	469	5,205	454	4,791
Ferroalloys, n.e.c	5,775	7,965	27,485	16,158	14,498	24,581
Total ferroalloys[1]	66,053	41,929	124,761	66,875	98,533	63,417
Metals:						
Manganese	6,391	8,531	4,082	5,915	5,162	7,242
Silicon	2,767	47,826	4,420	88,543	2,120	61,647
Chromium	238	2,555	259	3,627	222	2,964
Total ferroalloy metals[1]	9,396	58,912	8,761	98,084	7,504	71,854
Grand total	75,449	100,841	133,522	164,959	106,037	135,271

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1984 Gross weight (short tons)	1984 Content (short tons)	1984 Value (thousands)	1985 Gross weight (short tons)	1985 Content (short tons)	1985 Value (thousands)
Manganese alloys:						
Ferromanganese containing 1% or less carbon	5,020	4,431	$4,554	5,575	4,877	$5,098
Ferromanganese containing more than 1% to 4% carbon	53,509	43,419	25,674	30,383	24,689	12,923
Ferromanganese containing more than 4% carbon	350,781	273,849	87,450	330,916	257,178	86,368
Ferrosilicon manganese	138,494	[1]91,339	44,746	165,523	[1]109,719	51,423
Spiegeleisen	220	([2])	73	270	([2])	111
Total manganese alloys[3]	548,023	413,039	162,496	532,667	396,463	155,922
Ferrosilicon:						
8% to 30% silicon	46	7	13	345	43	41
30% to 60% silicon, over 2% magnesium	10,912	5,030	7,252	7,586	3,484	4,981
30% to 60% silicon, n.e.c	31,607	15,668	12,879	41,887	20,788	14,590
60% to 80% silicon, over 3% calcium	6,798	4,300	6,206	8,554	5,340	7,714
60% to 80% silicon, n.e.c	93,125	70,005	45,829	96,154	72,228	46,222
80% to 90% silicon	1,063	923	619	875	754	460
Over 90% silicon	100	94	76	20	19	11
Total ferrosilicon	143,651	96,027	72,874	155,421	102,656	74,019
Chromium alloys:						
Ferrochromium containing 3% or more carbon	400,676	225,488	160,054	304,829	171,587	131,570
Ferrochromium containing less than 3% carbon	25,132	17,236	23,397	26,236	17,525	24,976
Ferrosilicon-chromium	7,942	3,032	3,736	3,940	1,493	2,085
Total chromium alloys	433,750	245,756	187,187	335,005	190,605	158,631
Ferronickel	43,048	15,847	68,429	36,529	12,742	60,253
Other ferroalloys:						
Ferrocerium and other cerium alloys	152	([2])	1,651	125	([2])	1,302
Ferromolybdenum	1,043	772	4,438	712	473	3,721
Ferrotitanium and ferrosilicon-titanium	579	([2])	861	483	([2])	982
Ferrotungsten and ferrosilicon-tungsten	393	315	3,420	130	103	951

See footnotes at end of table.

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals —Continued

Alloy	1984 Gross weight (short tons)	1984 Content (short tons)	1984 Value (thousands)	1985 Gross weight (short tons)	1985 Content (short tons)	1985 Value (thousands)
Other ferroalloys —Continued						
Ferrovanadium	1,450	1,170	$11,839	966	778	$7,757
Ferrozirconium	759	(2)	932	629	(2)	729
Ferroalloys, n.e.c.[4]	3,949	(2)	22,876	4,197	(2)	24,179
Total other ferroalloys[3]	8,325	XX	46,017	7,241	XX	39,620
Total ferroalloys[3]	1,176,797	XX	r537,004	1,066,863	XX	488,445
Metals:						
Manganese	13,314	(2)	12,978	8,570	(2)	9,054
Silicon (96% to 99% silicon)	6,753	(2)	7,113	9,354	(2)	9,684
Silicon (99% to 99.7% silicon)	17,588	17,408	19,361	41,563	41,128	42,954
Silicon (over 99.7% silicon)[5]	880	(2)	28,907	885	(2)	30,729
Chromium	4,677	(2)	24,073	3,954	(2)	19,615
Total ferroalloy metals[3]	r43,211	XX	r92,433	64,326	XX	112,036
Grand total[3]	r1,220,009	XX	r629,436	1,131,189	XX	600,481

rRevised. XX Not applicable.
[1]Manganese content only.
[2]Not recorded.
[3]Data may not add to totals shown because of independent rounding.
[4]Principally ferrocolumbium.
[5]This category not previously included.

Source: Bureau of the Census.

WORLD REVIEW

World demand for ferroalloys rose slightly compared with that of 1984. Overcapacity and oversupply has plagued the world ferroalloy industry in recent years, a situation that is expected to continue for the foreseeable future. Some of the restructuring required to bring production in line with demand has already taken place in the United States and Japan. However, Brazil announced plans to triple its ferroalloy capacity by 1990, mainly for silicon metal and silicon alloys. Brazil's major cost advantage is its large hydroelectric energy reserves. Reacting to Brazilian competition, the Norwegian industry underwent a reorganization that reduced the number of active producer groups from four to two. Efforts were being made to reduce costs and ensure a substantial share of the world market.

The EEC expanded its membership from 10 to 12 countries by incorporating Spain and Portugal. EEC membership for the two countries was to take effect on January 1, 1986. The EEC's Exécutive Commission announced in June 1985 that it had decided against allowing the official formation of Euromang, a cartel made up of EEC ferromanganese producers. Euromang failed to submit a plan to permanently reduce ferromanganese capacity by 30%, a requirement for EEC approval. At midyear, the Commission issued "General Objectives Steel 1990," a working document that projected declines in manganese consumption in both ironmaking and steelmaking. The EEC doubled quotas for duty-free imports of ferrochromium into member countries in 1985. The EEC also set quotas for this material for 1986. EEC ferrosilicon producers met with Commission officials to discuss the low level of prices set in 1983 for ferrosilicon delivered to the EEC border. As a result, the Commission began to monitor the ferrosilicon market and asked producers from countries accused of dumping in 1983 to provide details of all transactions in the Common Market since April 1985. A decision to implement a price increase was to be made after comments from non-EEC producing countries were received. Resistance to an EEC price increase could lead to Community antidumping legislation. The EEC Council of Ministers agreed to maintain the duty-free quota for imports of ferrosilicon for 1986 at about 14,000 tons, of which the Federal Republic of Germany would be the chief beneficiary. A plan to support research on ways to make its mining and materials industries more competitive was approved by the EEC's Commission.

France, the United Kingdom, and the United States reduced, or planned to reduce, the amount of material held in their respective stockpiles. However, Japan planned to increase the amount of material held in its stockpile, while the Republic of Korea announced plans to initiate a stockpiling program.

It was reported in Metal Bulletin that the Republic of South Africa's Government was considering withholding exports of chromium in retaliation for tougher U.S. sanctions. Greece planned to enter the North American ferrochromium market. The Government of Norway announced it will require licenses for companies to import goods such as manganese ore from the Republic of South Africa.

Despite initial improvements in their balance of payments, the main debtor countries have failed so far to secure a viable long-term economic future.

Albania.—Albania is the world's third-ranked producer of chromite. Albanian chromite ore is massive, hard, and of good quality. The average chromium oxide content is 43%, and the ratio of chromium to iron is 3 to 1. Albania reportedly signed a trade agreement with Czechoslovakia in late 1985. Albanian exports will include chrome and nickel ore in return for Czechoslovak steel products, vehicles, and machinery. In midyear, Albania raised the possibility of sending some of its large nickeliferous iron ore reserve deposits to the Province of Kosovo in Yugoslavia for ferronickel smelting. However, political considerations may preclude such an arrangement.[4]

Australia.—French metals producer Pechiney and the Australian group Pioneer Concrete Ltd. agreed to form a joint venture to construct a silicon metal plant near Hobart, Tasmania. The joint venture intends initially to build a single 18.5-megawatt (MW) submerged arc furnace, which will produce about 13,000 tons per year of alloy or chemical-grade silicon metal, based on technology of Pechiney's subsidiary Pechiney Electrométallurgie. The new facility, estimated to cost $34 million, will be 60% owned by Pioneer.

Belgium.—Production facilities for manganese ferroalloys and chemicals were included when Société Générale de Belgique SA consolidated its main chemical subsidiaries into Gechem in the final months of the year. In the restructuring, Société Européene des Dérivés du Manganèse (Sedema) was absorbed from Société Carbochimique SA (CARBOCHIM) into Société d'Applications de la Chimie, de l'Electricité et des Métaux SA (SADACEM). Principal ownership of SADACEM was divided between CARBOCHIM, 65%, and Gechem, 26%. Gechem owned 99% of CARBOCHIM. Placed within a Gechem business sector were the SADACEM chemical plant at Tertre and Chemetals in the United States, both of which had been owned by Sedema, and the manganese ferroalloy plant of Belgische Vennootschap voor Mangaanproduktie SA (BELGOMANG) at Langerbrugge. Ownership of BELGOMANG was shared equally between SADACEM and a state-owned company.

SADACEM and Sedema, member companies in Société Générale de Belgique, combined forces to buy Gulf Chemical & Metallurgical Corp.'s Freeport, TX, plant from the Lissauer Group. SADACEM, a ferroalloy producer, and Sedema will operate the plant as equal partners. The facility will be used to recover molybdenum and vanadium from spent catalysts used in the petroleum refining industry.[5]

Brazil.—Brazil announced plans to triple its output of ferrosilicon and silicon metal by 1990, from the current level of about 190,000 tons to about 590,000 tons. Brazil has abundant supplies of raw materials, low-cost electric energy, and cheap labor, all of which would be expected to make Brazil a major supplier of silicon materials to the world market.

Cia. de Ferro-Ligas da Bahia S.A. (FERBASA) installed the first of three 13,000-ton-per-year furnaces at its new 75% ferrosilicon plant in Salvador. The plant will have a capacity of about 39,000 tons per year. The facility has a 10-year contract to export about 24,000 tons per year to Marubeni Corp., Japan. Eletrometalur S.A. Indústria e Comércio and Ila og Lilleby Smelteverker A/S of Norway formed a joint venture to produce silicon metal in Brazil. Two 14,000-kilowatt furnaces will be built at Captain Eneas in Minas Gerais State. The plant is expected to produce about 20,000 tons per year of high-quality silicon metal, all of which will be exported. Minerações Brasileiras Reunidas S.A.'s (MBR) ferrosilicon project was approved by Conselho de Nao-Ferrosos e de Siderúrgia S.A. MBR planned to build two 15,000-kilovolt-ampere (kV•A) furnaces in the Pirapora industrial complex. The first unit was scheduled for completion in 1987. Eletrovale, a joint venture 60% owned by Cia. Vale do Rio Doce (CVRD) and Eletrometalur, and 20% each by Mitsubishi Corp. and Kawasaki Steel Corp., began construction of its 27,000-ton-per-year ferrosilicon plant at Nova Era in Minas Gerais State. The plant was scheduled to go on-stream in late 1986.

Italmagnésio S.A. Indústria e Comércio planned to begin silicon metal production by March 1986 by converting its new 24-megavolt-ampere (MV•A) submerged arc ferrosilicon furnace to silicon metal production. The new furnace was scheduled to be put on-line in January 1986. Furnace output was expected to be 1,100 tons of silicon metal per month. Italmagnésio also planned to build a 13-MV•A furnace for silicon metal production. The furnace was expected to be completed by June 1986. Cia. Brasileira Carbueto de Calcio S.A. (CBCC) converted an old 30-MV•A ferrosilicon furnace to silicon metal production. CBCC also brought a new 30-MV•A furnace on-stream about midyear for ferrosilicon production. The new unit's production capacity was rated at about 20,000 tons per year. Ferro-Ligas Assofun S.A. began installation of an electric furnace for ferrosilicon production at its ferroalloy facility in São Joas da Boa Vista, which would double its capacity to about 15,000 tons per year. The company began negotiations with Nippon Kokan K.K. and Mitsui Co. Ltd. in an effort to establish a joint venture to raise part of the financing needed for construction.

Alcan Alumínio do Brasil S.A. sold its ferroalloys division to Cia. Paulista de Ferro-Ligas. Alcan's properties included two single-furnace facilities with a total capacity of about 19,000 tons per year of 75% ferrosilicon. Alcan produces silicomanganese at a third plant. All of the plants are in Minas Gerais. Brazil's Interior Minister approved new investment in the Inoculantes e Ferro-Ligas Nipo Brasileiros S.A. (INONIBRAS) ferrosilicon project. INONIBRAS planned to increase capacity to 29,000 tons per year from 7,000 tons. Osaka Special Alloy Ltd., Japan, holds a 30% share in the company, whose smelter is in Mato Grosso State. Cia. de Ferro-Ligas Minas Gerais S.A. put a 15-MV•A furnace online in August, increasing its ferrosilicon capacity from 26,000 tons per year to 40,000 tons of the 75% silicon alloy.

Metalman Indústria e Comércio Manganese Electrolitico, a subsidiary of Metalur Administração Participações Ltda., planned to install a $40 million plant at Rosario near São Paulo. The plant will produce electrolytic manganese metal and electrolytic manganese dioxide, among others. CVRD will provide the 80,000 tons per year of manganese ore required for the calcination and reduction process from its mineral deposit in Carajás. The plant's first phase was scheduled for completion in late 1987.

Both Paulista de Ferro-Ligas and Prometal-Produtos Metallúrgicos S.A. announced plans to build plants to convert Carajás manganese ore to ferromanganese and silicomanganese. Each plant would have a rated capacity of about 40,000 tons per year and be situated in the region. Production was planned to start in the 1986-88 period. Pilot plant trials demonstrated the feasibility of producing standard ferromanganese and silicomanganese with feed material from the Azul deposit using charcoal as a reductant.

Urucum Mineração S.A., operator of Brazil's largest manganese ore deposit, had projected 1985 ore production at 55,000 tons. The company may construct a ferroalloys plant near the mine.

FERBASA announced that it expected to reach an installed capacity of about 165,000 tons for all chrome alloys in 1985. The company exported nearly 50% of its major product, H-C FeCr, in 1984.

Construction began in Brazil on a new $1.7 million plant capable of producing about 200 tons per year of ferrotungsten and about 200 tons per year of tungsten carbide powders. The plant was expected to be completed in early 1987 and will use scheelite ores mined at Currais Novos, Rio Grande do Norte. Plant ownership will be divided among Tenenge Tecnica Nacional de Engenharia S.A. with 60%, Tomaz Salustino, 35%, and the Rio Grande do Norte State Government, 5%.

Cia. Brasileira de Metalúrgia e Mineração (CBMM) announced that it will begin producing columbium metal for export in 1987. CBMM planned to build an electron beam furnace at its ferrocolumbium plant in Araxá. Plant production is expected to be about 100 tons per year of metal, which will go to the superconductor industry. CBMM already is the world's largest producer of ferrocolumbium and columbium oxide.[6]

Canada.—In the first half of the year, Elkem Metals Canada came under full ownership of Elkem of Norway. Elkem Metals

Canada owns plants at Beauharnois and Chicoutimi, Quebec. Products include silicon metal, ferrosilicon and manganese ferroalloys.

Renzy Mines began construction of a new $4 million plant near Edmonton, Alberta, for recovery of vanadium pentoxide and other nonferrous oxides from fly ash by 1986. The fly ash will come from tar sands that Suncoroil will provide under a profit-sharing agreement. Suncoroil's Fort MacMurray oil sands refinery will supply up to about 34,000 tons per year of fly ash until stocks run out. Production of ferrovanadium would likely be undertaken if market conditions were right.[7]

Chile.—A strike by unionized workers in May halted ferromolybdenum (FeMo) and molybdic oxide (MoO_3) production for about 2 weeks at Molíbdenos y Metales S.A.'s (Molymet) plant in San Bernardo. Molymet, a major world producer of molybdenum (Mo) products, has an annual capacity of about 5 million pounds of contained Mo as FeMo and 22 million pounds of contained Mo as MoO_3. The company refused to take delivery of concentrates for conversion during the strike.

China.—China, a net importer of many ferroalloys since 1982, resumed exports of a wide range of ferroalloys in 1985. Exports in considerable quantities of ferrochromium, ferromanganese, and ferrosilicon were resumed, with lesser quantities of ferromolybdenum, ferrotitanium, ferrotungsten, ferrovanadium, and silicomanganese. China also began to further develop its more than 1-million-ton-per-year ferroalloy production capacity to coordinate with the Boashan steel complex, which has recently come onstream.

China, which had already agreed to buy 55,000 tons of chrome ore from Etibank, Turkey, purchased an additional 11,000 tons of Turkish ore from private sector interests.

China also planned to expand domestic production of ferrosilicon by building a 40,000-ton-per-year ferrosilicon plant in Gansu Province. The facility is due onstream in mid-1987. The China National Machinery and Equipment Import and Export Corp. of Beijing contracted with Mannesmann Demag Hüttentechnik AG of the Federal Republic of Germany for the engineering, planning, and supply of the plant. Two Demag 25-MV•A submerged arc furnaces will be supplied. A Chinese silicon metal producer redesigned two furnaces in the Jinshan plant in Jingzhou to meet the growing demand for silicon metal. China's exports of silicon metal to Japan in 1985 increased dramatically, compared with those of 1984.[8]

Colombia.—Cerro Matoso S.A. restarted its ferronickel plant in December and was operating at 66% of capacity. The furnace had been shut down for repairs in January and in August. Continued heavy financial losses and repeated technical difficulties make the future of the project uncertain. Plant production of contained nickel was estimated at 25 million pounds.

Dominican Republic.—Falconbridge Dominicana C por A announced in October that it planned to shut down for a 5-week period beginning December 20. The shutdown will prevent excessive accumulation of the company's stocks but may have come too late in the year to stop the price erosion in the market. Falconbridge had previously shut down for 1 week in August.

Finland.—Outokumpu Oy started up its new ferrochromium plant at Tornio. The company's expected production was about 140,000 tons of charge chrome in 1985, and 175,000 to 200,000 tons in 1986. Although Finland is a significant charge chrome producer, its production is very small compared with that of the Republic of South Africa. With respect to consumption by the Finnish stainless steel industry and assuming 90% recovery in the process, 140,000 tons of ferrochromium (52% chromium) would be approximately equivalent to 410,000 tons of stainless steel, based on a chromium content of about 16%.[9]

France.—Pechiney Electrométallurgie and Bozel Electrométallurgie, part of the electrometallurgy department of Pechiney, have an installed power capacity of 420 MW. Silicon metal and silicon alloys account for about 50% of this capacity. The two companies are leading world producers of silicon for silicon applications. About 40% of the silicon metal produced goes to the light metal castings market. The two Pechiney subsidiaries also produce a wide range of ferrosilicon for the steel industry and the foundry sector. Standard-grade ferrosilicon is made mainly in plants at Dunkirk and Laudun. High-purity material is produced at the Bellegarde facility. Silicon metal is produced mainly at the Montricher, Anglefort, Les Clavaux, Rioupéroux, and Château-Feuillet plants in France. In December, Pechiney announced that the Anglefort plant will be progressively targeted to produce silicon metal. One of Anglefort's ferrosilicon furnaces was being converted to silicon metal production and was expected to come on-stream early in 1986.[10]

Late in 1985, International Alloys & Metals was formed by two Pechiney subsidiaries, Pechiney World Trade and Pechiney Electrométallurgie, to market ferroalloys. Three key consumer markets for the company are the EEC countries, Japan, and the United States.

The Government of France began selling various materials including charge ferrochrome contained in its strategic stockpile.

Greece.—HFA, a subsidiary of the state-controlled Helenic Industrial Mining & Investment Co., announced that it planned to double the capacity of its integrated ferrochromium smelter to about 110,000 tons per year at its Tsingeli plant in central Greece by late 1986. The expansion of smelting capacity would be achieved by replacing the plant's 20-MV•A furnace with a 36-MV•A unit. After the expansion of capacity has been completed, HFA plans to export between 27,000 and 33,000 tons of ferrochromium to the United States and Canada, 44,000 to 55,000 tons to Europe, and 22,000 to 27,000 tons to Japan. Currently, almost all of HFA's ferrochromium production is sold in the European market. Bomar Resources Inc. was named as the exclusive U.S. representative for HFA.

In March, operations resumed at Larco S.A.'s Larymna ferronickel smelter in Beotia after a 2-week strike and a furnace explosion in February. The smelter also reportedly operated at about 50% of capacity in 1984 and produced about 15,000 tons of contained nickel.[11]

Iceland.—Icelandic Alloys Ltd.'s production of ferrosilicon dropped below 1984 levels, owing to a 7-week shutdown of one of its 35,000-kV•A electric furnaces. The plant operated at full capacity in 1984. Financial restructuring of the company to reduce long-term debt has been completed. Icelandic Alloys also obtained long-term sales guarantees from Elkem, Norway, and Sumitomo Corp., Japan, which will provide more effective plant utilization in years of poor demand for ferrosilicon. Construction of the 25,000-ton-per-year silicon metal plant at Reydarsjordur has been delayed until 1986.

India.—Orissa Mining Corp. Ltd. (OMC) began production at its new 55,000-ton-per-year ferrochromium plant in Bamnipal, Keonjhar District, Orissa State. Power shortages delayed commissioning operations. Initial output was expected to go to Japan. The plant incorporates a number of technical innovations that were expected to reduce the cost of producing ferrochromium by 25%, compared with that of conventional plants. OMC also filed an official application for the construction of a second ferrochromium plant in Orissa. However, the Indian Government linked the construction of a coal-fired powerplant as a condition for the construction of a second plant. OMC will be expected to finance the powerplant, thereby incurring a large debt burden on the second ferrochromium plant. Most of Orissa's power currently comes from hydroelectric plants that are susceptible to power cuts during the drought season.

Indian Charge Chrome Ltd. (ICC), a subsidiary of Indian Metals and Ferro Alloys Ltd. (IMFA), signed a $100 million contract with a Swedish consortium to build a coal-fired powerplant to supply electrical power to ICC's new 50,000-ton-per-year charge chrome plant at Choudar in Orissa and its 45,000-ton-per-year plant at Therubali. Ferroalloys producers have experienced severe electrical power shortages in Orissa owing to severe droughts that affected hydroelectric supplies. The new powerplant should permit the plants to operate at capacity. Output of both plants is for export.

Ipicol and Aryan Mining and Trading Corp. planned to build a 2,700-ton-per-year electrolytic manganese plant in Orissa State, pending approval by the Government of India. Technical assistance for building the plant will be supplied by Sumitomo Metal Industries Ltd. and Chuo Denko K.K. of Japan.

Ispat Alloys Ltd. in Balasore, Orissa, was issued a letter of intent by the Government to produce about 2,700 tons per year of silicon metal. IMFA is the only current producer of silicon metal, with a capacity of about 5,500 tons per year. Ispat's capacity is small compared with those of other units in the world, which are designed to produce about 8,000 to 26,000 tons of silicon metal per year. The metal is needed as an additive in aluminum alloys and as raw material in the semiconductor industry.[12]

Italy.—Industria Elettrica S.p.A. (Indel) began installation of additional silicon metal capacity at its Ospitale di Cadore facility. A new 24-MV•A furnace is being added to the existing 10-MV•A and 24-MV•A furnaces. The expansion will raise Indel's capacity to about 31,000 tons per year from a current level of about 19,000 tons. All of the new output is slated for export. Indel also produces about 22,000 tons per year of 75% ferrosilicon at its Domodossola plant. The company is also studying the possible production of ferrochromium and other alloys.

Elkem of Norway acquired a 20% share in Officine Elettrochimiche Trentine S.p.A. (OET), a ferroalloys producer in northern Italy. Elkem also undertook to market all of OET's products outside Italy. OET makes various specialized, highly refined alloys such as magnesium ferrosilicon, high-purity ferrosilicon, and calcium silicon. The company reportedly is Western Europe's largest producer of ferrotitanium.[13]

Japan.—Japan's Ministry of International Trade and Industry (MITI) plans to offer domestic ferrochrome, ferronickel, and ferrosilicon producers financial support in exchange for scrapping or mothballing plant capacity by March 31, 1987. MITI promised producers who comply with the Law of Extraordinary Measures for Depressed Industries that they will be exempt from having to pay any or most of their fixed property taxes. Most ferrosilicon producers were expected to accept the offer by March 31, 1985, while ferrochrome and ferronickel producers were expected to conform to the plan by March 31, 1986. MITI indicated these measures were necessary to offset major inroads by foreign ferroalloys producers whose power costs are much below those of Japanese producers. Under the plan, domestic ferrochrome capacity would be cut 10% from the current 573,000-ton-per-year operating level, while ferronickel operating capacity would be cut 12% from the present 420,000-ton-per-year level. Ferrosilicon capacity was expected to be reduced by about 55,000 tons per year to 295,000 tons per year. Eight ferrochrome producers, five ferrosilicon producers, and four ferronickel producers agreed to cut their plant capacities in conformance with the Government's recommendations. In March, MITI's Industrial Structure accepted proposals by the country's ferrochromium and ferronickel producers for Government assistance. H-C FeCr production capacity would be cut by 10% and ferronickel production capacity would be cut 12% over a period ending June 30, 1988. However, the proposed restructuring will not affect ferrochromium supply unless active operating capacity is reduced.

Japan's Metal Mining Agency received $17.6 million to increase the size of its national and semigovernmental ferroalloy stockpiles by 2 days of consumption during the fiscal year that began March 1, 1985. The stockpiles now jointly contain 16 days of consumption of ferrochrome, manganese, molybdenum, nickel, tungsten, and vanadium. MITI also submitted a budget request to the Ministry of Finance in August to increase both stockpiles by an additional 2 days of consumption. This expansion, to begin March 31, 1986, would raise the stockpiles to 20 days of consumption.

Japan planned to reduce duties on nine ferroalloys by April 1, 1986, according to MITI. Ferromolybdenum would be cut, on an ad valorem basis, by 20% to 3.92%; ferrocolumbium, ferrosilicon, ferrovanadium, and silicomanganese by 20% to 3%; ferrochromium by 10% to 7.2%; ferromanganese by 20% to 7.68%; and ferrotungsten by 20% to 4.9%. Later, the Japanese Finance Ministry indicated that implementation of the tariff reductions would be moved up to January 1 in an effort to calm U.S. sentiment against alleged unfair trade practices by Japan.

Total production of ferroalloys decreased slightly compared with that of 1984. Ferrochromium, ferromanganese, silicomanganese, and ferrosilicon production amounted to about 385,000 tons, 487,000 tons, 239,000 tons, and 166,000 tons, respectively. Production of manganese ferroalloys overall declined by about 9%, that of ferrosilicon by about 2%, while ferrochromium increased by about 8%.

At midyear, Mizushima Gokintetsu Ltd. began production of H-C FeMn in a shaft furnace situated within a steelmaking complex of parent company Kawasaki Steel. Demand for manganese ferroalloys continued to be diminished through hot metal pretreatment practices by steelmakers, especially at Nippon Steel Corp.[14]

Korea, Republic of.—The Republic of Korea announced plans to begin stockpiling ferrochromium and molybdenum. This action was taken to ensure adequate supplies of raw meterials for the country's stainless steel industry. The Korean Office of Supply expected the stockpile to hold about 1,300 tons of ferrochromium and about 200 tons of molybdenum by yearend 1985.[15]

New Caledonia.—Société Métallurgique le Nickel (SLN) planned to restructure its operations in New Caledonia into a separate wholly owned subsidiary. The subsidiary will operate SLN's New Caledonia Mines and the Doniambo smelter. It will also be responsible for ore exports. SLN's Thio and Kouaoua mining operations have been subjected to destructive attacks by separatists with consequent interruption of ore deliveries to the Doniambo smelter. However, SLN arranged to buy ore from some of New Caledonia's six independent mines in case of further disruptions to its own mining operations. SLN produces ferronickel, nickel concentrates, and nickel metal. The smelter's expected production in 1985 was about 50,000 tons of contained nickel. Toward yearend 1986, SLN lowered its projected output for the Doniambo smelter to about 48,000 tons of contained nickel.[16]

Norway.—In December, Elkem announced plans to buy Orkla Industrier A/S's 50% share in Orkla Metal A/S's ferrosilicon plant in Thamshavn and its 51% share holding in Bjoelvefossen A/S. Elkem also began negotiating with a third Norwegian ferroalloy producer, Tinfos Jernverk A/S, with the aim to establish a close working agreement in the areas of technology and marketing. With this consolidation of the Norwegian ferrosilicon industry, Elkem would effectively control about 386,000 tons per year of Norwegian ferroalloy capacity and about 110,000 tons per year of U.S. production through its U.S. subsidiary Elkem Metals. Additionally, Elkem holds a 30% interest in and an exclusive marketing agreement with Icelandic Alloys.

In October, Norway's Finance Minister proposed an increase in the electricity tax to be applied to all consumers at a uniform rate, from a current 0.37 to 0.39 cent per kW•h, effective in 1986. Norwegian ferrosilicon producers had sought some reduction in the electricity tax because of the depressed state of the ferrosilicon market.

Hafslund A/S began construction of an 11,000-ton-per-year metal powder plant at its Sarpsborg ferrosilicon facility. The plant, scheduled to come on-line early in 1986, will produce high-quality metal powders by water atomization. Products will include fine-grained 15% ferrosilicon for heavy media separation of ores and scrap.[17]

Elkem became 100% owner of Elkem Metals, United States, and Elkem Metals Canada. Elkem also acquired a 20% share in OET of Italy, a ferroalloys producer. Additionally, Elkem undertook to market all of OET's products outside Italy. OET makes various specialized, highly refined alloys such as magnesium ferrosilicon, high-purity ferrosilicon, and calcium silicon, among others. Orkla Industrier acquired a 51% interest in Bjoelvefossen, a ferrosilicon producer. Tinfos Jernverk planned to convert its two 12,000-kV•A ferrosilicon furnaces to silicon metal production, one by July 1985 and the other by February 1986.

Loss of ferrosilicon production owing to furnace breakdowns was experienced by Finnfjord Smelteverk A/S, Orkla Metal, and Hafslund early in 1985. Loss of silicon metal production was reported by Elkem, owing to a furnace breakdown in October at its Fiskaa works.

South Africa, Republic of.—The Republic of South Africa is the world's largest producer and exporter of both chrome ore and ferrochrome. The country's mines and smelters reportedly operated near capacity. The Republic of South Africa is also a major supplier of electrolytic manganese metal, ferromanganese, and manganese ore, among others. High inflation and rising energy costs were expected to cause problems for ferroalloy producers in 1985. In April, the Government of Norway announced that the country's companies would require licenses to import goods from the Republic of South Africa. Norwegian ferroalloy producers expressed concern that this action might lead to a limit or ban on shipment of manganese ore from the Republic of South Africa on which their production of ferromanganese and silicomanganese depends.

Gencor took over operating responsibility for the 132,000-ton-per-year Tubatse charge chrome plant at Steelport from Union Carbide on April 1. Gencor holds a 51% interest in Tubatse, and Union Carbide holds the remaining 49%. Union Carbide continued to market all of Tubatse's ferrochrome output. The Tubatse plant is among the five largest ferrochrome producers in the Republic of South Africa.

Emcor and Deltamang, the world's two largest producers of electrolytic manganese metal, merged their operations to form a new company, Manganese Metal Co. Pty. Ltd. (MMC). Emcor owns a 51% share of the new company. Emcor's plant is near Johannesburg, while Deltamang's facility is in the eastern Transvaal. Construction of a 22,000-ton-per-year electrolytic manganese plant by Brazil's Eletrometalur was expected to put extreme pressure on South African producers to maintain their market share. However, the Republic of South Africa has an abundant supply of manganese raw materials from domestic sources, reliable and competitive energy supplies, and a good labor supply, all of which makes it likely that its manganese industry will remain a key supplier for some years.

Silicon Smelters Ltd., a susidiary of South African Manganese Amcor Ltd., announced plans to expand their silicon metal production capacity by about 26,000 tons per year over a 4-year period. A fourth furnace at Silicon Smelters' Witkop plant was scheduled to come on-line in 1987 with a fifth furnace to follow 2 years later.[18]

Spain.—Sociedad Española de Carburos Metálicos S.A. reportedly planned to invest about $19 million in the construction of a hydroelectric power installation at Santa Eugenia in Galicia. This action is part of an attempt by the company to improve power consumption efficiency.

Ferroaleaciones Españolas S.A. (FESA) requested the same power rate reduction from Spain's Ministry of Industry that was granted to five other domestic ferroalloys producers during the past 2 years. FESA also maintained that it was eligible for lower rates since the price of ferrochrome, the company's main product, was depressed. FESA operates a plant at Medino del Campo, of which certain operations could be shut down without the lower power rate granted other ferroalloys producers.[19]

Sweden.—Uddevalla Kiselmetalverk AB, a joint venture formed by HB-Consult and Skanska Cement, planned to build a 33,000-ton-per-year silicon metal plant in Uddevalla. The plant was scheduled to come onstream in early 1988. The facility's overall production costs were expected to be low since waste heat from the furnaces will be purchased by the Uddevalla's district heating system.

Malmo Industrikombinat AB, also jointly owned by Skanska Cement and HB-Consult, planned to build a 55,000-ton-per-year ferrosilicon plant at Swede Harbour, Malmo. Construction was scheduled to begin in April 1986, with startup of the plant planned for 1988. Power costs for the facility will be partially offset by the sale of waste heat from the furnaces to the Malmo municipality.[20]

Turkey.—Bilfer Madencilik AS reportedly planned to reactivate several idled chrome ore mines. This action was in response to improved market conditions. The company's production goal in 1985 was about 80,000 tons of salable metallurgical-grade chrome ore, about three times that produced in 1984. An estimated 28,000 tons of material had been sold by November to China, the Republic of South Africa, and the United States.

Egemetal Madencilik A/S signed an agreement with Bomar Resources, United States, and Etibank, the Turkish state mining agency for possible development of chromite ore reserves in the Orhanel region. Initial work on the project will be limited to data collection and research and development. The agreement calls for establishment of a new company owned 40% each by Etibank and Egemetal, and 20% by Bomar Resources, allowing the company to qualify for Government incentives granted to foreign capital investment.[21]

U.S.S.R.—CBMM, Brazil, announced in May that the U.S.S.R. purchased 220 tons of the company's high-purity columbium oxide, amounting to about one-third of CBMM's current annual production capacity. The material was scheduled for delivery in 1985. The U.S.S.R. was also expected to buy about 600 tons of standard-grade ferrocolumbium from CBMM.

United Kingdom.—Brandeis Intsel Co. Ltd. completed the sale of about 25% of the United Kingdom's stockpile of strategic metals. The materials sold included about 26,000 tons of H-C FeMn, 29,000 tons of manganese ore fines, 1,400 tons of battery-grade manganese ore, 105 tons of ferrovanadium, and 100 tons of cobalt. Total market value of the materials sold was estimated at $13 million. The stockpile reportedly also contains ferrochromium, chromium ore, and vanadium pentoxide. The Government announced in November 1984 that it planned to sell its stockpile, less than 2 years after it had started to build it.

Venezuela.—C.V.G. Ferrosilicio de Venezuela C.A. (FESILVEN) shipped about 60,000 tons of ferrosilicon, compared with about 40,000 tons in 1984. Production increased to about 56,000 tons from 40,000 tons for the same period, taking the company close to its current rated capacity of 60,000 tons. The company planned to replace imported coal from Colombia and coke from France and the United Kingdom with domestically produced material. FESILVEN also began drawing up plans to use locally available charcoal.

Yugoslavia.—Feronikl's (FENI) ferronickel complex in Kavadarci, Macedonia, was permanently closed in 1985, and buyers for the plant and equipment were being sought. The plant, which was idled in 1984, was completed in 1982. FENI had planned to export from 80% to 90% of its production. According to Government analyses, the plant could not operate economically for the next 10 to 15 years because of low-grade ores and low nickel prices.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1]

(Thousand short tons)

Country, furnace type,[2] and alloy type[3]	1981	1982	1983	1984[p]	1985[e]
Albania: Electric furnace, ferrochromium[e]	31	33	39	44	47
Argentina: Electric furnace:					
Ferromanganese	25	27	28	26	24
Silicomanganese	14	17	15	15	18
Ferrosilicon	11	19	17	22	15
Other	[r]2	5	([4])	4	5
Total[5]	[r]52	67	60	67	62
Australia: Electric furnace:[6]					
Ferromanganese	74	60	59	84	[7]76
Silicomanganese	[r]33	33	22	34	[7]30
Ferrosilicon	20	22	21	17	20
Total[5]	127	115	101	135	126
Austria: Electric furnace, undistributed	13	15	15	14	15
Belgium: Electric furnace, ferromanganese[e]	99	99	99	105	99
Brazil: Electric furnace:					
Ferromanganese	119	[r]135	114	117	[7]149
Silicomanganese	157	[r]179	197	205	[7]199
Ferrosilicon	[r]162	[r]157	193	216	[7]248
Silicon metal	21	20	23	30	[7]32
Ferrochromium	131	107	85	138	[7]140
Ferrochromium-silicon	10	3	6	8	[7]10
Ferronickel	[r]3	[r]4	9	10	[7]10
Other	[r]18	[r]16	14	23	[7]26
Total	[r]621	[r]621	641	747	[7]814
Bulgaria: Electric furnace:					
Ferromanganese[e 8]	37	37	[r]33	[r]24	33
Ferrosilicon[e]	22	22	[r]19	[r]17	15
Other[e]	1	1	1	1	1
Total[5]	60	60	53	42	[7]50
Canada: Electric furnace:					
Ferromanganese[e 8]	120	152	118	128	130
Ferrosilicon	128	[e]116	94	[e]88	93
Silicon metal	31	[e]30	28	[e]28	28
Other[e 9]	31	--	--	--	--
Total[5]	310	[e]298	239	[e]244	250
Chile: Electric furnace:					
Ferromanganese	6	3	6	5	5
Silicomanganese	([4])	NA	NA	NA	NA
Ferrosilicon	3	2	5	7	6
Other	1	2	2	2	2
Total[5]	9	6	13	15	14
China: Furnace type unspecified:[e 10]					
Ferromanganese[8]	580	520	540	540	540
Ferrosilicon	215	215	215	215	215
Silicon metal	24	24	24	24	24
Ferrochromium[11]	130	130	130	130	130
Other[9]	80	80	80	80	80
Total[5]	1,029	970	[r]990	[r]990	990
Colombia: Electric furnace, ferrosilicon[e 12]	1	1	1	1	1
Czechoslovakia: Electric furnace:					
Ferromanganese[e 8]	110	[r]105	[r]103	[r]96	103
Ferrosilicon[e]	35	[r]33	[r]33	[r]31	33
Silicon metal[e]	6	[r]5	[r]5	[r]4	5
Ferrochromium[e]	30	[r]28	[r]28	[r]26	28
Other[e 9]	10	10	10	[r]9	10
Total[5 13]	191	[r]181	179	166	[7]177
Dominican Republic: Electric furnace, ferronickel	[r]55	16	58	71	76
Egypt: Electric furnace, ferrosilicon	6	7	7	8	8
Finland: Electric furnace, ferrochromium	57	60	65	65	66

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country, furnace type,[2] and alloy type[3]	1981	1982	1983	1984[p]	1985[e]
France:					
Blast furnace:					
Spiegeleisen[e]	1	1	1	1	1
Ferromanganese	344	365	297	362	364
Electric furnace:					
Silicomanganese[14]	11	32	36	38	39
Ferrosilicon	208	186	212	226	226
Silicon metal	66	63	[e]62	[e]55	55
Ferrochromium[11]	30	16	22	21	21
Other[15]	131	115	113	131	132
Total[5]	791	778	743	834	837
German Democratic Republic: Electric furnace:					
Ferromanganese[e 8]	74	69	69	[r]71	69
Ferrosilicon[e]	28	26	26	[r]26	25
Silicon metal[e]	4	3	4	4	4
Ferrochromium[e]	22	22	19	[r]21	21
Other[e 9]	21	17	20	18	17
Total[5 13]	149	138	141	140	137
Germany, Federal Republic of:					
Blast furnace:					
Ferromanganese	236	220	148	263	179
Ferrosilicon[e]	55	46	44	[r]77	47
Electric furnace:[e]					
Ferromanganese[8]	21	21	19	28	34
Ferrosilicon	46	37	34	66	66
Ferrochromium	55	46	42	77	79
Other[9]	47	40	36	72	67
Total[5]	461	411	323	583	473
Greece: Electric furnace:					
Ferrochromium	--	--	20	36	39
Ferronickel[e]	56	56	55	[r]58	61
Total	56	56	75	94	100
Hungary: Electric furnace:					
Ferrosilicon	12	[e]12	11	[e]10	10
Silicon metal[e]	2	2	2	2	2
Other	3	[e]3	2	2	2
Total[13]	17	17	15	14	14
Iceland: Electric furnace, ferrosilicon	37	[r]46	55	67	[r]67
India: Electric furnace:					
Ferromanganese	227	[r]174	[e]169	[r e]134	180
Silicomanganese	18	15	[r e]3	[r e]35	1
Ferrosilicon	67	[r]44	[e]52	[r e]56	30
Silicon metal	4	[e]4	[e]4	[e]3	3
Ferrochromium	35	[r]46	[e]65	[r e]61	64
Ferrochromium-silicon	5	[r e]5	[e]3	[r e]4	5
Other	10	15	[r e]4	[r e]([4])	1
Total[5]	365	[r]304	296	295	284
Indonesia: Electric furnace, ferronickel	22	24	23	25	24
Italy:					
Blast furnace:					
Spiegeleisen	([16])	([16])	([16])	([16])	--
Ferromanganese	([16])	([16])	([16])	([16])	--
Electric furnace:					
Ferromanganese	[r]80	[r]82	69	56	61
Silicomanganese	60	64	41	80	55
Ferrosilicon	61	70	57	78	66
Silicon metal[e]	17	17	15	15	15
Ferrochromium	11	40	13	14	13
Other[17]	14	13	37	56	44
Total[5 17]	242	286	232	300	255

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country, furnace type,[2] and alloy type[3]	1981	1982	1983	1984[p]	1985[e]
Japan: Electric furnace:					
Ferromanganese	626	593	429	535	[7]487
Silicomanganese	312	297	245	257	[7]239
Ferrosilicon	259	212	174	169	[7]166
Silicon metal	13	9	--	--	--
Ferrochromium	337	362	335	357	[7]385
Ferronickel	269	236	199	239	[7]250
Other[e]	4	7	5	7	4
Total	1,820	1,716	1,387	1,564	[7]1,531
Korea, North: Furnace type unspecified:[e 10]					
Ferromanganese[8]	77	77	77	77	77
Ferrosilicon	33	33	33	33	33
Other[9]	22	22	22	22	22
Total	132	132	132	132	132
Korea, Republic of: Electric furnace:					
Ferromanganese	75	66	58	65	67
Ferrosilicon	35	35	36	39	39
Other	30	37	48	55	61
Total[5]	141	139	142	159	166
Mexico: Electric furnace:					
Ferromanganese	145	155	153	[e]176	[7]169
Silicomanganese	28	34	46	[e]47	[7]44
Ferrosilicon	25	32	26	[e]25	[7]31
Ferrochromium	3	7	3	[e]8	[7]7
Other	2	([4])	1	[e]2	[7]([4])
Total[5]	204	227	229	[e]258	[7]250
New Caledonia: Electric furnace, ferronickel	121	120	93	[r e]125	156
Norway: Electric furnace:					
Ferromanganese	257	224	312	252	[7]237
Silicomanganese	236	238	215	278	[7]267
Ferrosilicon	346	326	407	452	[7]425
Silicon metal	[e]61	72	85	100	112
Ferrochromium	13	[r e]11	[r e]4	[r e]4	--
Ferrochromium-silicon	1	[e]1	[r e]([4])	[r e]([4])	--
Other[15]	5	5	7	4	3
Total[5]	919	876	1,028	1,092	[7]1,045
Peru: Electric furnace:					
Ferromanganese	([4])	--	([4])	([16])	([4])
Ferrosilicon	--	--	([4])	([16])	([4])
Total	([4])	--	([4])	([16])	([4])
Philippines: Electric furnace:[e]					
Ferrosilicon	25	30	22	20	21
Ferrochromium	11	13	24	36	44
Total	36	43	46	56	65
Poland:					
Blast furnace:					
Spiegeleisen	7	4	4	4	3
Ferromanganese	115	96	93	99	88
Electric furnace:					
Ferromanganese[e 8]	[r]45	[r]39	[r]53	[r]53	54
Ferrosilicon[e]	[r]47	[r]41	[r]57	[r]56	57
Silicon metal[e]	[r]10	[r]8	11	11	12
Ferrochromium[e]	[r]45	[r]39	[r]53	[r]53	54
Other[e 9]	[r]15	[r]14	[r]19	[r]19	18
Total[5 13]	[r]283	[r]241	290	295	[7]287
Portugal: Electric furnace:					
Ferromanganese[e 18]	72	30	37	33	32
Silicomanganese[e 18]	20	18	18	17	15
Ferrosilicon[e]	26	23	24	22	21
Silicon metal[e]	35	35	35	33	31
Other[e]	([4])	([4])	([4])	([4])	([4])
Total[5 13]	153	106	115	105	99

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country, furnace type,[2] and alloy type[3]	1981	1982	1983	1984[p]	1985[e]
Romania: Electric furnace:[e]					
Ferromanganese	77	83	88	96	88
Silicomanganese	36	39	42	45	43
Ferrosilicon	46	50	53	57	55
Silicon metal	4	4	4	5	5
Ferrochromium	40	43	46	50	49
Total[5]	203	218	234	253	240
South Africa, Republic of: Furnace type unspecified:[e 10]					
Ferromanganese	[r]500	[r]490	[r]160	[r]210	315
Silicomanganese	[r]50	[r]40	[r]160	[r]210	315
Ferrosilicon	[r]120	[r]100	[r]100	[r]120	90
Silicon metal	[r]30	[r]30	[r]25	[r]35	40
Ferrochromium	[r]830	[r]520	[r]800	[r]980	920
Ferrochromium-silicon	[r]20	[r]20	[r]15	[r]35	30
Other[19]	1	1	1	[r]([4])	([4])
Total[5]	[r]1,550	[r]1,200	[r]1,260	[r]1,590	1,710
Spain: Electric furnace:					
Ferromanganese	106	96	[e]94	[e]94	95
Silicomanganese	77	78	[e]77	[e]77	77
Ferrosilicon	94	70	[e]68	[e]66	67
Silicon metal[e]	20	20	19	[r]66	68
Ferrochromium	19	17	[e]15	[e]15	19
Other	7	6	[e]6	[r e]1	4
Total[5 13]	323	286	279	321	331
Sweden: Electric furnace:					
Ferrosilicon	21	16	21	[r e]22	22
Silicon metal	16	[e]18	[e]18	[e]18	18
Ferrochromium	161	129	132	[e]138	136
Ferrochromium-silicon	25	22	20	[e]22	22
Other	1	1	1	[e]1	1
Total[5 13]	223	185	192	200	199
Switzerland: Electric furnace:[e]					
Ferrosilicon	3	3	2	3	3
Silicon metal	2	2	2	2	2
Total	5	5	4	5	5
Taiwan: Electric furnace:					
Ferromanganese	21	21	24	22	20
Ferrosilicomanganese	16	23	20	25	25
Ferrosilicon	19	19	20	26	19
Total[5]	56	63	65	73	64
Thailand: Electric furnace:					
Ferromanganese	([4])	--	--	--	--
Ferrosilicon	([4])	--	--	--	--
Total	[r]1	--	--	--	--
Turkey: Electric furnace:					
Ferrosilicon	--	[e]5	[e]5	8	8
Ferrochromium	45	44	33	53	53
Total	45	49	38	61	61
U.S.S.R.:					
Blast furnace:					
Spiegeleisen[e]	55	55	55	55	55
Ferromanganese[e]	606	606	606	606	606
Electric furnace:[20]					
Ferromanganese[e]	[r]474	[r]496	[r]551	[r]661	744
Silicomanganese[e]	35	35	37	39	41
Ferrosilicon[e]	717	750	794	827	827
Silicon metal[e]	70	70	70	70	66
Ferrochromium[e]	441	457	457	463	463
Ferrochromium-silicon[e]	11	11	13	13	13
Other[15]	230	248	250	250	254
Total[5]	[r]2,636	[r]2,725	2,834	2,984	3,069

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country, furnace type,[2] and alloy type[3]	1981	1982	1983	1984[p]	1985[e]
United Kingdom:					
Blast furnace, ferromanganese	93	67	91	83	88
Electric furnace, undistributed[e]	14	12	14	14	13
Total[5]	107	79	106	97	101
United States: Electric furnace:[21]					
Ferromanganese	193	119	86	[22]171	[22]154
Silicomanganese	173	69	W	([23])	([23])
Ferrosilicon	580	299	314	490	442
Silicon metal	130	77	122	141	121
Ferrochromium	164	92	20	[24]95	[24]110
Ferrochromium-silicon[25]	62	27	16	([26])	([26])
Other[27]	219	136	198	190	151
Total[5]	1,521	819	757	1,088	[7]977
Uruguay: Electric furnace, ferrosilicon	([4])	([4])	([4])	([4])	([4])
Venezuela: Electric furnace:					
Ferromanganese	2	2	2	2	2
Silicomanganese	[r]2	[r]2	10	10	8
Ferrosilicon	[r]24	[r]52	51	49	46
Total[5]	[r]29	[r]56	63	61	56
Yugoslavia: Electric furnace:					
Ferromanganese	56	43	44	[r e]55	52
Silicomanganese	32	22	29	[r e]42	42
Ferrosilicon	88	78	86	[r e]105	103
Silicon metal	31	33	29	[r e]41	41
Ferrochromium	76	56	70	[r e]74	74
Ferrochromium-silicon	6	7	7	[r e]7	7
Other	1	4	12	[r e]12	12
Total[5]	291	243	277	335	[7]330
Zimbabwe: Electric furnace:					
Ferromanganese	2	2	2	2	2
Ferrosilicon	28	14	30	47	47
Ferrochromium	[r]203	198	174	196	198
Total[5]	233	215	207	245	248
Grand total[5]	[r]15,833	[r]14,352	14,240	16,165	16,108
Of which:					
Blast furnace:					
Spiegeleisen[28]	[r]63	[r]60	60	60	59
Ferromanganese[28]	[r]1,394	[r]1,354	1,235	1,413	1,325
Ferrosilicon	55	46	44	77	47
Total blast furnace	[r]1,512	[r]1,460	1,339	1,550	1,431
Electric furnace:[10]					
Ferromanganese[29]	[r]3,143	[r]2,933	2,819	3,091	3,166
Silicomanganese[29 30]	[r]1,294	[r]1,212	1,193	1,429	1,433
Ferrosilicon	[r]3,598	[r]3,203	3,375	3,787	3,666
Silicon metal	[r]597	[r]546	587	687	684
Ferrochromium[31]	[r]2,920	[r]2,516	2,694	3,155	3,160
Ferrochromium-silicon[25 31]	140	[r]96	80	89	87
Ferronickel[32]	[r]526	[r]456	437	528	577
Ferrosilicomanganese	16	23	20	25	25
Other[32]	[r]906	[r]798	887	961	920
Undistributed	27	27	29	28	28

See footnotes at end of table.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1] —Continued

(Thousand short tons)

Country, furnace type,[2] and alloy type[3]	1981	1982	1983	1984[p]	1985[e]
Total electric furnace[5]	[r]13,167	[r]11,810	12,121	13,780	13,745
Furnace type unspecified:					
Ferromanganese[10]	1,157	1,087	777	827	932

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]Table includes data available through July 15, 1986.

[2]To the extent possible, ferroalloy production of each country has been separated according to the furnace type from which production is obtained; production derived from metallothermic operations is included with electric-furnace production.

[3]To the extent possible, ferroalloy production of each country has been separated so as to show individually the following major types of ferroalloys: spiegeleisen, ferromanganese, silicomanganese, ferrosilicon, silicon metal, ferrochromium, ferrochromium-silicon, and ferronickel. Ferroalloys other than those listed that have been identified specifically in sources, as well as those ferroalloys not identified specifically but which definitely exclude those listed previously in this footnote have been reported as "Other." For countries for which one or more of the individual ferroalloys listed separately in this footnote have been inseparable from some other ferroalloys owing to the nation's reporting system, such deviations are indicated by individual footnotes. In instances where ferroalloy production has not been subdivided in sources, and where no basis is available for estimation of individual component ferroalloys, the entry has been reported as "Undistributed."

[4]Less than 1/2 unit.

[5]Data may not add to totals shown because of independent rounding.

[6]Data for year ending Nov. 30 of that stated.

[7]Reported figure.

[8]Includes silicomanganese.

[9]Includes ferrochromium-silicon and ferronickel, if any was produced.

[10]Although furnace type has not been specified for any ferroalloy production for China, North Korea, and the Republic of South Africa, all output of these countries has been included under "Electric furnace" (and metallothermic) output except for their production of ferromanganese, which is reported separately.

[11]Includes ferrochromium-silicon, if any was produced.

[12]Colombia is reported to produce ferromanganese also, but output is not reported quantitatively, and no basis is available for estimation.

[13]Totals for 1981-85 represent estimates for silicon metal plus reported totals for all other types.

[14]Includes silicospiegeleisen.

[15]Includes ferronickel, if any was produced.

[16]Revised to zero.

[17]Series excludes calcium silicide.

[18]Estimated figures based on reported exports and an allowance for domestic use.

[19]Ferrovanadium only; other minor ferroalloys may be produced, but no basis is available for estimation.

[20]Soviet production of electric furnace ferroalloys is not reported; estimates provided are based on crude source material production and availability for consumption (including estimates) and upon reported ferroalloy trade, including data from trading partner countries.

[21]U.S. production of ferronickel cannot be reported separately in order to conceal corporate proprietary information.

[22]U.S. output of ferromanganese for 1984 and 1985 includes silicomanganese and manganese metal.

[23]U.S. output of silicomanganese for 1984 and 1985 included with ferromanganese.

[24]U.S. output of ferrochromium for 1984 and 1985 includes ferrochromium-silicon, chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.

[25]U.S. output of ferrochromium-silicon includes chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.

[26]U.S. output of ferrochromium-silicon for 1984 and 1985 included with "Ferrochromium."

[27]Includes ferronickel.

[28]Spiegeleisen for the Federal Republic of Germany is included with "Blast furnace ferromanganese."

[29]Ferromanganese includes silicomanganese (if any was produced) for countries carrying footnote 8 on "Ferromanganese" data line.

[30]Includes silicospiegeleisen for France.

[31]Ferrochromium includes ferrochromium-silicon (if any was produced) for countries carrying footnote 11 on "Ferrochromium" data line.

[32]Other includes ferronickel production for France, Norway, the U.S.S.R., and the United States.

Yugoslavian ferrosilicon producers planned to implement production cutbacks late in the year because of power availability problems and for economic reasons. Yugometal, the state marketing entity, announced in July that the new Kosovo ferronickel smelter was expected to export at least 11,000 tons of contained nickel to Austria, the Federal Republic of Germany, and Italy. Albania raised the possibility of sending some of its large nickeliferous iron ore deposits to the Kosovo Province for smelting there. Albanian ore shipments would depend on Yugoslavia completing its part of the new rail link from Shkodra to Titograd.

TECHNOLOGY

A novel application of plasma technology to metallurgical processes was reported in France. It involves the production of H-C FeMn via the blast furnace route. Société du Ferromanganese de Paris-Outreau (SFPO), believed to be the first company in the world to use plasma torches on a commercial-scale blast furnace, began this practice in the latter part of 1984. Modification to one of three existing blast furnaces at SFPO's Boulogne plant consisted of attaching a 1.5-MW megawatt plasma torch to each of three of the nine tuyeres of the furnace to superheat the blast. Each blast furnace has an annual capacity of 150,000 tons of ferromanganese. Coke consumption has been reduced up to 6% as a result of the installation. Since SFPO is a net producer of electricity and the price of electric power undergoes seasonal fluctuations, plasma usage at the Boulogne plant tends to be emphasized during the summer months when income from the plant's surplus electricity is at a minimum.[22]

Middleburg Steel & Alloys continued testing its experimental plasma furnace for ferrochromium production at its Krugersdorp plant in the Republic of South Africa. During initial trials, the 16-MV•A furnace was operated at a feed rate of about 4 tons per hour using a power input of 5 to 6 MW. Owing to downtime and interrupted operations, energy consumption was excessive, about 7-MWh per ton, or about twice that of the conventional SAEF. Subsequently, a number of changes were made in the system to improve efficiency of operation. More recently, the furnace was operated at 11 MW, which approaches maximum design capacity of 14 MW. The feed rate was 8 to 9 tons per hour. According to plant operators, energy consumption has been improved considerably, approaching that of a conventional furnace. Chromium recovery exceeds 90%, greater than that achieved in conventional smelting.[23]

The Bureau of Mines funded a research project on plasma smelting of Montana Stillwater chromite concentrates at the Mineral Resource Research Center of the University of Minnesota. A ferrochrome product was produced in the 200-kW furnace equipped with a hollow graphite electrode. The furnace is similar in design to Middleburg Steel & Alloys' 12- to 14-MW ASEA/MINTEK dc furnace developed at Krugersdorp.

The Center for Metals Production (CMP), administered by the Mellon Institute of Carnegie-Mellon University, Pittsburgh, PA, continued research in such areas as plasma technology, among others. The CMP was established in 1984 with a 5-year contract that averages $2.5 million per year from the Electric Power Research Institute (EPRI). EPRI, headquartered in Palo Alto, CA, is a nonprofit research and development organization. Its goal is to bring together electric utilities; energy intensive industries such as aluminum, ferroalloys, and steel; Government agencies; universities; and trade associations to do the type of front-end, collaborative research that has proven successful in Japan and other nations. The overall goal of this research effort is to help revive and strengthen the North American metals industry.

Japan's MITI has launched a national research project to develop a new process for ferrochromium production using alternate energy sources. The objective is to achieve production costs comparable to the cost of importing ferrochromium from the Republic of South Africa. Ferrochromium is normally produced in a SAEF. Of the three major Japanese steelmaking companies that have independently developed a new ferrochromium production process, Nippon Steel's appears to be the most promising. The process involves chromium ore smelting in a Linz-Donawitz converter by injection of powdered coal with oxygen and bottom blowing with argon to produce ferrochromium for argon-oxygen decarburization conversion to stainless steel. The new process is expected to lower the cost of ferrochromium production in Japan by 20% to 30%.

Mizushima Gokintetsu also in Japan, and a subsidiary of Kawasaki Steel, reported preparations to start using a coke-fed shaft furnace to produce H-C FeMn by a process similar to that of the blast furnace. The shaft furnace, converted from a SAEF at a cost of nearly $12 million, has a capacity of about 100,000 tons per year and represents about one-fourth of Japan's 1984 production of H-C FeMn. The shaft furnace is expected to lower costs below those of electric smelting by taking advantage of the availability and relatively low prices of reducing gases and other gases produced within the steelmaking complex where the shaft furnace is located. The shift from electric to shaft furnace smelting in Japan contrasts with the discontinuance of blast furnace smelting of ferromanganese in the United States nearly 10 years ago.

Another technological innovation in Japan reportedly is making it possible for steel mills to use manganese ore directly in the converter instead of ferromanganese. Information on the percentage breakdown of manganese ore and ferromanganese used in steelmaking in Japan is not known but some sources estimate that the share of ore will increase to 30% in the future.

Researchers at the U.S. Department of Energy's Argonne National Laboratory in Argonne, IL, have developed a two-step process to extract manganese and other metals from low-grade ores. The key element in the process is a mixture of chloride salts of magnesium, potassium, and sodium that melts at about 400° C and dissolves almost all of the manganese contained in the crushed ore. Unwanted materials remain in the depleted ore. A low voltage is then applied across the liquid mixture, and dissolved manganese is recovered in elemental form as deposits on carbon electrodes. The Government is currently assessing the possibility of adapting the process to deep-sea mining of metal-rich nodules known to rest on the ocean floor.[24]

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[1]Physical scientist, Division of Ferrous Metals.

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Fluorspar

By Lawrence Pelham[1]

Fluorspar was recovered by one major producer and three small producers. Domestic fluosilicic acid (H_2SiF_6) recovery, a byproduct of some phosphoric acid and hydrofluoric acid (HF) plants, increased 12% over revised 1984 production. In the chemical industry, fluosilicic acid continued to augment fluorspar as a source of fluorine.

The United States depended on foreign sources for over 90% of its fluorspar requirements. Imports and consumption decreased because of significant decreases in fluorspar consumption by HF and iron and steel producers and a substantial decrease in consumer stocks.

Domestic Data Coverage.—Domestic production data for fluorspar are developed by the Bureau of Mines from four separate, voluntary surveys of U.S. operations. Surveys are conducted to obtain fluorspar mine production and shipments, fluosilicic acid production, fluorspar briquet production, and fluorspar consumption. Of the five fluorspar mining operations to which a survey request was sent, 100% responded, representing 100% of the production shown in table 1. Of the 16 fluosilicic acid producers, 87% responded, representing 99% of the quantity reported. Of the five briquet producers, 80% responded, representing 78% of the quantity reported. The consumption survey was sent to approximately 140 operations quarterly and 40 additional operations annually. Of the operations surveyed quarterly, 55% responded for the first quarter, 74% responded for the second quarter; 42% responded for the third quarter; and 54% responded for the fourth quarter. Of the 40 operations surveyed annually, 50% responded. Together, quarterly and annual responses represented 100% of the apparent consumption data shown in table 1.

Table 1.—Salient fluorspar statistics[1]

	1981	1982	1983	1984	1985
United States:					
Production:					
Mine production ________ short tons__	415,862	199,714	W	W	W
Material beneficiated ________ do____	419,058	231,726	W	W	W
Material recovered ________ do____	111,281	76,316	W	W	W
Finished (shipments) ________ do____	115,404	77,017	[e]61,000	[e]72,000	[e]66,000
Value, f.o.b. mine ____ thousands__	$18,412	$13,293	[e]$10,000	W	W
Exports ________ short tons__	11,261	10,573	9,236	12,266	9,671
Value ________ thousands__	$1,194	$1,084	$962	$1,292	$1,063
Imports for consumption _____ short tons__	826,783	543,723	453,314	703,711	552,959
Value[2] ________ thousands__	$104,938	$67,665	$47,032	$65,241	$49,639
Consumption (reported) ______ short tons__	932,855	530,565	564,187	752,581	567,623
Consumption (apparent)[3] ________ do____	897,572	618,493	613,705	[r]742,431	682,965
Stocks, Dec. 31:					
Domestic mines:					
Crude ________ do____	200,698	164,094	W	W	W
Finished ________ do____	12,924	10,816	W	W	W
Consumer ________ do____	216,207	207,880	99,253	120,267	46,590
World: Production ________ do____	[r]5,616,455	[r]4,953,735	4,655,787	[p]5,270,263	[e]5,267,976

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Does not include fluosilicic acid (H_2SiF_6) or imports of hydrofluoric acid (HF) and cryolite.
[2]C.i.f. U.S. port.
[3]U.S. primary and secondary production plus imports, minus exports, plus adjustments for Government and industry stock changes.

Legislation and Government Programs.—At yearend, the National Defense Stockpile inventory was unchanged from 1984 levels at 895,983 short tons of acid grade and 411,738 tons of metallurgical grade. The stockpile goals for fluorspar remained at 1.4 million tons for acid grade and 1.7 million tons for metallurgical grade.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. The status of fluorspar was deferred until further detailed studies could be made. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

As in previous years, a 22% depletion allowance was granted against Federal income tax applied to the mining of domestic fluorspar compared with a 14% allowance for foreign production.

DOMESTIC PRODUCTION

Illinois remained the leading producing State, accounting for over 90% of all U.S. shipments. Data on shipments of fluorspar by State and grade were withheld to avoid disclosing company proprietary data.

Ozark-Mahoning Co., the Nation's largest fluorspar producer, operated three mines and a flotation plant in Pope and Hardin Counties, IL. Hastie Trucking and Mining Co. operated near Cave-In-Rock, IL. Hastie mined very little ore but shipped metallurgical-grade fluorspar from its stockpile to consumers. Inverness Mining Co., a former producer, dried imported fluorspar at its facilities at Cave-In-Rock, IL, and East Liverpool, OH, for sale primarily to consumers in the ceramic industry.

In the West, J. Irving Crowell, Jr. and Son produced and shipped metallurgical-grade fluorspar from its Crowell-Daisy Mine in Nye County, NV. D&F Minerals Co. produced and shipped a small quantity of metallurgical-grade fluorspar from its Paisano Mines, south of Alpine, TX. The Spor Bros. Fluorine Mine in Millard County, UT, reported mining activity.

Reported shipments of fluorspar briquets for use in steel furnaces increased 47% to approximately 148,000 tons from a revised production of 101,000 tons in 1984. Fluorspar briquets were produced by two plants owned by Cametco Inc., one plant owned by Mercier Corp., one plant owned by National Briquetting Co., and one plant owned by Oglebay Norton Co. Oglebay Norton also dried, packaged, and shipped imported ceramic- and acid-grade fluorspar.

Fourteen plants processing phosphate rock for the production of phosphoric acid and two plants producing HF sold or used 75,000 tons of byproduct fluosilicic acid, which was equivalent to 132,000 tons of fluorspar, valued at $4.2 million. Fluosilicic acid sold or used in 1984 was revised to 67,000 tons. According to the U.S. Department of Commerce, domestic production of sodium silicofluoride (100% Na_2SiF_6) was 21,622 tons in 1984. Total shipments were 19,594 tons in 1984 valued at $5,336,000. Sodium silicofluoride was made primarily from fluosilicic acid, which was converted to sodium salt by reaction with sodium carbonate, sodium hydroxide, or sodium chloride.

In 1985, Moodie Minerals Exploration Co. invested capital into the Babb-Barnes Mine and mill at Salem, KY, and planned to resume production. The mine had been owned, but not operated, by the Marathon Oil Co. The mine was last operated by Frontier Resources Inc., which had closed the mine in 1978 for economic reasons.

CONSUMPTION AND USES

Acid-grade fluorspar, containing greater than 97% calcium fluoride (CaF_2), was used as feedstock in the manufacture of HF, the key ingredient in the manufacture of fluorine chemicals for the aluminum, fluorochemical, and uranium industries. Ceramic-grade fluorspar, containing 85% to 95% CaF_2, was used in the ceramic industry for the production of glass and enamel, to make welding rods, and as a flux in making steel. Metallurgical-grade fluorspar, containing 60% to 85% or more CaF_2, was used primarily by the iron and steel industry as a flux.

Reported domestic consumption of fluorspar decreased 25% because of large decreases in the use of fluorspar for HF and iron and steel production. The HF and steel industries accounted for 72% and 25%, respectively, of reported consumption. According to the American Iron and Steel Institute (AISI), raw steel production decreased from 92.53 million tons in 1984 to 87.35 million tons in 1985. A comparison of the AISI data with fluorspar consumption data collected in the Bureau of Mines canvass of U.S. steel producers shows, on the average, a decreasing rate of fluorspar consumption per ton of raw steel produced during 1983-85; however, steel production in open-hearth furnaces showed an increasing rate of fluorspar consumption. On the basis of furnace type, the average fluorspar consumption per ton of raw steel was as follows:

Type of furnace	Fluorspar consumption (pounds per short ton)		
	1983	1984	1985
Open hearth	6.44	8.61	10.78
Basic oxygen	4.19	3.99	2.68
Electric	3.80	2.94	2.08
Industry average	4.30	4.06	3.08

In the ceramic industry, fluorspar was used as a flux and as an opacifier in the production of flint glass, white or opal glass, and enamels. Fluorspar was used in the manufacture of glass fibers, aluminum, cement, and brick, and was also used in the melt shop by the foundry industry.

Seven companies produced HF in seven plants. The U.S. Department of Commerce, Bureau of the Census, reported that anhydrous, technical, and aqueous HF "produced and withdrawn from the system" was approximately 162,400 tons, compared with 168,100 tons reported at yearend 1984 but later revised to 190,134 tons. HF produced and consumed in the same plant in 1984 was reported as 48,348 tons.

The Harshaw Filtrol Partnership closed its anhydrous HF unit at its Harvard-Denison chemical manufacturing facility in Cleveland, OH. The HF operation was in need of a large capital investment to maintain a competitive and safe operating level, and the company felt that market conditions for the expenditure were unjustified.

The consumption pattern of HF was reported as follows: fluorocarbons, 41%; aluminum production, 31%; petroleum alkylation, 4%; stainless steel production, 4%; uranium processing, 4%; rare metals, 4%; other, including glass etching, fluoride salts, and herbicides, 12%.[2] Chlorofluorocarbons were produced by five companies. According to U.S. International Trade Commission data, production of trichlorofluoromethane (F-11) decreased 12% to 81,300 tons; dichlorodifluoromethane (F-12) output decreased 17% to 141,000 tons; and chlorodifluoromethane (F-22) production decreased 14% to 109,350 tons.

Another major use of HF was in the synthesis of fluorine chemicals used in aluminum reduction cells. An estimated 40 to 60 pounds of fluorine was consumed for each ton of aluminum produced. Aluminum fluoride was used by aluminum producers to lower the melting point and increase the conductivity of electrolytes in the smelting process. It was also used as a flux ingredient for the removal of magnesium in the refining of aluminum scrap. Aluminum fluoride was used by the ceramic industry for some body and glaze mixtures and in the production of specialty refractory products. It was used in the manufacture of aluminum silicates and in the glass industry as a filler.

HF was consumed in concentrating uranium isotope 235 for use as nuclear fuel. It was also used in stainless steel pickling, petroleum alkylation, glass etching, oil and gas well treatment, and in the manufacture of a host of fluorine chemicals used in dielectrics, metallurgy, wood preservatives, pesticides, mouthwashes and decay-preventing dentifrices, plastics, and water fluoridation.

Fluosilicic acid was used primarily in water fluoridation, either directly or after being processed to sodium silicofluoride, and by the aluminum industry.

Allied Corp. started up a commercial-scale plant at Metropolis, IL, to produce fluorinated carbon products. Allied reported that its fluorinated carbons, which are made by reacting carbon with elemental fluorine, are nonfusable powders with good chemical resistance, high thermal stability, a low coefficient of friction, and variable electrical resistivity. Fluorinated carbons were used as a cathode material in lithium cells and as a solid lubricant.[3]

Table 2.—U.S. consumption (reported) of fluorspar, by end use

(Short tons)

End use or product	Containing more than 97% calcium fluoride (CaF_2)		Containing not more than 97% calcium fluoride (CaF_2)		Total	
	1984	1985	1984	1985	1984	1985
Hydrofluoric acid (HF)	530,527	408,880	--	--	530,527	408,880
Glass and fiberglass	4,952	1,337	846	1,083	5,798	2,420
Enamel and pottery	--	--	1,619	1,211	1,619	1,211
Welding rod coatings	8,414	9,867	2,600	1,460	11,014	11,327
Primary aluminum and magnesium	--	--	--	W	--	W
Iron and steel castings	924	--	15,591	8,689	16,515	8,689
Open-hearth furnaces	--	--	35,893	34,647	35,893	34,647
Basic oxygen furnaces	--	--	105,253	69,615	105,253	69,615
Electric furnaces	2,021	2,065	42,597	28,087	44,618	30,152
Other	--	--	1,344	682	1,344	682
Total	546,838	422,149	205,743	145,474	752,581	567,623
Stocks, Dec. 31	70,446	37,732	49,821	8,858	120,267	46,590

W Withheld to avoid disclosing company proprietary data; included with "Other."

Table 3.—U.S. consumption (reported) of subacid grades of fluorspar in 1985, by end use

(Short tons)

End use or product	Containing not more than 97% calcium fluoride (CaF_2)		
	Flotation concentrates	Lump or gravel	Briquets or pellets
Chemicals and allied products: Welding fluxes	1,460	--	--
Glass, ceramic, bricks:			
Glass	1,083	--	--
Other glass, clay products	1,211	--	--
Primary metals:			
Iron and steel foundries	122	8,541	26
Steel mills:			
Basic oxygen furnaces	1,685	25,012	42,918
Electric furnaces	1,814	25,075	1,198
Open-hearth furnaces	3,054	28,663	2,930
Other identified end uses	49	633	--
Total	10,478	87,924	47,072

Table 4.—U.S. consumption of fluorspar (domestic and foreign), by State

(Short tons)

State	1984	1985
Alabama, Kentucky, Tennessee	68,643	56,490
Arizona, Colorado, Utah	12,141	9,028
Arkansas, Kansas, Louisiana, Missouri	161,450	125,306
California	W	W
Connecticut, Massachusetts, New York, Rhode Island	6,540	4,108
Illinois	10,747	5,827
Indiana	37,919	37,306
Michigan	2,294	W
New Jersey	W	W
Ohio	72,723	36,538
Oregon and Washington	W	W
Pennsylvania	54,950	30,130
Texas	278,728	237,484
West Virginia	14,480	1,633
Other[1]	31,966	23,773
Total	752,581	567,623

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Iowa, Maryland, Virginia, Wisconsin, and data indicated by symbol W.

STOCKS

Fluorspar consumer stocks decreased 61% to about 47,000 tons.

PRICES

Domestic producer prices of all grades of fluorspar and fluorspar briquets reported in the Engineering and Mining Journal (E&MJ) remained at 1984 levels. E&MJ yearend price quotations serve as a general guide but do not necessarily reflect actual transactions.

Yearend price quotations in the Chemical Marketing Reporter (CMR) were $0.6875 per pound for anhydrous HF and $43.00 per 100 pounds for aqueous HF, 70%, in tanks. The CMR yearend price for cryolite was $550 per ton. CMR yearend price quotations for fluosilicic acid were $151.00 per ton for 15-gallon drums, 30% basis, and $110.00 per ton for tanks, 23% basis. All of these prices were unchanged from those of 1984.

Table 5.—Prices of domestic and imported fluorspar

(Dollars per short ton)

	1984	1985
Domestic, f.o.b. Illinois-Kentucky:		
Metallurgical: 70% effective CaF_2 briquets	125	125
Ceramic, variable calcite and silica:		
88% to 90% CaF_2	100	100
95% to 96% CaF_2	170	170
97% CaF_2	165-175	165-175
Acid, dry basis, 97% CaF_2:		
Carloads	173	173
88% effective CaF_2 briquets	179	179
European and South African:[1] Acid, term contracts	140-180	140-180
Mexican:[2]		
Metallurgical:		
70% effective CaF_2, f.o.b. vessel, Tampico	80.06	80.06
70% effective CaF_2, f.o.b. cars, Mexican border	75.63	75.63
Acid, bulk: 97+%, Mexican border	108.33	108.33

[1]C.i.f. east coast, Great Lakes, and gulf ports.
[2]U.S. import duty, insurance, and freight not included.

Source: Engineering and Mining Journal, Dec. 1984 and 1985.

FOREIGN TRADE

According to Bureau of the Census data, U.S. fluorspar exports of all grades decreased 21% and had an average value of $110 per ton. Synthetic cryolite exports decreased 24% to 13,000 tons, representing 15,600 tons of equivalent fluorspar, valued at $5.4 million.

Imports for consumption of fluorspar decreased significantly. Acid-grade imports decreased by 17%, and imports of subacid-grade material decreased by 34%. Imports from Mexico, the largest foreign supplier, were 51% of the combined fluorspar total. The Republic of South Africa supplied 33%; Spain, 6%; China, 4%; Italy, 3%; and Morocco, 3%. Small quantities were also imported from Canada, France, the Federal Republic of Germany, and the United Kingdom. The average unit value of imported acid- and subacid-grade fluorspar was $97.12 and $63.53, respectively.

U.S. import duties remained in effect for all grades of fluorspar. The duty was $1.875 per ton for acid grade and 13.5% ad valorem for ceramic and metallurgical grades.

Imports for consumption of HF decreased slightly to a quantity equivalent to about 157,000 tons of fluorspar. Imports for consumption of natural and synthetic cryolite decreased 27% and had an average value of $603 per ton. Cryolite imports represented 20,000 tons of equivalent fluorspar.

The United States also imported many fluorochemicals, including ammonium bifluoride, chlorodifluoromethane, dichlorodifluoromethane, fluorocarbon polymers, hexafluoropropylene, polytetrafluoroethylene, and trichlorodifluoromethane.

Table 6.—U.S. exports of fluorspar, by country

Country	1984		1985	
	Quantity (short tons)	Value	Quantity (short tons)	Value
Australia	--	--	33	$3,287
Canada	11,863	$1,188,601	8,503	851,036
Dominican Republic	317	82,759	1,018	185,447
Mexico	--	--	25	3,287
Venezuela	86	21,066	90	19,563
Total	12,266	1,292,426	[1]9,671	1,062,620

[1]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district

Country and customs district	1984		1985	
	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)
CONTAINING MORE THAN 97% CALCIUM FLUORIDE (CaF_2)				
Canada:				
Buffalo	--	--	24	$1
Detroit	259	$25	--	--
Laredo	81	6	437	41
Total	340	31	461	42
China:				
Baltimore	39	11	--	--
New Orleans	--	--	5,882	551
Total	39	11	5,882	551
France: Houston	113	37	517	199
Italy:				
Houston	61,619	7,325	15,765	1,557
New Orleans	--	--	2,480	259
Total	61,619	7,325	18,245	1,816
Mexico:				
El Paso	90,738	8,219	72,255	6,657
Houston	--	--	6,112	675
Laredo	120,437	11,125	95,580	8,967
New Orleans	15,612	1,646	3,451	194
Nogales	--	--	290	6
Total	226,787	20,990	177,688	16,499
Morocco: New Orleans	--	--	15,674	1,564
South Africa, Republic of:				
Houston	44,675	3,656	36,772	3,259
New Orleans	140,096	14,833	132,245	13,598
Philadelphia	9,958	959	12,085	1,294
Total	194,729	19,448	181,102	18,151
Spain:				
Cleveland	20,648	2,211	12,968	1,337
New Orleans	17,173	1,803	19,449	1,794
Total	37,821	4,014	32,417	3,131
United Kingdom: Milwaukee	--	--	24	2
Grand total	521,448	51,856	432,010	41,955

See footnote at end of table.

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district —Continued

Country and customs district	1984 Quantity (short tons)	1984 Value[1] (thousands)	1985 Quantity (short tons)	1985 Value[1] (thousands)
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE (CaF_2)				
Canada:				
Buffalo	425	$39	284	$19
Detroit	177	12	153	6
Pembina	--	--	97	11
Total	602	51	534	36
China:				
Baltimore	30,473	2,460	16,831	1,334
New Orleans	20,602	1,409	--	--
San Francisco	11,453	966	--	--
Total	62,528	4,835	16,831	1,334
Germany, Federal Republic of:				
Chicago	--	--	37	15
Houston	11	3	--	--
Total	11	3	37	15
Italy: Los Angeles	23	9	--	--
Mexico:				
Buffalo	401	42	1,318	82
Detroit	2,544	202	2,555	137
El Paso	16,699	796	9,453	441
Laredo	39,097	3,067	23,204	1,325
New Orleans	50,120	3,425	57,148	3,754
Philadelphia	7,445	725	9,869	560
Total	116,306	8,257	103,547	6,299
South Africa, Republic of: New Orleans	2,793	230	--	--
Grand total	182,263	13,385	120,949	7,684

[1]Customs, insurance, and freight (c.i.f.) value at U.S. port.

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption of hydrofluoric acid (HF), by country

Country	1984 Quantity (short tons)	1984 Value[1] (thousands)	1985 Quantity (short tons)	1985 Value[1] (thousands)
Canada	43,441	$36,644	36,637	$33,869
France	17	14	--	--
Germany, Federal Republic of	56	82	119	112
Japan	4,422	3,429	4,137	2,859
Korea, Republic of	--	--	17	13
Mexico	66,399	60,694	62,504	56,233
Mozambique	--	--	601	533
Netherlands	--	--	20	18
Spain	35	29	35	28
Taiwan	--	--	17	16
United Kingdom	61	48	324	336
Total	114,431	100,940	104,411	94,017

[1]Customs, insurance, and freight (c.i.f.) value at U.S. port.

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of cryolite, by country

Country	1984 Quantity (short tons)	1984 Value[1] (thousands)	1985 Quantity (short tons)	1985 Value[1] (thousands)
Brazil	17	$12	--	--
Canada	13,883	7,079	2,414	$1,287
China	19	10	--	--
Denmark	2,724	2,018	3,737	2,492
France	256	295	--	--
Germany, Federal Republic of	444	377	666	380
Greenland	65	61	--	--
Italy	--	--	3,327	1,960
Japan	3,663	2,554	5,169	3,244
Netherlands	98	72	907	532
United Arab Emirates	830	446	--	--
United Kingdom	723	200	376	108
Total	22,722	13,124	16,596	10,003

[1]Customs, insurance, and freight (c.i.f.) value at U.S. port.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Assessment and development work continued at Eaglet Mines Ltd.'s Quesnet Lake property in British Columbia. The large, low-grade deposit reportedly contained recoverable fluorspar, silver, lead, zinc, and molybdenum. Minworth Ltd., a British firm, continued development work to reopen a fluorspar mine near St. Lawrence, Newfoundland. The mine had been last operated in 1977 by the St. Lawrence Corp. and Newfoundland Fluorspar Ltd., formerly a subsidiary of Aluminum Co. of Canada Ltd.

France.—The Belgian firm Solvay & Cie. planned to spend approximately $10 million to increase production capacity of its fluorinated monomer and polymer complex in Tavaux, France. Plans were to increase vinylidene fluoride, used in the manufacture of fluorinated thermoplastic polymers and elastomers, from 1,650 tons per year to 5,500 tons and polyvinylidene fluoride (PVDF), a fire-retardant resin, from 1,650 tons to 2,500 tons by October 1986. Solvay has been the world's second largest producer of PVDF after Pennwalt Corp.[4]

United Kingdom.—Shell Chemicals UK Ltd. began expanding the capacity of its fluorochemicals production unit at Stanlow, Cheshire, by more than 50%. The unit, the largest of its kind in the world, has produced a variety of fluorinated compounds derived by halogen exchange chemistry. The expansion was to be completed during 1986.

Table 10.—Sales of Mexican fluorspar, by grade

(Short tons)

Grade	1981	1982	r1983	r1984	1985
Acid	532,765	338,732	400,579	508,235	409,800
Ceramic	100,511	27,202	49,285	54,562	51,982
Metallurgical	250,121	120,478	117,190	230,375	309,490
Submetallurgical	211,505	116,030	93,563	117,113	57,779
Total	1,094,902	602,442	660,617	910,285	829,051

rRevised.

Source: Instituto Mexicano de la Fluorita A.C.

Table 11.—Fluorspar: World production, by country[1]

(Short tons)

Country[2] and grade[3]	1981	1982	1983	1984[p]	1985[e]
Argentina	22,878	[illegible]6,155	31,950	25,526	27,500
Brazil (marketable):					
Acid grade	39,932	35,274	47,399	[e]49,600	51,800
Metallurgical grade	19,184	20,944	28,660	[e]33,000	37,500
Total	59,116	56,218	76,059	[e]82,600	89,300
China:[e]					
Acid grade	88,000	88,000	110,000	110,000	110,000
Metallurgical grade	440,000	440,000	440,000	606,000	606,000
Total	528,000	528,000	550,000	716,000	716,000
Czechoslovakia[e]	106,000	106,000	106,000	106,000	105,000
Egypt	590	99	13	[e]55	55
France:					
Acid and ceramic grade	185,960	177,725	155,957	175,378	165,000
Metallurgical grade	96,452	90,825	60,488	80,469	77,200
Total	282,412	268,550	216,445	255,847	242,200
German Democratic Republic[e]	110,000	110,000	110,000	110,000	110,000
Germany, Federal Republic of (marketable)	79,155	86,685	88,964	87,744	88,000
Greece[e]	[4]322	330	330	330	330
India:					
Acid grade	14,711	13,676	[e]12,000	[e]13,000	13,000
Metallurgical grade	5,924	6,294	[e]5,000	[e]6,000	6,000
Total	20,635	19,970	[e]17,000	[e]19,000	19,000
Italy:					
Acid grade	142,019	147,850	113,439	121,618	116,000
Metallurgical grade	39,018	36,180	82,409	85,904	83,000
Total	181,037	184,030	195,848	207,522	199,000
Kenya: Acid grade	105,849	97,804	65,129	51,343	55,000
Korea, North: Metallurgical grade[e]	44,000	44,000	44,000	44,000	44,000
Korea, Republic of: Metallurgical grade	7,125	4,042	7,012	5,150	5,500
Mexico:					
Acid grade	559,973	450,845	448,640	379,725	[4]417,469
Ceramic grade	119,049	59,525	50,706	40,307	[4]30,011
Metallurgical grade	338,409	182,983	80,469	235,079	[4]297,897
Submetallurgical grade[5]	212,746	116,845	87,082	115,878	[4]57,779
Total	1,230,177	810,198	666,897	770,989	[4]803,156
Mongolia: Metallurgical grade[e]	656,000	739,000	772,000	[r]816,000	816,000
Morocco: Acid grade	73,524	55,336	66,469	72,642	77,000
Pakistan	[r]6	[r]897	370	3,003	2,600
Romania: Metallurgical grade[e]	22,000	22,000	22,000	22,000	22,000
South Africa, Republic of:					
Acid grade	497,819	323,882	256,563	318,892	[4]341,949
Ceramic grade	6,744	10,613	7,061	4,963	[4]6,310
Metallurgical grade	42,758	30,188	31,356	28,010	[4]36,676
Total	547,321	364,683	294,980	351,865	[4]384,935
Spain:					
Acid grade	235,471	173,289	210,265	279,128	248,000
Metallurgical grade	47,963	40,868	45,840	46,788	49,600
Total	283,434	214,157	256,105	325,916	297,600
Thailand:					
Acid grade	60,827	89,314	51,466	62,998	44,000
Metallurgical grade	173,405	194,099	176,324	253,783	220,000
Total	234,232	283,413	227,790	316,781	264,000
Tunisia: Acid grade	38,409	36,607	37,493	49,064	49,600
Turkey: Metallurgical grade[e]	[4]2,189	2,200	2,200	2,200	2,200
U.S.S.R.[e]	585,000	595,000	595,000	606,000	617,000
United Kingdom	[r]281,640	[r]221,344	144,733	150,686	165,000
United States (shipments)	115,404	77,017	[e]61,000	[e]72,000	66,000
Uruguay[e]	(6)	(6)	(6)	(6)	--

See footnotes at end of table.

Table 11.—Fluorspar: World production, by country[1] —Continued

(Short tons)

Country[2] and grade[3]	1981	1982	1983	1984[p]	1985[e]
Grand total	[r]5,616,455	[r]4,953,735	4,655,787	5,270,263	5,267,976

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 13, 1986.
[2]In addition to the countries listed, Bulgaria is believed to have produced fluorspar, but production is not officially reported, and available information is inadequate for the formulation of reliable estimates of output levels.
[3]An effort has been made to subdivide production of all countries by grade (acid, ceramic, and/or metallurgical). Where this information is not available in official reports of the subject country, the data have been entered without qualifying notes.
[4]Reported figure.
[5]Same grade range as metallurgical but primarily contains greater quantities of silica impurities.
[6]Revised to zero.

TECHNOLOGY

The Oak Ridge National Laboratory developed a new method of removing silica from silicon carbide powders using gaseous hydrogen fluoride.[5]

A 2-year study jointly funded by E. I. du Pont de Nemours & Co. Inc. and Allied determined that trichlorotrifluoroethane, a chemical solvent sold as fluorocarbon-113 and used to clean metals and sensitive equipment such as electronic components, did not appear to be a carcinogen, mutagen, or teratogen in animal tests or human experience.[6]

The National Institutes of Health and Du Pont continued sponsoring research to develop a "blood substitute," or oxygen-transport fluid, using perfluorochemicals. Alpha Therapeutics Corp., a U.S. subsidiary of Green Cross Corp. of Osaka, Japan, applied for Food and Drug Administration (FDA) approval of its perfluorochemicals, emphasizing its use in treating heart problems and cancer. Admamantech, a subsidiary of Sun Co. Inc., was also conducting studies on perfluorochemicals.

The FDA approved the sale of flecainide acetate, the first of a new electrophysiologic class of drugs for the treatment of irregular heart rhythms. It was the first fluorine containing drug approved for cardiac arrhythmias.[7]

[1]Physical scientist, Division of Industrial Minerals.
[2]Chemical Marketing Reporter. V. 228, No. 10, 1985, p. 50.
[3]Chemical Week. V. 137, No. 23, 1985, p. 5.
[4]———. V. 137, No. 3, 1985, p. 43.
[5]Work cited in footnote 4.
[6]Chemical & Engineering News. V. 63, No. 30, 1985, p. 17.
[7]———. V. 63, No. 46, 1985, p. 61.

Gallium

By Deborah A. Kramer[1]

Domestic consumption of gallium increased moderately over that of 1984. No domestic primary gallium production was reported in 1985, and as a result, imports supplied most of the U.S. gallium demand. Gallium metal was used to produce gallium compounds, mainly gallium arsenide, for use in electronic devices, such as integrated circuits, light-emitting diodes (LED), and laser diodes.

Domestic Data Coverage.—Domestic consumption data for gallium are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the 53 operations to which a survey request was sent, 75% responded, representing 61% of the consumption shown in tables 1, 2, and 3. Consumption for the 13 nonrespondents was estimated using import data and information on domestic consumption trends.

Table 1.—Salient U.S. gallium statistics

(Kilograms unless otherwise specified)

	1981	1982	1983	1984	1985
Production[e]	1,500	1,560	--	--	--
Imports for consumption	5,536	5,199	7,294	9,669	7,961
Consumption	6,810	6,660	6,425	7,060	7,396
Price per kilogram	$630	$630	$525	$525	$525

[e]Estimated.

Legislation and Government Programs.—The Environmental Protection Agency (EPA) issued final regulations under the Clean Water Act for specified nonferrous metals manufacturing operations. These regulations limit the discharge of pollutants by existing and new operations into navigable waters and into publicly owned treatment works. Primary and secondary gallium operations were included under the EPA regulations, and effluent discharges were to be regulated for arsenic, fluoride, lead, and zinc contaminants. Daily and monthly effluent limits for these elements varied according to type of manufacturing operation and effluent source.[2]

DOMESTIC PRODUCTION

The U.S. gallium supply was obtained almost exclusively from imports. Eagle-Picher Industries Inc. recovered and refined gallium from primary and secondary material at its plant in Quapaw, OK.

Startup problems, including delays in equipment deliveries, bad weather, and extra time required to train operational crews, delayed the opening of Musto Exploration Ltd.'s primary gallium and germanium recovery plant near St. George, UT. The plant reportedly began limited production of 99.9%-pure gallium in October, but full-scale operation was postponed until 1986. Development continued on the Apex Mine ore zone, which reportedly contained recoverable quantities of copper, silver, and zinc, as well as gallium and germanium. Musto's plant was the only operation in the world to recover gallium or germanium as principal products, and when fully operational, the plant's annual production capacity was expected to be 10,000 kilograms of gallium and 17,900 kilograms of germanium.

According to a report published by the U.S. Geological Survey, most of the copper-rich ore at the Apex Mine was removed during previous mining operations, leaving behind iron-rich minerals containing most of the gallium and germanium. The remaining ore was defined as a goethite-limonite-hematite zone that contains local concentrations of jarosite, azurite, and malachite. Gallium was concentrated primarily in jarosite and in some limonite.[3]

CONSUMPTION

Domestic gallium consumption continued to increase primarily for use in electronic devices. Over 95% of the gallium consumed was in the form of compounds, mainly gallium arsenide, for semiconductors, LED, and laser diodes.

Gallium arsenide continued to receive attention during the year because of its semiconductor applications. Ford Motor Co. announced that it would construct a $33 million facility in Colorado Springs, CO, to produce gallium arsenide integrated circuits. The plant, which was expected to have the capability to produce 25,000 gallium arsenide wafers per year, was scheduled to begin production by yearend. Ford planned to develop gate-array chips and static random-access memory chips at the new facility.[4]

Spectrum Technology Corp., a manufacturer of gallium arsenide wafers, planned an expansion to increase manufacturing output by 300%. Expansion completion at the company's Holliston, MA, headquarters was scheduled for June.

General Electric Co. (GE) planned to invest $3.5 million in advanced equipment for its gallium arsenide research and development center in Syracuse, NY. GE intended to increase design productivity and produce monolithic microwave integrated circuits. By establishing a 3-inch-wafer handling capability, the company expected to increase the number of designs that could be developed.[5]

Table 2.—U.S. consumption of gallium, by end use

(Kilograms)

End use	1983	1984	1985
Specialty alloys	43	42	65
Electronics[1]	5,915	6,320	7,071
Research and development	410	641	260
Unspecified	57	57	--
Total	6,425	7,060	7,396

[1]Light-emitting diodes, semiconductors, and other electronic devices.

Table 3.—Stocks, receipts, and consumption of gallium[1]

(Kilograms)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
1984:				
97.0% to 99.9%	110	39	44	105
99.99%	4	r307	254	r57
99.999%	4	20	20	4
99.9999% to 99.99999%	1,712	r5,790	6,742	r760
Total	1,830	r6,156	7,060	r926
1985:				
97.0% to 99.9%	105	65	65	105
99.99%	57	396	419	34
99.999%	4	14	16	2
99.9999% to 99.99999%	760	6,919	6,896	783
Total	926	7,394	7,396	924

rRevised.
[1]Consumers only.

PRICES

The price of 99.99999%-pure gallium metal, quoted in American Metal Market (AMM), remained at $525 per kilogram in 100-kilogram lots throughout the year. At yearend, prices for the following gallium materials were published by AMM, in dollars per kilogram: gallium metal, 99.99% pure, in 100-kilogram lots, $435; gallium metal 99.9999% pure, imported, $430 to $460; gallium oxide, 99.99% pure, imported, $380 to $400; and gallium oxide, 99.999% pure, $415.

Quoted prices of gallium materials were unchanged from yearend 1984, except for that of imported 99.9999%-pure metal, which increased by $50 to $60 per kilogram.

FOREIGN TRADE

Export data for gallium metal and compounds were combined with data for other metal exports by the Bureau of the Census and could not be separately identified. Gallium metal and its compounds were exported in the form of electronic and electrical components.

Imports of gallium metal and waste and scrap declined moderately from those of 1984. Switzerland, France, and the Federal Republic of Germany, in decreasing order of receipts, continued to be the primary import sources, accounting for over 91% of U.S. imports. The average declared value of imported gallium increased to $433 per kilogram in 1985 from $419 per kilogram in 1984.

Beginning January 1, 1985, import duties for gallium compounds and gallium metal (TSUS 423.00 and TSUS 632.24, respectively) were 4% ad valorem for most favored nations (MFN) and 25% ad valorem for non-MFN.

Table 4.—U.S. imports for consumption of gallium (unwrought, waste and scrap), by country

Country	1984 Kilograms	1984 Value	1985 Kilograms	1985 Value
Belgium-Luxembourg	--	--	55	$19,800
Canada	1	$440	3	4,191
China	400	154,696	--	--
France	2,449	997,182	1,563	711,496
Germany, Federal Republic of	1,554	575,790	1,423	587,876
Hungary	168	61,430	--	--
Japan	89	40,317	105	29,351
Malaysia	5	1,630	40	14,400
Netherlands	131	49,120	50	19,725
New Zealand	132	53,030	--	--
Suriname	--	--	30	15,100
Sweden	--	--	201	112,302
Switzerland	4,088	1,938,711	4,268	1,847,744
Taiwan	--	--	50	17,000
United Kingdom	651	176,802	163	49,017
Other	r1	r883	10	19,080
Total	9,669	4,050,031	7,961	3,447,082

rRevised.

Source: Bureau of the Census.

WORLD REVIEW

Data for world gallium production were unavailable, but world production of primary gallium was estimated to be about 30,000 kilograms.

Japan.—Gallium demand in Japan was estimated to be between 36,000 and 40,000 kilograms for production of gallium arsenide and gallium phosphide used for LED, laser and infrared diodes, and other semiconductor applications. A significant portion of this demand was supplied by scrap material generated by manufacturing operations. Limited availability of Bayer liquor at Sumitomo Chemical Co. Ltd.'s alumina plant, as a result of a reduced operating rate, prevented the company's Niihama primary gallium recovery facility from operating at its full 10,000-kilogram-per-year capacity. Sumitomo also refined crude gallium and recovered gallium from scrap at its Niihama facility.[6]

Dowa Mining Co. Ltd. announced plans to construct a new gallium recovery plant at Kosaka to increase its annual gallium production capacity to 10,000 kilograms. Plant completion was expected late in 1985 or early 1986. Dowa's annual capacity at yearend 1985 was estimated to be 5,000 kilograms for primary gallium recovery and 1,000 kilograms for scrap recycling.

Switzerland.—Alcan Aluminium Ltd. (Canada) purchased the production technology, inventories, and markets of Swiss Aluminium Ltd.'s (Alusuisse) gallium operation. Alusuisse operated a gallium refinery at Neuheusen with an annual capacity of 10,000 kilograms. It was expected that the processing equipment would be moved to the Alcan rolling mill at Rorschach after the acquisition was finalized.

TECHNOLOGY

Scientists at the Bell Communications Research Center reportedly developed a technique called vapor levitation epitaxy (VLE) to float wafers on a cushion of gas while crystal layers are grown on the wafer. Gallium arsenide, indium phosphide, indium gallium arsenide, and indium gallium arsenide phosphide were grown by VLE. VLE reportedly produces exceptionally pure materials, which are important in fiber optics communication systems. The process also makes possible the growth of ultrathin layers of material, a few atoms thick, which are crucial to advanced optical device production. VLE reportedly allows the growth of structures that were not possible previously, and these structures can be grown on larger wafers with greater uniformity than was possible with existing production systems.[7]

Gould Inc. reportedly developed a gallium aluminum arsenide-gallium arsenide transistor, which the company claims is 3 times faster than conventional gallium arsenide devices and 10 times faster than conventional silicon devices. Use of a molecular beam epitaxy (MBE) process results in a structure that confines electron flow to a two-dimensional layer, providing lower noise levels. The new transistor was designed to replace gallium arsenide devices in very-high-frequency applications, such as satellites, radar, and electronic warfare systems, where low noise levels are required.

Using MBE techniques, scientists at Philips Research Laboratories in the United Kingdom reportedly produced gallium arsenide quantum well lasers that emit light in the visible part of the spectrum. Conventional gallium arsenide lasers emit light in the infrared wavelengths unless traces of aluminum are added to the active region to reduce the emission wavelength. In the production of the quantum well lasers, fast shutters are used to interrupt the molecular beams, allowing for changes in crystal composition within one atomic layer. One application for the laser already exists in optical information storage and retrieval systems, such as compact disk players.[8]

Researchers at the University of Illinois reportedly grew layers of gallium arsenide and gallium aluminum arsenide on silicon substrates by MBE. The researchers claim that performance of devices made from these wafers is almost identical to those fabricated from gallium arsenide substrates. Potential advantages of this technology include integration of high-speed gallium arsenide devices with silicon devices, the use of lower cost and high-quality silicon substrates, and development of gallium arsenide technology on larger silicon wafers. In the process, silicon substrates are cleaned to obtain a carbon-free surface by a series of alternating oxidation and oxide removal steps. Cleaned substrates, with a thin oxide layer, are loaded into an MBE system. Gallium arsenide growth is initiated by deposition of an arsenic layer, which provides nucleation sites for a layer of gallium. In this manner, atomic layers of gallium and arsenic are alternately deposited. Initially, a thin gallium arsenide layer is grown at a slow growth rate and low substrate temperature, after which the growth rate and substrate temperature are slowly raised to 1 micrometer per hour and 580° C, respectively.

Ferrofluidics Corp. was awarded a grant from the Israel-United States Binational Industrial Research Foundation for one-half the cost of the firm's $1.6 million gallium arsenide study program. The goal of the 3-year project was to develop a Czochralski gallium arsenide growing system, which was to be fully automated and would operate at low pressure. The company expected this system would produce improved material for use in both optical and semiconductor applications.

A newly formed company, Emcore Inc., offered modular production-scale equipment to produce gallium arsenide wafers. According to the company, the equipment can produce up to 40 wafers per day and can be altered to a customer's needs, unlike conventional equipment, which has a welded construction. Metal organic chemical vapor deposition (MOCVD) technology was used to fabricate the gallium arsenide wafers. In MOCVD, vapors of organic gallium and arsenic compounds are injected into a heated chamber where they decompose, and the gallium and arsenic deposit on a seed gallium arsenide wafer. By this method, deposition thickness can be carefully controlled, and chemical doping can be performed.

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Federal Register. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 50, No. 183, Sept. 20, 1985, pp. 38276-38402.

[3]Bernstein, L. R. Geology and Mineralogy of the Apex Germanium-Gallium Mine, Washington County, Utah. U.S. Geol. Surv. Bull. 1577, 1986, 9 pp.

[4]Guiles, M. G. Ford To Begin Manufacturing Semiconductors. The Wall Street J., v. 205, No. 52, Mar. 15, 1985, p. 12.

[5]Solid State Technology. GE Expands GaAs R&D. V. 28, No. 12, Dec. 1985, pp. 18-19.

[6]Metal Bulletin Monthly (London). Rapid Expansion in Gallium. No. 174, June 1985, pp. 41-43.

[7]Photonics Spectra. Floating Along. V. 19, No. 6, June 1985, pp. 40-41.

[8]———. More Progress in Quantum Well Lasers. V. 19, No. 11, Nov. 1985, p. 46.

Gem Stones

By Staff, Bureau of Mines

The value of gem stones and mineral specimens produced in the United States during 1985 was estimated to be $7.4 million, virtually the same as that of 1984. Amateur collectors accounted for much of the activity in many States. Small mine operators produced jade, opal, sapphire, tourmaline, and turquoise, which they sold mainly to wholesale and retail outlets, in gem and mineral shops, gem shows, and to jewelry manufacturers.

Domestic Data Coverage.—Domestic production data for gem stones are developed by the Bureau of Mines from the "Gem Stones" survey, a voluntary survey of U.S. operations. Of the 43 operations to which a survey request was sent, 33% responded. Production for the 29 nonrespondents was estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

DOMESTIC PRODUCTION

Mines and collectors in 46 States produced gem materials with an estimated value of $1,000 or more in each State. Ten States supplied 88% of the total value as follows: Arizona, $2.7 million; Nevada, $1.3 million; California, $550,000; Montana and Maine, $400,000 each; Oregon, $350,000; Wyoming, $225,000; and Arkansas, New Mexico, and Washington, $200,000 each. Estimated production increased 10% in California, 17% in Idaho, but decreased 11% in Montana and 13% in Oregon.

Lac Minerals Ltd. entered a joint venture with Superior Oil Co. in the continuing exploration of the Wyoming-Colorado border area near Tie Siding, WY, for diamond. The land holdings involve 63 unpatented claims and rights on an additional 2,500 acres leased from a Union Pacific subsidiary. Exploration revealed the existence of kimberlite pipes and dikes. A 3,000-short-ton bulk sample was processed through Superior's pilot plant at Fort Collins, CO, and found to be diamondiferous. A 500-carat sample of gem and industrial-quality diamonds was offered for sale by the parties, as part of the characterization studies, to determine the economic value.

A major new deposit of pink tourmaline (rubellite) associated with purple apatite was discovered at the Mount Rubellite Quarry near Hebron, ME. Purple and lavender apatite crystals also were found. The discovery could be the most significant gem stone find in Maine since the tourmaline discovery at Newry in 1972.

Exmin Corp. leased some lands in Minnesota's Morrison, Todd, and Wadena Counties to explore for diamonds. Some diamonds and kimberlite have been reported in Michigan and Wisconsin, and exploration continued in these two States in 1985.

A Texas partnership, Hanvey-Boulle Ltd., expressed a willingness to spend up to $2 million to take a core sample at the Crater of Diamonds State Park, Murfreesboro, AR, to determine if diamond mining is feasible. The State of Arkansas has final right of approval, and the Arkansas State Parks, Recreation, and Travel Commission appointed a special committee to examine any plans for commercial operations. A detailed proposal was requested from the firm by the committee. The firm indicated that the core sampling would involve drilling to a depth of 500 feet to determine the number of diamonds per hundred tons of soil. The firm also leased 3,000 acres of land surrounding the park, including several hundred acres leased from Anaconda Mining Co.[1]

CONSUMPTION

Domestic gem stone output went to amateur and commercial rock, mineral, and gem stone collections, objects of art, and jewelry. Value of apparent consumption increased slightly to $3,008 million from that of 1984.

U.S. consumption of colored stones, led by emerald, ruby, and sapphire, decreased. Annual sales of emerald continued to be almost equal to those of ruby and sapphire combined. The value of all imported gem stones, other than diamond, decreased 10%, with other cut, set and unset, principally cultured pearls, decreasing 12%, followed by emerald with a 10% decrease.

According to data reported by the U.S. Department of Commerce, the sales value of merchandise sold by jewelry stores in 1985 increased 9%, to $11.1 billion, over that of the previous year. Jewelers of America Inc. data indicated a substantial gain in colored gem stones sales, compared with diamond sales, for the Nation, and even more strongly for the Southwest.

PRICES

The U.S. price of 1.0-carat, D-flawless, investment-grade diamond fluctuated between $10,500 and $13,500 per carat, and at yearend was $12,750 per carat. However, only a few hundred of these perfect 1-carat stones have been available each year, and their value may have amounted to less than 0.2% of the total market.

Prices for colored stones experienced little change during the year.

Table 1.—Prices of U.S. cut diamonds, by size and quality

Carat weight	Description, color[1]	Clarity[2] (GIA terms)	Price range per carat[3] in 1985	Median price per carat[3] November 1984	Median price per carat[3] August 1985
0.04-0.08	G-I	VS_1	$400- $590	$490	$482
.04- .08	G-I	SI_1	400- 500	450	440
.09- .16	G-I	VS_1	440- 750	560	550
.09- .16	G-I	SI_1	410- 600	475	460
.17- .22	G-I	VS_1	670- 1,200	835	810
.17- .22	G-I	SI_1	490- 1,150	690	675
.23- .28	G-I	VS_1	720- 1,400	965	950
.23- .28	G-I	SI_1	650- 1,300	770	755
.29- .35	G-I	VS_1	860- 1,300	1,260	1,235
.29- .35	G-I	SI_1	720- 1,500	1,050	1,010
.46- .55	G-I	VS_1	1,400- 2,300	2,000	1,950
.46- .55	G-I	SI_1	850- 1,845	1,545	1,500
.69- .79	G-I	VS_1	1,700- 2,900	2,500	2,460
.69- .79	G-I	SI_1	1,400- 2,450	1,950	1,910
1.00-1.15[4]	D	FL	10,500-13,500	12,750	12,750
1.00-1.15	E	VVS_1	6,600- 7,900	7,500	7,200
1.00-1.15	G	VS_1	3,400- 5,200	4,200	4,120
1.00-1.15	H	VS_2	2,400- 4,800	3,300	3,300
1.00-1.15	I	SI_1	2,000- 3,800	2,600	2,600

[1]Gemological Institute of America (GIA) color grades: D—colorless; E—rare white; and G-I—traces of color.

[2]Clarity: FL—no blemishes; VVS_1—very, very slightly included; VS_1—very slightly included; VS_2—very slightly included, but more visible; and SI_1—slightly included.

[3]Jewelers' Circular-Keystone. V. 156, No. 14, Dec. 1985, p. 42; and v. 156, No. 12, Oct. 1985, p. 276. These figures represent a sampling of net prices that diamond dealers in various U.S. cities charged their customers during the month.

[4]The Diamond Registry Bulletin. V. 15, No. 1, Jan. 1985.

Table 2.—Prices of U.S. cut colored gem stones, by size[1]

Gem stone	Carat weight	Price range per carat in 1985[2]	Median price per carat,[1 2] November 1984
Amethyst	10	$6.50- $25	$17
Aquamarine	5	50 - 200	150
Citrine	10	5 - 20	10
Emerald:			
Colombian	1	250 -5,000	1,500
Zambian	1	250 -4,000	1,400
Commercial, 2d quality[3]		300 -1,600	550
Garnet, tsavorite	1	175 - 500	725
Ruby:			
Medium to better	1	460 -2,000	1,200
Commercial, 2d quality[3]	1	220 - 700	330
Sapphire:			
Medium to better	1	50 -1,500	700
Commercial, 2d quality[3]	1	165 - 480	220
Tanzanite	5	50 - 750	762
Topaz	5	10 - 500	210
Tourmaline, green[4]	5	50 - 250	132
Tourmaline, pink[4]	5	40 - 200	137

[1]Medium to better quality.
[2]Jewelers' Circular-Keystone. V. 155, No. 12, Dec. 1984, p. 44; and v. 156, No. 1, Jan. 1985, p. 52. These figures represent a sampling of net prices that colored stone dealers in various U.S. cities charged their cash customers during the month.
[3]The Gemstone Registry Bulletin. V. 2, No. 2, Jan. 1984, and v. 3, No. 1, Jan. 1985, p. 8.
[4]The Gemstone Registry Bulletin. V. 17, No. 3, Feb. 28, 1986, p. 8.

FOREIGN TRADE

The declared customs value of U.S. imports of rough and polished natural diamond, excluding industrial diamond, was up slightly to $3.0 billion. Total polished diamond imports, principally from Israel, 29%; India, 19%; and Belgium, 13%; were valued at $2.7 billion. Imports in the over-0.5-carat category, mostly from Israel, 30%; Belgium, 28%; and Switzerland, 13%; increased 7% in value to $1.1 billion. The value of imports in the less-than-0.5-carat group, mostly from India, 31%; Belgium, 29%; and Israel, 29%; increased slightly to $1.6 billion. Imports of rough natural diamond, 53% from the Republic of South Africa, decreased 4% in caratage and slightly in value. A 5% increase in South African carat value, from $325 to $341, was indicated.

The total value of emerald imports decreased 10% to $139 million. The total value of ruby imports decreased 13% to $70 million, and sapphire imports decreased 15% to $71 million. Average carat values increased 45% for emerald to $51. Average carat values increased 15% for ruby to $19 and decreased 18% for sapphire to $19.

Export value of all gem materials other than diamond increased 12% to $60.1 million. Of this total, other precious and semiprecious stones, cut but unset, were valued at $35.4 million; other natural precious and semiprecious stones, not set or cut, $12.2 million; synthetic gem stones and materials for jewelry, cut, $4.1 million; pearls, natural, cultured, and imitation, not strung or set, $3.6 million; and other, $4.2 million. Reexports of all gem materials, other than diamond, decreased 24% to $39.9 million. Reexport categories were precious and semiprecious stones, cut but unset, $22.9 million; and other, $16.9 million.

Table 3.—U.S. exports and reexports of diamond (exclusive of industrial diamond), by country

Country	1984 Quantity (carats)	1984 Value (millions)	1985 Quantity (carats)	1985 Value (millions)
Exports:				
Belgium-Luxembourg	128,521	$65.0	179,829	$82.3
Canada	19,043	11.0	23,012	12.2
France	2,153	7.1	1,763	8.3
Germany, Federal Republic of	3,677	3.7	2,937	2.5
Hong Kong	63,320	64.8	42,302	61.7
Israel	101,532	53.0	109,842	56.7
Japan	29,043	54.2	31,218	46.5
Singapore	3,734	9.2	2,039	4.4
Sweden	9	(1)	21	(1)
Switzerland	20,113	73.9	29,025	95.6
Thailand	3,813	2.4	5,226	2.8
United Arab Emirates	29	(1)	--	--
United Kingdom	5,707	14.2	3,966	4.0
Other	4,468	4.4	6,865	8.3
Total	385,162	362.9	438,045	385.3
Reexports:				
Belgium-Luxembourg	[2]1,072,640	57.4	839,257	56.7
Canada	7,834	.6	4,243	.3
China	17,784	.7	8,120	.4
Germany, Federal Republic of	32,530	1.5	53,318	1.6
Hong Kong	27,244	17.6	42,021	14.0
India	228,205	6.5	153,323	3.9
Israel	126,400	26.3	196,743	31.4
Japan	98,398	8.5	114,713	8.5
Netherlands	21,793	3.4	106,819	5.2
Switzerland	110,486	46.3	41,953	41.2
United Kingdom	93,442	32.6	297,044	12.2
Other	50,592	10.3	82,324	10.6
Total	1,887,348	211.7	1,939,878	186.0

[1]Less than 1/10 unit.
[2]Artificially inflated in 1984 by auction of approximately 1 million carats of U.S. Government stockpile industrial diamond stones with subsequent reexports as gem stones to Belgium-Luxembourg and India.

Source: Bureau of the Census.

Table 4.—U.S. imports for consumption of diamond, by kind, weight, and country

Kind, weight, and country of origin	1984 Quantity (carats)	1984 Value[1] (millions)	1985 Quantity (carats)	1985 Value[1] (millions)
Rough or uncut, natural:[2]				
Belgium-Luxembourg	160,100	$32.8	130,996	$32.9
Brazil	1,431	.3	90,280	6.6
Cape Verde	--	--	21	(3)
Colombia	216	.2	--	--
Congo	12,977	4.4	80	.2
Guyana	2,475	.1	636	(3)
Israel	14,880	4.7	27,198	8.3
Netherlands	4,675	4.1	9,643	8.0
South Africa, Republic of	794,912	258.3	555,907	189.4
Switzerland	7,748	7.2	15,106	10.4
United Kingdom	22,125	4.6	116,601	52.0
Venezuela	34,811	2.3	21,036	.8
Other	28,163	6.9	75,309	8.9
Total	1,084,513	325.9	1,042,813	317.5
Cut but unset, not over 0.5 carat:				
Belgium-Luxembourg	1,424,655	433.6	1,466,325	444.8
Brazil	20,567	6.0	22,790	2.5
Canada	38,567	5.2	19,607	6.6
Hong Kong	100,017	20.3	146,416	39.4
India	3,107,794	544.8	2,667,906	486.8
Israel	1,113,127	399.5	1,237,123	448.2
Malaysia	21,949	7.8	17,772	6.0
Netherlands	56,924	23.5	85,811	26.9
South Africa, Republic of	38,301	23.8	48,074	16.9
Switzerland	56,670	23.8	153,329	38.7
United Kingdom	33,332	15.3	35,138	13.4

See footnotes at end of table.

Table 4.—U.S. imports for consumption of diamond, by kind, weight, and country —Continued

Kind, weight, and country of origin	1984		1985	
	Quantity (carats)	Value[1] (millions)	Quantity (carats)	Value[1] (millions)
Cut but unset, not over 0.5 carat —Continued				
Other	44,030	$16.0	68,754	$22.2
Total	6,055,933	1,519.6	5,969,045	1,552.4
Cut but unset, over 0.5 carat:				
Belgium-Luxembourg	410,638	379.8	369,838	314.7
Hong Kong	13,697	22.5	24,259	37.0
India	83,415	23.2	47,709	16.1
Israel	342,221	259.5	439,038	340.9
Netherlands	32,846	33.6	34,951	35.5
South Africa, Republic of	61,595	89.8	76,025	77.4
Switzerland	56,618	134.0	46,098	148.5
United Kingdom	34,643	68.9	46,832	75.1
Other	51,200	48.6	54,397	91.5
Total	1,086,873	1,059.9	1,139,147	1,136.7

[1]Customs value.
[2]Includes some natural advanced diamond.
[3]Less than 1/2 unit.

Source: Bureau of the Census.

Table 5.—U.S. imports for consumption of natural precious and semiprecious gem stones, other than diamond, by kind and country

Kind and country	1984		1985	
	Quantity (carats)	Value (millions)	Quantity (carats)	Value (millions)
Emerald:				
Argentina	12,474	$1.3	122	(1)
Belgium-Luxembourg	10,092	2.8	106,895	$3.4
Brazil	197,367	13.8	219,068	6.0
Colombia	271,559	48.9	197,249	56.1
France	11,456	2.5	20,928	3.8
Germany, Federal Republic of	52,883	2.4	26,176	1.7
Hong Kong	114,630	11.3	317,142	10.8
India	3,220,565	16.7	1,413,167	11.0
Israel	162,559	19.6	101,683	11.5
Japan	28,516	1.4	12,661	1.4
Paraguay	25,790	(1)	--	--
South Africa, Republic of	3,118	.1	2,436	.4
Switzerland	103,859	20.8	163,048	23.9
Taiwan	2,758	(1)	1	(1)
Thailand	116,812	4.5	74,418	1.1
United Kingdom	20,008	4.6	20,403	2.8
Other	55,709	3.9	65,916	5.1
Total	4,410,155	154.6	2,741,313	139.0
Ruby:				
Austria	75,977	.1	99	(1)
Belgium-Luxembourg	14,246	1.9	11,381	1.7
Brazil	10,712	.1	18,993	(1)
Colombia	948	.2	4,701	.1
France	11,277	1.4	9,712	1.9
Germany, Federal Republic of	65,703	1.6	35,204	1.6
Hong Kong	71,857	5.5	110,033	3.7
India	226,782	1.8	221,923	1.3
Israel	99,663	2.1	42,921	1.2
Japan	33,146	.6	21,242	.5
Switzerland	81,943	12.6	296,877	15.6
Thailand	4,107,406	43.0	2,770,136	31.2
United Kingdom	21,208	6.1	33,713	6.4
Other	32,977	2.7	103,762	4.5
Total	4,853,845	79.7	3,680,697	69.7

See footnotes at end of table.

Table 5.—U.S. imports for consumption of natural precious and semiprecious gem stones, other than diamond, by kind and country —Continued

Kind and country	1984 Quantity (carats)	1984 Value (millions)	1985 Quantity (carats)	1985 Value (millions)
Sapphire:				
Australia	13,415	$0.4	1,070	(1)
Austria	1,186	(1)	122	(1)
Belgium-Luxembourg	20,436	1.8	32,047	$0.9
Brazil	13,209	.1	1,424	(1)
Canada	9,260	.6	2,717	.5
Colombia	1,647	(1)	2,057	.1
France	11,185	2.5	18,973	1.9
Germany, Federal Republic of	67,298	1.8	32,028	1.2
Hong Kong	98,180	3.8	166,329	4.8
India	175,855	1.7	92,456	1.0
Israel	71,286	1.6	56,909	1.2
Japan	45,737	1.3	50,770	.8
Korea, Republic of	22,478	.1	2,664	(1)
Singapore	22,955	.8	5,910	.4
Sri Lanka	28,999	2.7	32,464	1.5
Switzerland	87,879	15.7	431,909	17.0
Thailand	2,917,584	39.2	2,765,371	32.4
United Kingdom	36,973	6.6	60,549	6.1
Other	32,816	2.3	72,000	1.0
Total	3,678,378	83.0	3,827,769	70.8
Other:				
Rough, uncut:				
Australia		1.9		1.5
Belgium-Luxembourg		.4		(1)
Brazil		14.0		14.0
Canada		.1		(1)
Colombia		10.3		9.8
Hong Kong		.6		.9
Nigeria	NA	2.6	NA	.3
Pakistan		.5		.4
South Africa, Republic of		1.6		.2
Switzerland		.5		.1
United Kingdom		.6		.8
Zambia		.4		.3
Other		2.3		4.8
Total	NA	35.8	NA	33.1
Cut, set and unset:				
Australia		2.8		4.1
Brazil		32.7		10.5
Canada		1.3		1.0
China		5.0		4.5
Germany, Federal Republic of		12.0		12.3
Hong Kong		20.4		29.5
India	NA	6.1	NA	5.2
Japan		240.7		200.9
Switzerland		.7		4.7
Taiwan		5.4		6.2
Thailand		2.8		3.4
United Kingdom		1.5		1.7
Other		5.6		12.6
Total	NA	337.0	NA	296.6

NA Not available.
[1]Less than 1/10 unit.

Source: Bureau of the Census.

Table 6.—Value of U.S. imports of synthetic and imitation gem stones, including pearls, by country

(Million dollars)

Country	1984	1985
Synthetic, cut but unset:		
Austria	0.8	0.4
France	1.4	.9
Germany, Federal Republic of	5.5	5.5
Japan	1.4	.1
Korea, Republic of	9.4	7.1
Switzerland	3.6	2.2
Other	1.7	1.4
Total	23.8	17.6
Imitation:		
Austria	17.4	23.0
Czechoslovakia	1.8	1.7
Germany, Federal Republic of	6.0	8.9
Japan	4.5	6.3
Other	2.7	3.6
Total	32.4	43.5

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1984		1985	
	Quantity	Value	Quantity	Value
Diamonds:				
Rough or uncut[1]	1,085	325,851	1,043	317,584
Cut but unset	7,143	2,579,466	7,108	2,689,178
Emeralds: Cut but unset	4,410	154,644	2,741	139,045
Coral: Cut but unset, and cameos suitable for use in jewelry	NA	3,120	NA	2,224
Rubies and sapphires: Cut but unset	8,532	162,677	7,509	140,618
Marcasites	NA	152	NA	256
Pearls:				
Natural	NA	2,823	NA	2,997
Cultured	NA	240,439	NA	228,004
Imitation	NA	6,171	NA	8,396
Other precious and semiprecious stones:				
Rough, uncut	NA	35,792	NA	33,168
Cut, set and unset	NA	90,421	NA	63,070
Synthetic:				
Cut but unset[2]	52,484	21,368	52,164	17,590
Other	NA	2,410	NA	2,457
Imitation gem stones	NA	26,182	NA	35,333
Total	XX	3,651,516	XX	3,679,920

NA Not available. XX Not applicable.
[1]Includes 2,084 carats of other natural diamond, advanced, valued at $700,100 in 1984, and 630 carats valued at $1,062,100 in 1985.
[2]Quantity in thousands of stones.

Source: Bureau of the Census.

WORLD REVIEW

De Beers Consolidated Mines Ltd.'s sales in 1985 through the Central Selling Organization were estimated to be $1.8 billion compared with $1.61 billion in 1984. Second half 1985 sales were unusually strong. Sales of colored gems also did very well.

Emeralds were produced in Australia, Colombia, Mozambique, Pakistan, the Republic of South Africa, the U.S.S.R., Zambia, and Zimbabwe. Sapphires were produced in Australia and Sri Lanka. Aquamarines were produced in Brazil and in very minor amounts in several other countries.

Australia.—Argyle Diamond Mines Joint Venture produced a total of about 17 million carats from its alluvial operation before the operation was closed in October. The second phase, production from the AK-1 kimberlite pipe, commenced on schedule in December. The firm estimated that the

AK-1 deposit would produce about 25 million carats per year for about 20 years.[2]

Botswana.—The new Jwaneng Mine expanded its diamond production. While mining was centered in the middle lobe, stripping proceeded on the northeastern lobe. The ore grade increased by 23% at the Jwaneng Mine, by 30% at the Letlhakane Mine, and by 8% at the Orapa Mine.

Burma.—The Ministry of Mines carried out exploration for diamonds by test pitting and drilling. It discovered 68 diamonds with a total weight of 65.31 carats in the period April 1, 1984, to December 31, 1984. Most of these were industrial diamonds.

Demand for Burmese rubies, particularly the bright red, continued to be strong. Very little material of comparable quality was available from other producers, such as Kenya, Tanzania, and Pakistan, in 1985. Rubies from Afghanistan were comparable but their availability was limited.

Guinea.—Diamonds from the Aredor project reached the New York market in midyear after some delay caused by adverse mining conditions. Société Mixte Aredor-Guinea was granted the sole right to explore and mine within its concession. Prior to this, private Guinean citizens could also mine in the concession. The private sector partners will market all the diamonds until the loans are paid off, after which the Government of Guinea will have the right to sell 30% of the rough gem diamonds and 50% of the rough industrial diamonds. The project was scheduled to produce from 250,000 to 500,000 carats per year.[3]

India.—The Indian diamond industry was almost exclusively dependent on imports of rough diamonds because domestic production usually totals under 15,000 carats. Imports of rough diamonds for Indian fiscal year 1983-84 totaled 28.4 million carats, the bulk of which came from De Beers. India's efforts to import diamonds directly from producers was of limited success. Some direct imports from Botswana, Ghana, and Sierra Leone were arranged. Indian exports of cut and polished diamonds for Indian fiscal year 1983-84 totaled 5.65 million carats, making India the world's leading diamond exporter, and diamonds India's largest single export item. Nearly 45% of the diamonds was exported to the United States. Japan was the second largest buyer, accounting for 11%, much less than that of the United States.

In response to foreign competition, the Indian industry announced plans to introduce foreign technology and machinery into what had been a cottage industry and was considering the production of sawn diamonds. The Government of India reduced duties on diamond cutting machinery and tools. Plans for a public-private joint venture to build a 1,300-acre self-contained diamond industrial park in Surat were announced.

India opened its first diamond exchange in Bombay on February 25. Titled the Bharat Diamond Bourse, it enrolled 150 members and provided them with customs clearance facilities and a vault for storing consignments.

The Government of India staged a series of income tax raids on diamond traders to seize records and diamond stocks as a part of its overall campaign against Government corruption and the underground economy. The industry responded by stopping all rough diamond imports and closing down operations. After a month of negotiations between the Government and the industry, activity resumed.[4]

Israel.—Imports of rough diamonds in the period January-October 1985 were $919 million, up 28.4% over the same period in 1984. Exports of cut and polished diamonds in the period January-October 1985 were $1,034 million, up 20.4% over the same period in 1984.

Namibia.—The Government-established Thirion commission of inquiry that had been investigating allegations of corruption and misappropriation of funds in the diamond industry for several years obtained evidence that the Diamond Board had not been exercising its regulatory powers over diamond mining as was originally intended. Interest centered on the alleged serious undervaluation of taxable diamond exports and on the excessive depletion of reserves in the diamond deposits. The Thirion commission's major purpose was to recommend ways of obtaining a greater degree of governmental control over the mining industry.

Pakistan.—The Pakistani Federal Bureau of Statistics reported that $1.5 million worth of gem stones was exported in the latest period, the fiscal year 1983-84, mainly to Hong Kong, the Federal Republic of Germany, the United States, and the United Kingdom. The exports, by type, included 130,282 kilograms of rough emeralds and 326 kilograms of cut emeralds, 6,062 kilograms of rough rubies and 3,912 kilograms of cut rubies, and 430 kilograms of rough sapphires and 865 kilograms of cut sapphires.

Table 8.—Diamond (natural): World production, by country[1]

(Thousand carats)

Country	1981			1982			1983			1984[p]			1985[e]		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem[2]	Industrial	Total	Gem[2]	Industrial	Total	Gem[2]	Industrial	Total
Angola	1,050	350	1,400	915	310	1,225	775	259	1,034	750	250	[e]1,000	375	250	625
Australia	21	184	205	[r]274	[r]183	[r]457	3,720	2,480	6,200	3,414	2,276	5,690	[3]4,235	[3]2,824	[3]7,059
Botswana	744	4,217	4,961	1,165	6,604	7,769	4,829	5,902	10,731	5,810	7,104	12,914	5,800	7,100	12,900
Brazil	163	926	1,089	80	450	530	80	450	530	200	550	750	200	800	1,000
Central African Republic	209	103	312	186	91	277	230	65	295	236	101	337	236	101	337
China[e]	190	760	950	200	800	1,000	200	800	1,000	200	800	1,000	200	800	1,000
Ghana	85	751	836	68	616	684	34	306	340	35	315	[e]350	65	585	650
Guinea[e]	12	26	38	13	27	40	23	17	40	[3]34	[3]14	[3]48	105	7	[3]112
Guyana[e]	4	6	10	[r]4	[r]7	11	5	[r]5	[r]10	[r]6	[r]8	[r]14	4	7	11
India	14	2	16	11	2	13	12	2	14	[r]13	2	15	14	2	16
Indonesia[e]	3	12	15	3	12	15	5	22	27	5	22	27	5	22	27
Lesotho	49	4	53	39	3	42	--	--	--	--	--	--			
Liberia	132	204	336	170	263	433	132	198	330	108	132	240	108	132	240
Namibia	1,186	62	1,248	963	51	1,014	915	48	963	884	46	930	894	47	941
Sierra Leone	208	97	305	203	87	290	242	103	345	240	105	[e]345	240	105	345
South Africa, Republic of:															
Finsch Mine	1,002	3,463	4,465	847	3,003	3,850	1,765	3,278	5,043	1,714	3,184	4,898	1,770	3,184	[3]4,954
Premier Mine	510	1,530	2,040	615	1,845	2,460	800	1,844	2,644	765	1,785	2,550	820	1,864	[3]2,684
Other De Beers' properties[4]	1,603	1,069	2,672	1,359	906	2,265	1,400	569	1,969	1,452	593	2,045	1,500	569	[3]2,069
Other	314	35	349	521	58	579	589	66	655	585	65	650	460	35	495
Total	3,429	6,097	9,526	3,342	5,812	9,154	4,554	5,757	10,311	4,516	5,627	10,143	4,550	5,652	[3]10,202
Swaziland	--	--	--	--	--	--	--	--	--	7	10	17	10	15	25
Tanzania	110	107	217	100	120	[e]220	183	78	261	186	80	266	186	80	266
U.S.S.R	2,100	8,500	10,600	2,100	8,500	10,600	3,700	7,000	10,700	4,300	6,400	10,700	4,400	6,400	10,800
Venezuela	102	388	490	99	394	[e]493	45	234	279	40	232	272	35	163	198
Zaire	[r]360	[r]6,801	[r]7,161	[r]308	[r]5,856	[r]6,164	3,355	8,627	11,982	5,169	13,290	18,459	5,493	14,124	19,617
World total	[r]10,171	[r]29,597	[r]39,768	[r]10,243	[r]30,188	[r]40,431	23,039	32,353	55,392	26,153	37,364	63,517	27,155	39,216	66,371

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 3, 1986. Total diamond output (gem plus industrial) for each country is actually reported except where indicated by a footnote to be estimated. In contrast, the detailed separate production data for gem and industrial diamond are Bureau of Mines estimates in the case of every country except Australia (1981-85), Central African Republic (1981, 1983-85), Guinea (1984), Liberia (1981, 1984), Sierra Leone (1981), and Venezuela (1981), for which source publications give details on grade as well as totals. The estimated distribution of total output between gem and industrial diamond is conjectural, and for most countries, is based on the best available data at time of publication.

[2]Includes near-gem and cheap-gem qualities.

[3]Reported figure.

[4]Other De Beers Group output from the Republic of South Africa includes Kimberley Pool, Koffiefontein Mine, and the Namaqualand Mines.

South Africa, Republic of.—The Minister of Finance announced a special temporary surcharge of 5% over and above the 20% surcharge already in effect on taxes paid by all domestic diamond and gold mines. The new surcharge was added in view of mining profits obtained owing to the favorable rand-dollar exchange rate in 1984. The Chamber of Mines, a mining trade association, responded by saying that any additional profits had been absorbed by increased capital expenditure.

De Beers reported about 95% of 1985 South African diamond production, or about 9.7 million carats. Its Finsch Mine, the largest diamond mine in the Republic of South Africa, produced 4.9 million carats, and its Premier Mine produced 2.7 million carats. Other sources indicate that in 1984, 73% of South African production was from Cape Province, 26% from Transvaal, and the balance from the Orange Free State.

The Finsch Mine worked slightly lower grade ore, in accordance with management's plan. The Premier Mine experienced no further collapse of the gabbro sill. Investigations indicated that retreatment of the mine's tailings pile appeared to be feasible, and the work was scheduled to begin during 1985.

Swaziland.—Trans Hex Co. was involved with its joint venture partner, the Swaziland Government, in a $5 million expansion of mining activity at its kimberlite pipe. The open pit extraction of industrial and low-quality gem diamonds, plus smaller amounts of good-quality gems, was expected to last at least 8 years. The expansion in capacity was expected to go on-stream in October 1985.

Zaire.—Société Minière de Bakwanga (MIBA) produced 6,896,000 carats in 1984 and exported 6,902,000 carats worth $57.9 million. MIBA invested $9.7 million in a new hydroelectric power station plus substantial sums on geological exploration and research, modernization of workers' housing, and improving the security of the operations.

Zambia.—The Government instituted new regulations on emerald mining in 1984, which were implemented in 1985. Prospecting and mining licenses must be obtained from the Ministry of Mines. Any company seeking a license must form a joint venture with the Government-owned Reserved Mineral Corp. holding a 55% majority of the shares. Several dozen local cooperatives have obtained licenses. The army and police have removed and will continue to remove illegal diggers from the emerald area until Reserved Mineral's new security service can take over completely.

TECHNOLOGY

Sumitomo Electric Co. perfected a technique for the mass production of large industrial diamonds from graphite. The graphite was subjected to ultrahigh pressure in the range of 50,000 to 60,000 atmospheres at a temperature of 1,400° C to 1,600° C for 100 hours. Attaining this critical temperature and pressure on a consistent basis was difficult, but was achieved. Heretofore, only small-sized diamonds could be mass produced. The firm planned to underprice natural diamond slightly and make its sales mainly to the semiconductor and precision toolmaking industries. Although the firm had no immediate plans for the production of gem diamonds, this breakthrough could clearly result in the production of gem diamonds in the near future.[5]

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[1]Arkansas Gazette. Texas Firm Willing To Spend $2 Million on Tests at Crater of Diamonds. Oct. 12, 1985, p. 2.

[2]Industrial Minerals (London). World of Minerals. No. 220, Jan. 1986, p. 8.

[3]Jewelers' Circular-Keystone. Upfront. V. 156, No. 6, Apr. 1985, p. G.

[4]Shor, R. What if India Offers Quality Diamonds at Bargain Rates? Jewelers' Circ.-Keystone, v. 155, No. 8, June 1985, pp. 187-201.

[5]Industrial Minerals (London). Synthetic Diamond Breakthrough. No. 213, June 1985, p. 10.

Gold

By J. M. Lucas[1]

Weak gold prices during 1985 did not appear to have appreciably lessened exploration and development activity for new gold deposits both in the United States and in the rest of the world.

Domestic gold production, at nearly 2.5 million ounces,[2] reached its highest level since 1942. Substantial increases in production were registered in Australia, Brazil, Colombia, Japan, New Zealand, and Papua New Guinea.

Overall world gold consumption remained steady, with increased demand for gold jewelry offsetting declines in other sectors. The supply of new gold to the market decreased from that of 1984 as central banks and government-controlled investor institutions became net buyers of gold instead of net sellers.

Table 1.—Salient gold statistics

	1981	1982	1983	1984	1985
United States:					
Mine production thousand troy ounces	1,379	1,466	r2,003	r2,085	2,475
Value thousands	$633,918	$550,968	r$849,071	r$751,833	$786,345
Percentage derived from:					
Precious metals ores	71	80	83	87	93
Base-metal ores	27	17	14	11	5
Placers	2	3	3	2	2
Refinery production:					
Domestic and foreign ores thousand troy ounces	805	719	892	r764	620
Secondary (old scrap) do	1,610	1,444	1,380	1,310	1,215
Exports:					
Refined do	5,238	1,637	1,881	3,482	2,888
Other do	1,199	1,333	1,258	1,499	1,078
Imports for consumption:					
Refined do	4,164	4,238	3,599	6,032	6,361
Other do	488	682	994	1,837	1,865
Gold contained in imported coins do	2,612	2,908	1,948	2,769	2,064
Net deliveries from foreign stocks in Federal Reserve Bank do	1,181	1,330	-220	381	484
Stocks, Dec. 31:					
Industry[1] do	635	776	r623	r765	639
Futures exchange do	2,449	2,303	2,530	2,359	2,110
Department of the Treasury:					
Gold medallion sales[2] do	189	63	634	419	48
Olympic gold coin sales do	--	--	--	[3]156	24
Consumption in industry and the arts do	3,276	3,423	3,061	r3,164	3,100
Price:[4] Average per troy ounce	$459.64	$375.91	$424.00	$360.66	$317.66
Employment[5]	7,500	6,800	r6,500	r6,900	6,900
World:					
Mine production thousand troy ounces	r41,250	r43,127	44,996	p46,408	e48,217
Official reserves[6] million troy ounces	1,150.0	1,145.1	1,143.0	r1,142.1	1,143.8

eEstimated. pPreliminary. rRevised.
[1]Unfabricated refined gold held by refiners, fabricators, dealers, and U.S. Department of Defense.
[2]Sales program began July 15, 1980.
[3]Includes coins sold in 1982 and 1983 for delivery in 1984.
[4]Engelhard Industries quotation.
[5]Mine Safety and Health Administration.
[6]Held by market economy country central banks and governments and international monetary organizations. Source: International Monetary Fund.

Table 2.—Volume of U.S. gold futures trading

(Million troy ounces)

Exchange	Location	1981	1982	1983	1984	1985
Chicago Board of Trade	Chicago	1.47	1.96	10.15	9.73	5.42
Commodity Exchange Inc	New York	1,041.67	1,212.40	1,038.28	911.55	788.40
International Monetary Market[1]	Chicago	251.82	153.35	99.40	.88	(2)
MidAmerica Commodity Exchange	do	15.59	12.73	11.59	2.02	1.04
Total		1,310.55	1,380.44	1,159.42	924.18	794.86

[1]A division of the Chicago Merchantile Exchange.
[2]Less than 1,000 ounces traded. Trading ceased July 10, 1985.

Domestic Data Coverage.—Domestic mine production data for gold are developed by the Bureau of Mines from two separate, voluntary surveys of U.S. operations. Typical of these surveys is the lode-mine production survey of gold, silver, copper, lead, and zinc mines. Of the 136 lode gold producers in operation to which a survey request was sent, 83% responded, representing 85% of the total lode-mine production of gold shown in tables 6 and 7. Production for the nonrespondents was estimated, using reported prior year production levels, adjusted by trends in employment and other guidelines such as company annual reports, the news media, and State agency reports.

Legislation and Government Programs.—More than 50 bills for gold and/or silver coins were introduced in the Congress in 1985; of this number, 2 were signed into law. The Statue of Liberty-Ellis Island Commemorative Coin Act, providing for the minting of gold and silver coins, became Public Law 99-61 on July 9. On December 17, the President signed the Gold Bullion Coin Act of 1985, thereby authorizing the U.S. Department of the Treasury to begin the minting of general-circulation gold coins. The coins, the first domestic legal tender gold coins to be minted in more than 50 years, were to be minted in four sizes containing from 0.10 to 1 troy ounce of gold. The enabling legislation, Public Law 99-195, specifically mandated that gold to be used in the minting come from U.S. mines and, in the absence of adequate available supplies at world prices, from Treasury bullion reserves.

With an executive order signed on October 1, the President banned imports of South African gold Krugerrand coins. The prohibition became effective on October 11, 1985.[3]

March 1 marked the completion of the Department of the Treasury's gold medallion sales program begun in mid-1980 and developed to reduce the outflow of U.S. dollars to foreign gold-coin-producing countries. During the life of the program, over 1.7 million ounces of gold in medallion form were sold. Legislation to extend the program for another 5 years was pending in the Congress.

On October 4, 1985, the Environmental Protection Agency (EPA) issued final rules establishing effluent limitations guidelines and standards limiting the discharge of pollutants into navigable waters and into publicly owned treatment works by existing and new sources conducting particular nonferrous metals manufacturing operations. Included in the rulemaking were primary and secondary precious metals operations.[4] Proposed effluent limitations guidelines and standards were issued by EPA on November 20, under the Clean Water Act, to limit effluent discharges of pollutants to waters of the United States from existing and new sources in the gold placer mining segment of the ore mining and dressing industry. EPA provided an extended comment period to allow affected miners adequate time to comment.[5]

Several States enacted legislation in 1985 affecting gold. On April 24, the Governor of Colorado approved legislation regulating the use of cyanide in Colorado mining operations.[6] In Washington State on May 21, the Governor signed legislation removing the State's sales tax on precious metal bullion and rare coins. The action was taken to align the State with practices in adjoining States and thereby discourage out-of-State commerce in these products.[7]

DOMESTIC PRODUCTION

Despite lower gold prices than those of 1984, the search for new gold deposits, the development of new gold mines, and the expansion of existing operations combined to result in yet another excellent year for the Nation's gold mining industry. Nevada, with a 1985 gold production of over 1 million ounces, continued as the number one gold-producing State in the Nation.

Of the 2.5 million ounces of gold produced in the Nation, 88% was attributed to the 25 leading producers. The average recovery grade of gold ores processed from lode-mine sources was 0.06 ounce per short ton, while placer gravels yielded an average of 0.02 ounce per cubic yard washed.

Domestic refinery production from domestic and imported ores, concentrates, and semirefined products declined from that of 1984, reflecting, in part, a substantial decline in the processing of gold-bearing copper ores of both foreign and domestic origin. The production of refined gold from old scrap, over 1.2 million ounces, declined for the fifth consecutive year from the high production level set in 1980, a year when historically high prices for precious metals attracted a large volume of scrap to the market.

Table 3.—Mine production of gold in the United States, by State

(Troy ounces)

State	1981	1982	1983	1984	1985
Alaska	26,531	30,513	39,523	r19,433	44,733
Arizona	100,339	61,050	61,991	r54,897	52,053
California	6,271	10,547	38,443	85,858	165,101
Colorado	51,069	64,584	63,063	60,010	43,301
Idaho	W	W	W	W	44,306
Michigan	--	--	--	--	W
Montana	54,267	75,171	161,436	181,190	160,262
Nevada	524,802	757,099	r960,657	r1,020,546	1,276,114
New Mexico	65,749	W	W	W	45,045
Oregon	2,830	W	322	W	W
South Carolina	--	--	--	--	W
South Dakota	278,162	185,038	309,784	310,527	356,103
Tennessee	W	--	--	--	--
Utah	227,706	174,940	238,459	W	135,489
Washington	W	W	W	W	W
Total	1,379,161	1,465,686	r2,002,526	r2,084,615	2,475,436

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Alaska.—Mineral exploration activity declined sharply in 1985, as indicated by a 59% reduction in expenditures directed toward exploration for all commodities, including gold. The decreased exploration activity was reportedly due to low base metal prices and budget cuts by several major mining companies that eventuated in some companies terminating their Alaska operations. Although overall expenditures for mineral development in Alaska declined, the largest increase registered, 11%, was directed toward the development of placer and lode gold projects. Gold production reported to the Bureau of Mines from Alaskan producers was nearly 45,000 ounces, compared with 19,433 ounces (revised) reported for 1984. However, an informal annual survey of Alaskan gold producers begun in 1981 and continued in 1985 by the Alaska State Division of Geological and Geophysical Surveys (DGGS) again suggested that a much larger total may have actually been produced. The State's survey indicated that about 190,000 ounces was recovered; this figure compares with similarly derived figures for 1982, 1983, and 1984 of 174,900, 169,000, and 175,000 ounces, respectively. The value of 1985 production was estimated by the State at $61 million, compared with about $63 million for 1984, and nearly $68 million for 1983. The lower 1985 value reflects again, as in recent years, gold's lower price, rather than reduced production.

Of the total indicated by the DGGS survey, an estimated 188,500 ounces of gold was produced by 266 placer mines operating in the State during 1985, an increase of 8% over 1984 estimated production. This increase, despite there being 15 fewer active operators, occurred primarily as a result of heightened activity at 4 large placer mines that together produced nearly 65,000 ounces of gold. Valdez Creek Mining Co. Inc.'s Valdez Creek Mine, for example, near Anchorage and the Denali Highway, increased output by over 10,000 to nearly 30,000 ounces. Low gold prices, regulatory restraints, water shortages, and exhaustion of reserves reportedly contributed to a slight decrease in production by the remaining operators. Environmental problems associated with placer mining were dominant.

Increasingly aggressive enforcement by State and Federal environmental regulatory agencies continued to involve greater numbers of operators.

Efforts by Alaska's placer miners to improve the quality of the process water discharged by their operations have in some instances resulted in a sharp increase in the amount of fine gold recovered. At several operations, technical innovations financed by the State's 1984 Placer Mining Demonstration Grant project resulted in both better gold recovery and cleaner water. The project, which had its first field demonstrations in 1985, awarded $2.7 million to qualifying miners; the focus was on fine gold recovery, water-use reduction, water-pollution control, and waste disposal. The maximum limit for an individual grant was $100,000, but miners could obtain a grant from both the Division of Natural Resources and the Department of Environmental Conservation.

At Klag Bay on Chichagof Island, south of Juneau, Queenstake Resources U.S.A. Inc., Vector Mining Co., and Exploration Ventures Co., which together form the Chichagof Joint Venture, concentrated their efforts on a two-phase underground drilling and drifting program at the old Chichagof gold mine, formerly one of Alaska's richest producers of lode gold. The partners budgeted $10 million for an accelerated development program in 1986. During the summer of 1985, Echo Bay Mines Ltd., of Edmonton, Alberta, Canada, acquired options from Barrick Resources Corp. to explore the Alaska Juneau (AJ) Mine near Juneau and the Treadwell Mine on nearby Douglas Island. Echo Bay intends to examine the feasibility of reopening these two former gold producers. The Planning Department of the City and Borough of Juneau conducted public hearings regarding its proposed Comprehensive Mining Ordinance aimed at regulating mining in areas within its jurisdiction, including both the AJ and the Treadwell. Debate on the issue continued through yearend.

Silverado Mines Ltd. and its partners Tri-Con Mining Inc. and Aurex Inc., a subsidiary of Marubeni American Corp., following delineation of new reserves and underground rehabilitation work, completed construction of a new 230-ton-per-day mill at the Grant Mine in midyear, and both the mill and mine began operations in October. At the end of December, however, Aurex withdrew from the project, reportedly because operating results were below its expectations; Silverado then suspended all operations. The company expected to reopen the mine at a later date.

Between September and November, Inspiration Resources Corp. of Claypool, AZ, conducted test production at its major offshore dredging operation, about 12 miles west of Nome. The mining rights were acquired earlier from Powerco Resources Corp. following its 1984 testing in the lease area. The company planned to begin full-scale dredging in 1986 at a rate of about 6,000 cubic yards per day. Onshore near Nome, Alaska Gold Co., the Northern Region's largest producer, processed 5,300 cubic yards per day with its Dredge No. 6 from late May to early November. Dredge No. 5 did not operate during the 1985 season, owing to a lack of thawed ground in which to operate.

In the Circle mining district of the Eastern Interior Region, Alaska's largest placer mining camp, 40 mining companies operated placer mines during the year. In the same district, Gold Dust Mining Co. placed into operation its jig recovery system that was manufactured in the Netherlands and transported to the site. The efficiency of the plant, employing a series of screens and jigs, exceeded company expectations, requiring up to 70% less water usage plus substantial recovery of fine gold in the 120- to 400-mesh range.

To the southwest, in the Mount McKinley-Denali area south along the Alaska Range, a number of mines were affected by court decisions voiding earlier National Park Service approvals of the Kantishna miners' operation plans. Overall, about 30 mines in 7 Alaskan National Parks were affected by the rulings, although most were able to complete the 1985 season.

West of Circle at Livengood, Livengood Placers Inc., 80% owned by Callahan Mining Corp., regained control of its placer property following the 1983 bankruptcy of the former lessee. During 1985, under an arrangement with the bankruptcy trustee, Livengood's contractor, Alaska Placer Development, did further cleanup on gravel left in the pit. Livengood continued to study alternatives for automated underground mining of the gold-bearing gravels on the property. Developments in Alaska were summarized in a draft report prepared by the DGGS.[8]

Arizona.—The production of gold in Arizona declined 5% from that of 1984, owing primarily to the continued decline in the production of gold-bearing ores at Arizona copper mines. Several precious metals miners in the State were affected by the year's weaker metals prices. After 4 years of pursuing ore bodies capable of being quickly and inexpensively brought into production, Phelps Dodge Corp. announced the closing of its Small Mines Div. Cumulative production by the division during its period of existence amounted to about 14,100 ounces of gold and 492,700 ounces of silver, with most of the production derived from small deposits in Cochise and Greenlee Counties. Tombstone Exploration Inc., following termination of mining operations in 1984, filed a bankruptcy petition under chapter 11 of the Federal bankruptcy laws. Posting debts of more than $350,000, the company indicated that the filing was a direct result of lower market prices for precious metals.

Exploration activity, although considerably less than that reported in recent years, continued, nevertheless, to be focused both on those many areas of the State where gold has been produced in the past as well as on those less well-explored areas, especially in western Arizona, where the potential for the discovery of detachment-hosted-type gold deposits, such as those recently recognized in Imperial County, CA, appeared to be geologically favorable. Cyprus Minerals Co. completed drilling its new Copperstone gold deposit at the north end of the Dome Rock Mountains near Parker in La Paz County. This detachment-hosted deposit was undergoing feasibility studies at yearend.

Although a number of old gold mines in the State's historic mining districts continued to be actively explored, there were others where work was curtailed owing to low metals prices. The interest of several companies appeared to be concentrated on old districts in the Bradshaw Mountains near Prescott in Yavapai County. The old lode and placer deposits formerly mined in the Big Bug District, east-southeast of Prescott, appeared to have garnered the attention of a number of companies. Joint venture partners Stan West Mining Corp. and Santa Fe Mining Inc. were reportedly pursuing interests around the old McCabe Mine. To the west, a few miles north of Congress, in Yavapai County, Echo Bay Inc., a subsidiary of Echo Bay Mines Ltd., completed a limited drilling program begun in 1984 on the old Congress Mines property. The company concluded at yearend that prevailing gold prices could not justify reopening the mine. In Yavapai County, near Wickenburg, McFarland & Hullinger, of Tooele, UT, and Global Energy Ltd., a Nevada corporation, reportedly had begun development at the old Oro Grande Mine.

California.—Gold mine developments in the State gained momentum in 1985 as several projects under construction development during the past 3 to 5 years commenced production or reached the final phase of development. These developments were reflected in the State's reported annual gold mine production, which nearly doubled in 1985, and had risen from about 4,100 ounces in 1980 to about 165,000 ounces in 1985. Capacity due on-stream in 1986 could more than double production in 1986 over that of 1985.

Following the discovery of its ore body in 1979 in a geological setting where previous gold exploration proved to be unproductive, the new McLaughlin Mine of Homestake Mining Co. poured its first bar of gold doré on March 4, 1985. The new mine and its attendant milling and administrative facilities is 60 miles north of San Francisco. At yearend, the new mine was approaching its design capacity of 1,050,000 tons per year, or 3,000 tons per day. From the pouring of the first bar through yearend, the mine produced 83,836 ounces of gold, including 4,922 ounces from ore mined in the preproduction period. The average cost of production was $422 per ounce. This high unit cost principally reflected startup costs. McLaughlin broke even in the fourth quarter of 1985 at a production cost of $322 per ounce. The mine was expected to achieve its design tonnage throughput early in 1986. The new $250 million facility was expected to yield 200,000 ounces of gold per year over the next 25 years; it represents the largest gold discovery in California in the 20th century.

Six miles north of Glamis, in Imperial County, Gold Fields Mining Corp., a wholly owned subsidiary of Consolidated Gold Fields PLC, of the United Kingdom, received final official approval in February 1985 to proceed with the final phases of construction at its Mesquite project. The new open pit, heap-leaching facility was scheduled to begin gold production in February 1986 at an expected annual rate of 130,000 to 160,000 ounces of gold, with cash costs, in 1985 terms, to be about $200 per ounce. The crushing plant commenced shakedown operations in October; leaching was expected to commence in January 1986. Ore was to be mined, prepared, and leached at a rate of 2 to 3 million tons per year. In November, the company announced that while development of the mine was under way, drilling in the vicinity of the mine to delineate additional reserves resulted in the discovery of three additional deposits bearing a geological similarity to the Mesquite deposit. Preliminary data on the new deposits indicated reserves of about 1.9 million ounces. The deposits are all near enough to the Mesquite facilities to be economically processed there.

At the Picacho Mine, east of Mesquite near the Picacho State Recreation Area on the Colorado River, Glamis Gold Ltd. of Vancouver, British Columbia, Canada, through its U.S. subsidiary Chemgold Inc., of Yuma, AZ, reported production of 28,000 ounces of gold in 1985. Gold production has increased significantly during each of the 3 years that this open pit, heap-leaching facility has operated. To the north, near Randsburg in Kern County, 125 miles northeast of Los Angeles, Chemgold continued work at its 1,000-acre Yellow Aster property. Airtrack percussion drilling in the LaMonte discovery zone resulted in establishing reserves of nearly 500,000 tons, grading 0.062 ounce per ton. Estimated proven, probable, and percussion-drilled probable reserves at the Yellow Aster amounted to over 8 million tons averaging 0.028 ounce of gold per ton.

Also in Kern County, Cactus Gold Mines Co., a joint venture between CoCa Mines Inc. and Ventures Trident L.P., was reportedly moving forward with construction and preproduction stripping at a small high-grade gold deposit. The planned open pit, heap-leaching operation was reportedly expected to produce about 30,000 ounces annually beginning in 1986.

Eastward into San Bernardino County, Amselco Minerals Inc., a subsidiary of British Petroleum Corp. Ltd., was reportedly exploring the old Colosseum Mine, in the Clark Mountains near the Nevada border. A few miles to the south, Vanderbilt Gold Corp., following a brief hiatus in 1984, resumed production at its open pit-underground Morningstar Mine at Ivanpah Mountain. Gold and silver were recovered using heap leaching. Full gold production at a rate of about 2,500 ounces per month reportedly was expected to be reached during early 1986. To the west, near Edwards Air Force Base, Beaver Resources Inc., in partnership with Agean Resources Inc., a subsidiary of Glamis Gold, continued exploration, development, and test leaching at its Kramer Hills property. To the north, just south of the Nevada Weapons Center, Queenstake Resources Ltd., of Vancouver, Canada, concentrated exploration efforts at its Argus project toward evaluating the potential for heap-leachable, open pit reserves at three vein systems defined during its 1984 mapping and sampling program. Sampling was conducted both over and within the existing workings of several old gold mines. Drilling and trenching was also performed. Many of the properties in Imperial, San Bernardino, and Kern Counties are believed to be detachment-type deposits related to regional low-angle thrust faulting.

Considerable activity continued to be centered around the numerous old mines within California's famous Mother Lode District. Near Angel's Camp in Calaveras County, Carson Hill Gold Mining Corp., a subsidiary of Grandview Resources Inc. of Vancouver, Canada, elected to proceed with development of its 5,000-ton-per-day heap-leaching operation. The Carson Hill Mine, a former gold producer, has open pit reserves of 16 million tons grading 0.046 ounce per ton. Full-scale plant construction and mine preparation were scheduled to start in early 1986, with first gold recovery expected to start in mid-1986. A drilling program to extend the known ore body limits was under way at yearend.

To the south, corporate members of the ABM Mining Group Inc., also of Vancouver, pursued development at their Jamestown Mine in Tuolumne County and Pine Tree Mine in Mariposa County. Both properties were under development at sites formerly hosting producing gold mines. The Jamestown Mine of ABM's subsidiary, Sonora Gold Corp., was scheduled to begin production in late 1986 at a rate of 130,000 ounces per year. ABM's Goldenbell Resources Inc. was to begin construction at the Pine Tree Mine in late 1986, with startup expected to take place in late 1987. Production was expected to be 75,000 to 100,000 ounces per year. Another ABM affiliate, Inca Resources Inc., pursued development at its Rich Gulch property, 22 miles west of Quincy in Plumas County. Production there was expected to begin in 1987. Also in Plumas County, Calgom Mining Inc. began full commercial production at its open pit, heap-leaching operation near Canyon Dam. The new mine, known as the Goldstripe, is a venture between NCA Mineral Inc., of Vancouver, and Calgom, a subsidiary of Sunbelt Mining Co., a wholly owned division of the Public Service Co. of New Mexico. Ore was being processed at the full planned capacity of 1,600 tons per day. Production was estimated to be about 20,000 ounces per year. To the south, in Sierra County, Brush Creek Mining & Development Co. Inc. continued production and development at its underground Brush Creek Mine and was proceeding with preparations to open two other nearby properties, the Gardner's Point Mine and the Gold Point Mine.

At its placer gold dredging operation near Marysville and the Yuba River, Yuba Placer Gold Co., a joint venture between Yuba Natural Resources Inc. and St. Joe Gold Co.'s Placer Service Corp., recovered about 23,000 ounces of gold during the fiscal year ending on October 31, an increase of 7,300 ounces over that of 1984. At yearend, the company was studying the feasibility of increasing the capacity of its dredge, the deepest digging gold dredge in the market economy countries. Numerous smaller dredging and placering operations were active in the State during the year.

Colorado.—In March, the State's largest gold producer, the Sunnyside Mine at Silverton, ceased mining and milling operations following financial difficulties stemming from low metals prices and the March 1984 decision by the mine's operators, Standard Metals Corp. of New York, to file for protection from its creditors under chapter 11 of the Federal Bankruptcy Code. In September, following approval by a Federal bankruptcy court, Standard Metals agreed to sell its interest in the mine to Echo Bay Mines Ltd. By yearend, Echo Bay was in the process of refurbishing the mine and expected to resume production by mid-1986. Echo Bay reportedly will operate the mine under the name of Sunnyside Gold Corp. Several other gold mining facilities in Colorado reportedly suspended operations in 1985. They include the joint operations of Hampton Gold Mining Areas PLC and Centennial Gold Corp. in Craig County; the Crystal Hill Mine and heap-leaching facility of Draco Mines at LaGarita; and Nerco Minerals Co.'s Victor Mine near Cripple Creek. At the Victor Mine, a joint venture between Nerco and Silver State Mining Corp., Nerco concentrated on renovating and expanding the mine's facilities to increase production. Limited production began during the last half of 1985 to test the new improvements; 6,000 and 2,000 ounces of gold and silver, respectively, were produced.

Galactic Resources Ltd., of Vancouver, was at yearend moving rapidly toward completion of construction at its large Summitville gold mine in the San Juan Mountains. The new Rio Grande County open pit, heap-leaching operation was due on-stream in early 1986 at a planned annual rate of about 120,000 ounces per year. Near Boulder, Cosmos Resources Ltd., of Vancouver, and the Steen family completed construction of their 50-ton-per-day mill and development of the underground workings at the Cash Mine at Gold Hill. Production of telluride ore was begun toward yearend. Cobb Resources Corp., of Albuquerque, NM, continued development work at its London Mine venture near Fairplay in Park County. Toward yearend, Cobb was negotiating with Houston Natural Gas Co. (HNG) to acquire HNG's 50% interest in the venture following HNG's earlier decision to concentrate its interests outside of hard minerals. Production was expected to begin in the fall of 1987.

In the Cripple Creek District, Cripple Creek and Victor Gold Mining Co., a joint venture between Texasgulf Minerals and Metals Inc. and Golden Cycle Gold Corp., began limited heap-leaching operations on approximately 3 million tons of old mine dumps within the district. The company also conducted an exploration drilling program on selected properties controlled by Texasgulf in the Cripple Creek area.

A number of former producing gold mines in the State underwent geological investigation or preproduction development in 1985. Gerber Minerals Corp. of Denver entered into a joint venture agreement with two limited partnerships to develop the old Gold King Mine property near Silverton. Also near Silverton, International North American Resources Inc. and P & G Mining Inc. reportedly formed a joint venture and conducted exploration and development aimed at returning the old Sultan Mountain gold and silver mine to productive status. Limited production was continued at the old Franklin Mine, near Idaho Springs, by Franklin Consolidated Mining Co. Inc.

Idaho.—In Valley County, Coeur d'Alene Mines Corp., of Wallace, continued construction and preproduction development at its Thunder Mountain property in the Payette National Forest, 40 miles east of McCall. Gold production at the open pit, heap-leaching facility was expected to begin in the spring of 1986 at a rate of 25,000 ounces per year. Climatological considerations dictate that a 4-month summer production season can be expected. The company estimated that as of June 30, 1985, proven, in-place minable ore reserves, at 1.788 million tons, contained an average of 0.095 ounce of gold per ton and 0.077 ounce of silver per ton. Exploration drilling on an adjoining area known as Lightning Peak indicated the presence of gold mineralization. Further work will be required to determine if minable reserves exist on the property. The Thunder Mountain project was a joint venture between Coeur d'Alene, Thunder Mountain Gold Inc. of Spokane, WA, and Phillips Petroleum Co.

To the west of Thunder Mountain, near Stibnite, gold recovery operations at the West End gold mine of TRV Minerals Corp. of Vancouver, and Superior Oil Co., a subsidiary of Mobil Oil Corp., were reportedly suspended during the 1985 operating season.

In the Yankee Fork mining district of Custer County, U.S. Antimony Corp. reportedly continued recovering gold and silver from three underground mines, an open pit, and a variety of old mine dumps dating from 1890 to 1910.

A number of small placer mining operations were reported to have been active along various Idaho waterways. Several seasonal operations were reportedly carried out along Prichard Creek and its tributaries near the old town of Murray, north of Wallace, in Shoshone County. Regulations of recreational and commercial placering operations continued to be a topic of concern in many areas of the State.

Preproduction permitting and production activities and exploration continued in many of Idaho's old mining districts. Exploration to locate and develop minable gold reserves was reportedly conducted by Concert Resources Inc. and Ican Resources Ltd. on their respective Blue Dog and Almaden properties in southwestern Idaho. Geodome Resources Ltd. of Hailey, ID, was reportedly nearing an early 1986 startup at its Sunbeam gold mine near Stanley in Custer County. Northwest of Stanley, Kellogg-based Golden Maple Mining and Leaching Co. was reported to be planning to reopen the old Valley Creek Mine as a small open pit, heap-leaching operation. Nevex Gold Inc. of Bellevue, WA, was reported to have been conducting a drilling program at its Robinson-Dike claims about 2 miles south of Dixie in Idaho County. At yearend, Liberty Bell Mines had reportedly purchased a relatively new flotation process mill from the Ensearch Exploration Inc.'s operations in Alaska; the mill was to be transported from Alaska to Liberty Bell's Monte Cristo claims in the Old Buffalo Hump mining district of Idaho County.

Montana.—Although the number of mining claims staked in Montana declined for the second consecutive year, there was a noticeable surge in exploration activity for precious metals on existing claims.

Placer U.S. Inc.'s Golden Sunlight Mine, east of Whitehall, the State's largest gold producer, produced 96,000 ounces of gold. Moderately increased mill throughput offset a lower average ore grade. Work continued on improvements to the mill circuit and expansion of the tailings system. Stripping of the stage II pit was under way in preparation for production in 1986.

Pegasus Gold Inc., of Spokane, WA, the second largest producer in the State, was actively engaged with several properties. At its Zortman-Landusky Mine, in the Little Rocky Mountains of Phillips County, Pegasus placed its new 7-million-ton heap-leach pad into production. Another pad, a so-called superpad, with a capacity to handle 20 million tons of ore, was under construction at yearend. Mining operations were confined to the Zortman Mine, on the western slopes of Ruby Gulch. No ore was mined at the Landusky pit because of ongoing studies there aimed at determining the optimal utilization of substantial new ore reserves acquired during 1984.

In Jefferson County, south of Helena, construction and permitting work continued at the Montana Tunnels project by joint venture partners Centennial Minerals Ltd., of Vancouver, and U.S. Minerals Exploration Co. (USMX), of Arvada, CO. On September 11, Pegasus made a tender for all of Centennial's outstanding common shares, and was anticipating the acquisition of the company's remaining shares in the near future. Through the acquisition of Centennial and execution of an agreement with USMX, Pegasus planned to develop the Mountain Tunnels project, with production to commence in May 1987 at a planned rate of 12,500 tons of ore per day; planned production was estimated at 106,000 ounces of gold and 1.7 million ounces of silver, plus values in lead and zinc. In October, the Montana Hard-Rock Mining Board gave final approval to the project. Near yearend, Pegasus let $3.5 million worth of engineering and construction contracts, with work to begin in March 1986. Pegasus placed its Beal project, in Silver Bow County, on standby pending resolution of environmental issues and the return of more favorable gold prices.

Golden Maple of Kellogg, ID, continued seasonal open pit mining and leaching operations at the old Gilt Edge property in Fergus County. In addition to leaching virgin ore, Golden Maple reportedly planned to process about 500,000 tons of on-site mill tailings left from earlier milling operations. Also in Fergus County, Triad Investments Inc. continued development work and leaching at the Kendall Mine, north of Lewiston. In Jefferson County's Elkhorn District, the Mount Hagen heap-leaching operation began production, and further development drilling was started at the deposit. To the north near Marysville, in Lewis and Clark County, AMAX Inc. and Gulf Titanium Ltd. began production at the historic old Belmont gold mine. Pending further development and possible construction of a mill on-site, the ore was being shipped to the East Helena, MT, smelter of ASARCO Incorporated. The Uncle Sam gold mine of Buckeye Mines Inc., in Madison County, was reopened and some ore was shipped.

Placer mining continued to flourish in Montana with operations in western Montana districts being particularly active. Three medium-sized operations were begun on Indian Creek, in Broadwater County. Seasonal operations were active in Meagher, Silver Bow, and Beaverhead Counties, and several properties were undergoing development in various counties farther west.

Exploration and development efforts were continued at a number of properties. In Madison County, Winchester Gold Corp. continued exploration and development at the old B and H Pete and Joe Mine. In Park County, southeast of Gardiner, Homestake Mining and American Copper & Nickel Co. Inc., a subsidiary of Inco Ltd., continued underground drilling and bulk sampling at their Jardine Joint Venture property. Production was scheduled to begin by mid-1987. Three different companies reportedly conducted some exploration drilling for gold in eastern Park County. Gold Coin Mining Inc., formerly Midas Gold Inc., of Spokane, WA, continued exploration at the old Gold Coin Mine in Deer Lodge County. The objective of the 1985 program was to prepare tunnel access to the mineralized zones so that a complete development program from underground could be conducted in 1986. Highlights of Montana mineral developments during 1985 were presented in a State report.[9]

Nevada.—Every year Nevada increases its margin over other States as the Nation's premier gold-producing State. Production, through 1985, has increased for 6 consecutive years. Gold occurrences, from isolated pockets through large disseminated deposits bearing millions of ounces of gold, were reportedly under examination or development in every county of the State in 1985. Nearly a dozen new gold mines or expansions of existing mines occurred in Nevada during the year.

On September 20, Carlin Gold Mining Co.'s new $130 million Gold Quarry Mine and No. 2 mill were officially dedicated. The new Eureka County facilities, about 14 miles south of the company's No. 1 mill and 8 miles north of the town of Carlin, will contribute substantially to Carlin's overall gold production capacity as well as that of its parent company, Newmont Mining Corp. By 1986, Carlin was expected to have the capacity to produce more than 330,000 ounces of gold annually, an increase of more than 100% over the capacity in 1984. The Gold Quarry deposit, discovered in 1980, contains an estimated 8 million ounces of gold, the second largest gold reserve in the State. Processing ore from the Gold Quarry Mine and the existing Maggie Creek Mine, both open pit operations, the new 2,500,000-ton-per-year No. 2 carbon-in-pulp mill will produce about 170,000 ounces of gold per year. Heap-leach pads adjacent to the mill will recover an estimated additional 35,000 ounces of gold per year.

In September, Newmont announced that exploration efforts by Carlin had resulted in the discovery of a new gold deposit about 3 miles from the Carlin Mine. The new deposit, designated as the "Genesis deposit," was expected to add about 5 million ounces of gold to the company's overall reserves of about 12 million ounces in the Carlin District. In addition to the Carlin, Gold Quarry, and Maggie Creek Mines, the company mined gold ore at its Blue Star and Bootstrap Mines.

In Humboldt County, northeast of Winnemucca, Pinson Mining Co., operator of the Pinson Mine, announced that testing and evaluation of the new Mag Zone, discovered about 0.5 mile from the Pinson mill in 1984, had resulted in the addition of about 3.1 million tons of milling-grade ore to the mine's reserves. Evaluation of another 1984 discovery, the CX Zone, immediately northeast of the Pinson open pit, was expected to add nearly 500,000 tons of reserves amenable to heap leaching and milling. Pinson Mining was owned by joint venture partners Lacana Gold Inc., Rayrock Mines Inc., United Siscoe Mines Inc., and private investors; effective December 31, United Siscoe sold its 26.25% interest in the partnership to American Barrick Resources Corp. Lacana Gold, a 70%-owned subsidiary of Lacana Mining Corp., of Toronto, Ontario, Canada, announced that feasibility studies on its new 51%-owned Santa Fe property in Mineral County were nearly complete and that exploration delineating 6 to 7 million tons of open pit oxide reserves had been completed. The company said, however, that a gold price of about $400 per ounce would be required to warrant proceeding to production. Lacana was also the owner and operator of the new Relief Canyon gold mine, which was opened in late 1984, east of Lovelock in Pershing County; however, owing to poor gold recovery, operations at Relief Canyon were suspended at yearend 1985. The company is also a partner in the Dee Mine in Elko County, opened concurrently with Relief Canyon. At yearend, the Dee mill was reported to be running at 950 tons per day, well in excess of its design capacity.

Freeport-McMoRan Gold Co. (FMG), a wholly owned subsidiary of Freeport McMoRan Inc., reported increases over that of 1984 in mine and mill production at its Enfield Bell (Jerritt Canyon) Mine of 20% and 6%, respectively. Total mill production for the year was 255,300 ounces, 12,000 ounces more than that of 1984. Two separate open pits, the upper North Generator ore body and the Second Cut of Marlboro Canyon, were being mined at the Elko County property, a joint venture with FMC Gold Corp. Prestripping of the West Generator ore body was scheduled to begin on a limited basis in 1986. Construction of a new millsite heap-leaching facility was begun in the third quarter of 1985, and leaching was expected to begin in 1986. The company was actively and successfully involved in exploration during the year; in the Jerritt Canyon joint venture area, six apparently viable or "advanced projects" underwent further evaluation, while two advanced projects, the Big Springs project north of the joint venture area and the Manhattan project to the south in Nye County, also underwent further scrutiny. Two other properties, the Burns Basin and Mill Creek properties, both in the joint venture area, were deemed to be commercially viable projects. In June, FMG became a publicly traded company; later in the year, the company officially opened its new international exploration headquarters in Reno, and exploration offices were subsequently opened in Vancouver, British Columbia, Canada, and Anchorage, AK.

At Battle Mountain in Lander County, Battle Mountain Gold Co., in November, completed a year of mining at its new Fortitude gold and silver mine and in the process exposed the higher grade core of the ore body; mining of the core area was expected to substantially reduce production costs. Battle Mountain Gold was established in August following its release to shareholders from its former parent, Pennzoil Corp.

Gold production at the Round Mountain Mine in Nye County, reportedly the world's largest heap-leaching operation, increased about 20,000 ounces in 1985 to about 140,000 ounces, reflecting both a 32% expansion of leaching capacity and the leaching of lean ore stockpiled in prior years. Reclassification of extensive mineralization not previously included in the mine's ore reserves resulted in a doubling of reserves to about 4.1 million ounces of contained gold. The Round Mountain operation is a joint venture between Echo Bay Inc. (50% interest), Homestake Mining (25%), and Case, Pomeroy and Co. (25%).

A number of relatively small gold mines began producing during 1985. Some of those reportedly beginning production were Pacific Silver Corp.'s underground gold, silver, and copper Buckskin Mine west of Yerington in Mason County; the Little Bald Mountain Joint Venture heap-leaching operation in White Pine County; Silver State Mining's Tonkin Springs heap-leaching project in Eureka County; Nevex Gold's Haywood-Santiago heap-leaching project near Virginia City; the Sumich joint venture and underground operation in Lander County; and Electra Northwest Resources Ltd.'s Aurora project, a heap-leaching operation in Mineral County.

Construction was begun or authorized to begin at numerous deposits where exploration and feasibility studies had been proceeding over the past few years. These include AMAX's Sleeper project in Humboldt County; Silver King Mines Inc. and Pacific Silver's Star Pointer near Ely; Coeur d'Alene's project at Rochester; FMC Corp.'s Paradise Peak project near Gabbs in Nye County; Atlas Corp.'s Gold Bar property in Eureka County; the Florida Canyon project of Pegasus near Winnemucca; and the Top deposit of Placer U.S. in northeastern White Pine County.

Depressed gold and silver prices led to the closure of several mines including the Gooseberry Mine and United Mining Corp.'s Comstock operations, both in Storey County.

Periodical news media reports dealing with mineral exploration were rarely without reports on new developments in Nevada. In addition to reports about ongoing projects and discoveries associated with some of the operating mines discussed above, nearly 36 exploration projects were reported under way; many more smaller operations were undoubtedly in progress. One of the most notable discoveries reported during the year was Gold Fields' Chimney Creek Prospect, discovered near Golconda in Humboldt County; Gold Fields estimated that the new disseminated deposit contains 2 million ounces of gold.

New Mexico.—Citing impending depletion of economic ore reserves and increased mining costs associated with deeper ore and greater waste removal costs, Gold Fields Operating Co., a wholly owned subsidiary of Consolidated Gold Fields of London, United Kingdom, announced in mid-1985 that its Ortiz Mine at Cerrillos would cease production in 1986. The open pit, heap-leaching operation had been in production since February 1980.

A number of small surface and underground gold mines were active throughout the State during 1985.

Oregon.—Developments in Oregon were confined to exploration or intermittent production from small lode and placer operations. Of the 24 mining operations active in Oregon during 1985, 12 were placer mines. Most of these mines or mining areas were in Baker, Douglas, Grant, Jackson, and Josephine Counties; only a few produced over 50 ounces of gold. The most productive areas were in Baker and Grant Counties of eastern Oregon along Pine Creek near Hereford, on Clark Creek on the upper Burnt River, and on Boulder Creek near Granite.

Small seasonal lode-mine operations were again reported from the Pyx Mine in Grant County and from the Thomason Mine in Baker County. Closure of Silver King Mines' Iron Dyke Mine in Baker County during 1984 and only sporadic work there during 1985 sharply reduced the State's lode gold production.

According to a State review of the year's mining and exploration activities,[10] exploration and development activity in 1985 generally declined from 1984 levels, with the industry apparently continuing to shift its interests away from metallic minerals and toward nonmetallic minerals. Properties reported to have undergone some manner of exploration, from rudimentary investigation through drilling or rehabilitation of old workings, included the Bald Mountain-Ibex, Bear Creek Buttes, Cable Cove, Castle Rock, Coyote Hills, Dixie Meadows, Fall Creek Copper, Flagstaff, Flagstaff Butte, Goff, Gold Bug, Gold Note, John Hall, Little Baldy, Meadow Lake, Miller Mountain, Quartz Mountain, Red Butte, Rejax, Sunday Hill, Susanville, and Turner-Albright. Nearly one-third of the properties under investigation were in Baker and Grant Counties.

South Dakota.—Gold developments for the year were centered about the town of Lead, in Lawrence County in the Black Hills area of the State. Gold production at the Homestake Mine, the Nation's largest gold mine, increased to 343,103 ounces in 1985, 16% greater than its 1984 production of 295,941 ounces. The average cost of production decreased to $294 per ounce, compared with $324 per ounce in 1984. The lower costs not only reflected results from a cost-cutting program begun in early 1985, but also from record mine efficiency and mill throughput; the quantity of ore milled was the highest in the mine's century of existence. The average grade of ore from the underground operation was 0.174 ounce per ton, essentially the same as that of 1984. Mining and exploration work in 1985 continued below the 6,800-foot level, the deepest current working level. Major development work was continued on three deeper levels, extending to 8,000 feet below the surface.

Testing of the Terraville or open pit area, site of the original strike more than a century ago, confirmed earlier reserve estimates. A decision was thus made to put the area into full-scale production by 1987. Homestake also began a program to place a greater emphasis on exploration both at the mine and in the surrounding Black Hills

District and to evaluate new exploration targets generated through the development of new geologic models and structural interpretations.

Near Trojan, west of Lead, in the Bald Mountain mining district, Wharf Resources (USA) Inc. of Helena, MT, continued open pit, heap-leaching operations at its Annie Creek gold mine, and by yearend, Wharf had applied for the final round of permits required to expand the operation northeastward onto its Foley Ridge area of the project. Exploration and testing had been under way at Foley Ridge for several years. Subsequent preliminary investigation of the adjoining Portland property indicated the existence of a strongly mineralized near-surface deposit. Wharf, in partnership with Homestake, controls about 3,000 acres of mineral rights in the area.

To the north, at Richmond Hill in the Carbonate area, St. Joe Gold Corp. drilled 71 exploratory holes and detected the presence of disseminated gold, in addition to gold mineralization exposed at the surface. Preliminary metallurgical tests indicated that the oxidized ore would be suitable for heap leaching. Further exploration in the area was planned.

In the Ruby Basin District, about 2.5 miles southwest of Lead, Moruya Gold Mines of North America Inc., a subsidiary of Moruya Gold Mines (1983) NL, of Sydney, Australia, in a joint venture with Coin Lake Gold Mines Ltd., of Toronto, Ontario, Canada, acquired, from Anaconda Minerals Co., a large block of claims known collectively as the Golden Reward project. By yearend, Moruya had reportedly completed the first stage of a drilling program aimed at determining the gold potential of the old Golden Reward and other former producing properties within the claims area.

On Strawberry Hill, above Galena, 4 miles southeast of Lead, Gilt Edge Inc., a subsidiary of Lacana Gold, continued development on its Gilt Edge property. A production decision reportedly was to depend upon State permitting requirements and higher gold prices.

Utah.—Kennecott closed its Bingham Canyon Mine near Salt Lake City, at the end of March, owing to continuing financial losses. For many years, the Bingham Canyon open pit copper mine had been one of the Nation's leading byproduct gold producers. In December, Kennecott's parent company, the Standard Oil Co. of Ohio, a 55%-owned subsidiary of British Petroleum, announced a $400 million, 3-year project aimed at modernizing Kennecott's Utah Copper Div., operator of the mine.

In May, Texaco Inc. announced the sale of its Getty Gold Mine Co. to a wholly owned U.S. subsidiary of Barrick Resources of Toronto, Ontario, Canada. Getty operates the Mercur open pit gold mine and mill at Toole. Annual production at the 80,000-ounce-per-year facility will reportedly be expanded by about 15,000 ounces through the addition of heap-leaching capacity. With the closure of the Bingham Canyon Mine, the Mercur Mine became the largest gold producer in Utah.

Washington.—In September, Asamera Minerals (U.S.) Inc. and its partner Breakwater Resources Ltd., both subsidiaries of Canadian companies, dedicated the Cannon Mine on the outskirts of Wenatchee in Chelan County. The Cannon was developed as an underground mine. Overhand cut and fill was employed as the principal mining method, combined with a 4,000-ton-per-day underground crusher and a trackless system for ore haulage. The new 2,000-ton-per-day flotation mill produced a gold-silver-bearing concentrate that was shipped to smelters in Western Europe and Japan. At full production, the mine was expected to yield between 160,000 and 180,000 ounces of gold per year, plus about 70,000 ounces of silver per year. In October, the partners announced that they had acquired all of the property interests held in the immediate area of the mine by Tenneco Inc. and United Mining.

The flurry of exploration activity in Chelan County, touched off by Asamera-Breakwater's 1982 discovery, abated in 1985, with only 11 companies reporting work, compared with 27 reporting during 1984.

The second principal development in the State was Hecla Mining Co.'s announcement early in the year that exploration and development work at its Knob Hill Mine at Republic, in Ferry County, had resulted in the discovery of additional ore. The company was then able to postpone for perhaps 5 years its earlier decision to close the mine, in operation almost continuously since the early 1900's. Development of the two new gold and silver veins, the Golden Promise I and II, was proceeding at yearend from an exploration drift on the mine's 11th level. Total gold production for the year was 39,192 ounces, up 72% from that of 1984. Elsewhere in Ferry County, at the South

Penn property, 14 miles north of Republic, the mine's operator, Glamis Gold of Vancouver, conducted bulk leaching tests on finely crushed agglomerated material from its property. Vulcan Mountain Inc. continued heap leaching at its Gold Dike Mine and had expanded operations on the adjoining Gold Hill property before work was stopped for the winter. Exploration was conducted at several other Ferry County properties during the year.

To the west in Okanogan County, exploration and/or drilling was carried out on Crown Resource Corp.'s Key property, Sunshine Valley Minerals Inc.'s Billy Goat property, Keystone Gold Inc.'s Crystal Butte and Grey Eagle properties, and at several other properties in the county. Cordilleran Development Inc. continued geological mapping and heap-leaching operations at its Minnie Mine near Twisp.

Other gold mining operations reported to be active were CSS Management Corp.'s Apex and Damon properties near Skykomish in King County, and Younguist Mine Development and Consultation Inc.'s Wind River Mine near Carson, in Skamania County.

Gold and silver were reportedly the targets of 70% of the companies exploring in the State, with Stevens County the most active area as far as base and precious metals exploration was concerned. Mining and exploration activities in the State during the year were summarized by the Washington State Department of Natural Resources.[11]

Other States.—Two new gold mines opened east of the Mississippi River in 1985, and exploration of known or potential gold-bearing areas from Alabama north to Maine and west to Wisconsin and Minnesota continued, although at a somewhat subdued pace compared with the pace of the previous 3 or 4 years.

On October 18, Callahan Mining dedicated its new Ropes gold mine near Ishpeming in Marquette County, MI. The newly rehabilitated underground mine, closed since 1941, was expected to yield up to about 60,000 ounces per year following mill tuneup and normalization of mining operations near mid-1986. Mining started in August 1985, between the 800- and 900-foot levels where reserves are of lower grade than the mine's average of about 0.1 ounce per ton. Ore was hauled 16 miles to the mine's newly converted 2,000-ton-per-day mill at Humboldt. The first bar of gold doré recovered from the operation was poured on September 20. Callahan Mining was maintaining its exploration efforts to locate additional gold deposits in the Ishpeming area.

Near Kershaw in Lancaster County, SC, Piedmont Mining Co. brought the old Haile Mine back into production as an open pit, heap-leaching operation. Mining operations at the former underground producer, first opened in 1829, began in January 1985, and the first bar of production gold was poured in March. At full production, the mine was expected to produce 10,000 to 12,000 ounces per year. Piedmont was a privately held company based in Charlotte, NC. Meanwhile, near Ridgeway in Fairfield County, adjoining Lancaster County to the southwest, Amselco Minerals of Denver, CO, a subsidiary of British Petroleum, following several years of exploration in Fairfield and adjoining Richland County, announced in early 1986 that it had discovered two potentially viable gold deposits in Fairfield County about 1 mile apart near the Richland County line.

Small intermittent gold-placering operations were conducted in various gold-bearing areas of the South. A number of companies and individuals were actively exploring for gold in the old gold mining areas of North Carolina, and a few continued to investigate prospects in Alabama, Georgia, and Virginia. Corporate activity, however, generally declined during the second half of the year.

The University of Connecticut discovered traces of gold in several quartz samples collected in a study area near Cobalt in the Meshomasic State Forest. Although gold claims have in the past been staked in various areas of Connecticut, the discoveries near Cobalt were reportedly the State's first gold discoveries to be properly documented.

In Maine, exploration by Freeport-McMoRan at its Bald Mountain copper and precious metals deposit in Aroostock County was discontinued in January. Getty Mining Co.'s exploration at the Mount Chase base and precious metals deposit in northern Penobscot County apparently was suspended while Getty underwent a change in ownership. Noranda Exploration Co. reportedly continued its base and precious metals exploration programs in Franklin and Somerset Counties, while Scintilore Explorations Ltd., of Toronto, Ontario, Canada, reportedly conducted exploration at its Big Hill Prospect, 14 miles from Eastport in

Washington County.

In Minnesota during October, the State Department of Natural Resources (DNR) held its ninth sale of State copper, nickel, and associated minerals leases. Leases covering about 735,000 acres of State-owned mineral rights were offered. Much of the interest was reportedly focused on the potential for possible gold deposits in the greenstone belts in an area south of Ranier in northeastern Koochiching County and in the area bounded by Virginia, Eveleth, and Gilbert in central St. Louis County. Lease lands were also sought in Aitken, Itasca, Lake, and Pine Counties. The Kerr-McGee Corp. of Oklahoma was reportedly the successful bidder for the Koochiching and central St. Louis County offerings. Other companies also reportedly showing an interest in the lease areas included Boise Cascade's Normin Mining Co., Burlington Northern's Meridian Minerals Co., Lehmann Exploration Management Inc. of Minneapolis, and the American Shield Co. of Duluth. Seventeen companies were reportedly successful in their bidding efforts. Most of the companies were apparently interested in the potential for gold and other precious metals on the lands offered. To encourage interest in the leasable lands program, the DNR has reportedly improved its aeromagnetic mapping coverage and stepped up an effort to reexamine its collection of rock and core samples derived from earlier exploration on State lands. Several companies were also interested in exploring for gold on privately held lands, especially in northern Minnesota.

Near Rhinelander, WI, near Exxon Minerals Co.'s base metal deposit at Crandon, Mineralco, an Illinois company, and InteResources Inc. of San Antonio, TX, were reportedly investigating a possible disseminated gold prospect at Hickson Lake.

Table 4.—Mine production of gold in the United States, by month

(Troy ounces)

Month	1981	1982	1983[r]	1984[r]	1985
January	98,887	106,956	134,435	140,586	178,287
February	93,385	109,407	131,636	144,945	178,869
March	115,200	138,066	153,808	174,242	208,434
April	110,366	136,674	162,224	166,908	187,869
May	108,291	143,212	179,950	183,068	197,065
June	119,676	116,925	178,929	195,337	194,887
July	126,675	114,845	179,521	186,620	203,028
August	125,505	114,538	192,095	183,123	204,550
September	124,629	109,024	189,237	178,483	240,159
October	123,201	127,928	183,524	186,413	224,838
November	119,386	127,843	165,903	174,313	230,361
December	113,960	120,268	151,264	170,577	227,089
Total	1,379,161	1,465,686	2,002,526	2,084,615	2,475,436

[r]Revised.

Table 5.—Twenty-five leading gold-producing mines in the United States in 1985, in order of output

Rank	Mine	County and State	Operator	Source of gold
1	Homestake	Lawrence, SD	Homestake Mining Co	Gold ore.
2	Enfield Bell (Jerritt Canyon)	Elko, NV	Freeport Gold Co	Do.
3	Battle Mountain	Lander, NV	Battle Mountain Gold Co	Do.
4	Carlin & Maggie Creek Pit	Eureka, NV	Carlin Gold Mining Co	Do.
5	Round Mountain	Nye, NV	Round Mountain Gold Corp	Do.
6	Cannon	Chelan, WA	Asamera Minerals (U.S.) Inc	Do.
7	Golden Sunlight	Jefferson, MT	Golden Sunlight Mines Inc	Do.
8	Mecur	Tooele, UT	Barrick Mercur Gold Mines Inc	Do.
9	McLaughlin	Napa, CA	Homestake Mining Co	Do.
10	Pinson	Humboldt, NV	Pinson Mining Co	Do.
11	Zortman-Landusky	Phillips, MT	Pegasus Gold Inc	Do.
12	Cortez	Lander, NV	Cortez Gold Mines	Do.
13	Borealis Project	Mineral, NV	Tenneco Minerals Co	Do.
14	Dee	Elko, NV	Dee Gold Mining Co	Do.
15	Alligator Ridge	White Pine, NV	Amselco Minerals Inc	Do.
16	Grey Eagle	Siskiyou, CA	Noranda Grey Eagle Mines Inc	Do.
17	Gold Strike	Eureka, NV	Western States Minerals Corp	Do.
18	Ortiz	Santa Fe, NM	Gold Fields Operating Co	Do.
19	Delamar	Owyhee, ID	Nerco Minerals Co	Do.
20	Manhattan	Nye, NV	Tenneco Minerals Co	Do.
21	Picacho	Imperial, CA	Chemgold Inc	Do.
22	Valdez Creek	Cook Inlet, Susitna, AK	Valdez Creek Mining Co. Inc	Placer.
23	Northumberland	Nye, NV	Cyprus-Northumberland Mining Co	Gold ore.
24	Trixie	Utah, UT	Sunshine Mining Co	Do.
25	Morenci	Greenlee, AZ	Phelps Dodge Corp	Copper ore.

Table 6.—Gold produced in the United States, by State, type of mine, and class of ore

Year and State	Placer (troy ounces of gold)	Lode: Gold ore: Short tons	Lode: Gold ore: Troy ounces of gold	Lode: Gold-silver ore: Short tons	Lode: Gold-silver ore: Troy ounces of gold	Lode: Silver ore: Short tons	Lode: Silver ore: Troy ounces of gold	Lode: Copper ore: Short tons	Lode: Copper ore: Troy ounces of gold
1981	28,927	12,728,940	921,930	1,040,856	40,514	4,408,806	15,254	264,347,788	352,768
1982	38,466	17,918,046	1,124,225	1,213,247	37,697	5,318,490	13,539	[r]150,095,844	233,093
1983	53,887	[r]24,141,617	[r]1,593,406	1,124,556	[r]43,445	[r]7,512,261	[r]35,057	[r]137,668,016	258,222
1984	[r]37,597	[r]30,497,262	[r]1,736,998	[r]1,587,850	[r]55,382	4,380,945	25,785	[r]132,899,873	[r]198,729
1985:									
Alaska	W	W	W	--	--	--	--	--	--
Arizona	W	--	--	W	W	--	--	126,290,430	46,056
California	3,966	W	W	W	W	--	--	--	--
Colorado	--	811,529	27,067	--	--	W	W	--	--
Idaho	--	50,638	2,977	W	W	949,183	11,032	--	--
Michigan	--	W	W	--	--	--	--	--	--
Montana	1,123	7,528,000	158,556	W	W	40,832	158	2,842,971	W
Nevada	W	19,808,568	1,246,290	W	W	W	W	--	--
New Mexico	--	914,946	36,017	2,527	585	W	W	W	W
Oregon	W	W	W	--	--	--	--	--	--
South Carolina	--	W	W	--	--	--	--	--	--
South Dakota	--	2,545,704	356,103	--	--	--	--	--	--
Utah	--	1,243,782	97,233	--	--	--	--	W	W
Washington	--	W	W	--	--	--	--	--	--
Total[1]	50,587	35,908,918	2,241,836	1,043,854	41,801	3,836,130	31,288	149,464,862	74,633
Percent of total gold	2	XX	91	XX	2	XX	1	XX	3

Year and State	Lode: Lead and zinc ores: Short tons	Lode: Lead and zinc ores: Troy ounces of gold	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores: Short tons	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores: Troy ounces of gold	Lode: Old tailings, etc.: Short tons	Lode: Old tailings, etc.: Troy ounces of gold	Total[1]: Short tons	Total[1]: Troy ounces of gold
1981	638	30	3,152,611	11,582	361,588	[2]8,156	286,041,227	1,379,161
1982	--	--	(3)	(3)	[4]646,084	[5]18,666	[r]175,191,711	1,465,686
1983	--	--	(3)	(3)	[4]858,749	[6]18,509	[r]171,305,199	[r]2,002,526
1984	(3)	(3)	(3)	(3)	[7]472,359	[8]30,124	[r]169,838,289	[r]2,084,615

1985:								
Alaska	--	--	--	--	--	--	W	44,733
Arizona	--	--	--	--	W	W	126,408,664	52,053
California	--	--	--	--	--	--	2,492,622	165,101
Colorado	--	--	W	W	--	--	1,033,994	43,301
Idaho	--	--	--	--	W	W	5,583,063	44,306
Michigan	--	--	--	--	--	--	W	W
Montana	--	--	--	--	W	W	10,412,113	160,262
Nevada	--	--	--	--	W	W	22,833,817	1,276,114
New Mexico	--	--	--	--	35	344	18,605,044	45,045
Oregon	--	--	--	--	--	--	W	W
South Carolina	--	--	--	--	--	--	W	W
South Dakota	--	--	--	--	--	--	2,545,704	356,103
Utah	--	--	--	--	W	W	3,900,367	135,489
Washington	--	--	--	--	--	--	W	W
Total[1]	--	--	([3])	([3])	[4]4,476,684	[5]35,291	194,730,448	2,475,436
Percent of total gold	XX	--	XX	([3])	XX	1	XX	100

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of items withheld to avoid disclosing company proprietary data.
[2]Includes gold recovered from tungsten ore.
[3]Included with "Old tailings, etc."
[4]Includes lead-zinc ores.
[5]Includes gold recovered from lead-zinc and molybdenum ores.
[6]Includes gold recovered from lead-zinc ores.
[7]Includes lead and lead-zinc ores.
[8]Includes gold recovered from lead ore, lead-zinc ores, and molybdenum ore.

Table 7.—Lode gold produced in the United States, by State

Year and State	Amalgamation		Cyanidation		Smelting of concentrates			Smelting of ore		Total ore processed[1] (short tons)	Total gold recovered (troy ounces)
	Ore treated (short tons)	Gold recovered (troy ounces)	Ore treated (short tons)	Gold recovered (troy ounces)	Ore concentrated (short tons)	Concentrates smelted (short tons)	Gold recovered (troy ounces)	Ore smelted (short tons)	Gold recovered (troy ounces)		
1981	186,790	14,945	15,899,228	912,742	r269,468,293	6,213,345	404,750	486,916	[2]17,859	r286,041,227	[2]1,350,296
1982	r140,196	25,416	r19,901,354	1,101,721	r154,933,339	r3,245,464	290,023	r216,822	r10,060	r175,191,711	r1,427,220
1983	r137,658	24,689	r28,415,818	r1,631,608	r142,546,432	r3,044,307	r306,609	r205,291	r [2]9,996	r171,305,199	r [2]1,972,902
1984	r124,983	23,274	r34,902,191	r1,752,492	r134,735,157	r3,605,791	r257,238	75,958	[2]14,214	r169,838,289	r [2]2,047,218
1985:											
Alaska	--	--	W	W	--	--	--	--	--	W	W
Arizona	--	--	--	--	126,215,580	3,019,588	46,056	193,084	[2]5,997	126,408,664	[2]52,053
California	W	W	W	W	W	W	W	--	--	2,492,622	161,135
Colorado	W	W	W	W	250,767	38,028	18,151	500	6	1,033,994	43,301
Idaho	--	--	W	W	4,712,523	74,217	11,125	W	W	5,583,063	44,306
Michigan	--	--	W	W	--	--	--	--	--	W	W
Montana	--	--	7,527,700	157,906	2,883,803	39,293	418	610	815	10,412,113	159,139
Nevada	--	--	22,833,662	1,271,549	[3]80	1,556	25	75	[2]4,540	22,833,817	[2]1,276,114
New Mexico	--	--	914,946	36,017	W	W	W	W	W	18,605,044	45,045
Oregon	W	W	--	--	--	--	--	W	W	W	W
South Carolina	--	--	W	W	--	--	--	--	--	W	W
South Dakota	--	--	2,545,704	356,103	--	--	--	--	--	2,545,704	356,103
Utah	--	--	1,352,969	108,313	W	W	W	W	W	3,900,367	135,489
Washington	--	--	W	W	W	W	W	--	--	W	W
Total	20,812	3,741	39,602,183	2,159,731	154,886,138	3,220,471	231,706	221,315	[2]34,179	194,730,448	[2]2,429,357

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes old tailings and some nongold-bearing ores not separable, in amounts ranging from 0.15% to 0.25% of the totals for the year listed.
[2]Includes some placer production to avoid disclosing company proprietary data.
[3]Excludes molybdenum and tungsten ores from which gold was recovered as a byproduct and ores leached for recovery of copper.

Table 8.—Gold produced in the United States by cyanidation[1]

Year	Extraction in vats, tanks, and closed containers[2]		Leaching in open heaps or dumps[3]	
	Ore treated (short tons)	Gold recovered[4] (troy ounces)	Ore treated (short tons)	Gold recovered (troy ounces)
1981	7,023,836	648,334	8,875,392	264,408
1982	7,616,036	710,688	12,294,232	391,033
1983	11,317,285	1,086,205	[r]17,098,533	[r]545,403
1984[r]	13,503,143	1,165,983	21,399,048	586,509
1985	20,542,717	1,626,751	19,059,466	532,980

[r]Revised.
[1]May include small quantities recovered by leaching with thiourea, by bioextraction, and by proprietary processes.
[2]Includes autoclaves.
[3]May include tailings and waste ore dumps.
[4]May include small quantities recovered by gravity methods.

Table 9.—Gold produced at placer mines in the United States, by method of recovery[1]

Method of recovery	Mines producing	Washing plants	Material washed (thousand cubic yards)	Gold recoverable: Quantity (thousand troy ounces)	Gold recoverable: Value (thousands)	Gold recoverable: Average value per cubic yard
Bucketline dredging:						
1981	3	5	[2]2,190	15	$6,731	$3.073
1982	6	8	4,702	22	8,130	1.729
1983	3	4	4,785	30	12,512	2.615
1984[r]	2	3	4,840	29	10,387	2.147
1985	2	3	826	9	2,971	3.597
Dragline dredging:						
1981	1	7	[3]30	[4]6	1,200	13.023
1982	3	14	[3]29	[4]3	1,188	18.960
1983	2	13	[3]110	[4]3	1,333	3.481
1984	4	[r]13	[3]126	[4]4	1,593	[r] [5]2.908
1985	3	14	[3]156	[4]4	1,348	2.224
Hydraulicking:						
1981	7	7	113	1	526	4.678
1982	4	4	17	([6])	139	8.026
1983	1	1	3	([6])	117	43.342
1984	1	1	28	([6])	90	3.220
1985	--	--	--	--	--	--
Nonfloating washing plants:						
1981	9	13	[3]894	[4]9	4,438	4.869
1982	10	11	805	13	4,829	6.000
1983	6	6	961	18	7,450	7.750
1984	8	8	[r]310	3	1,036	[r]3.343
1985	6	6	959	31	9,690	10.102
Underground placer, small-scale mechanical and hand methods, suction dredge:						
1981	6	7	108	1	401	3.728
1982	15	15	30	([6])	174	5.848
1983	23	24	[3]167	[4]3	1,437	7.831
1984	10	11	[r]197	1	454	[r]2.304
1985	19	19	621	6	2,061	3.320
Total placers:[7]						
1981	26	39	[2] [3]3,335	[4]29	13,296	[5]3.719
1982	38	52	[3]5,584	[4]38	14,460	[5]2.475
1983	35	48	[3]6,026	[4]54	22,849	[5]3.792
1984[r]	25	36	[3]5,501	[4]38	13,560	[5]2.242
1985	30	42	[3]2,561	[4]51	16,069	[5]5.882

[r]Revised.
[1]Data are only for those mines that report annually on the Bureau of Mines voluntary survey; there are many more, usually smaller and less well-established operations, mainly in Alaska, that do not report.
[2]Does not include platinum-bearing material from which byproduct gold was recovered.
[3]Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.
[4]Includes gold recovered at commercial sand and gravel operations.
[5]Gold recovered as a byproduct at sand and gravel operations is not used in calculating average value per cubic yard.
[6]Less than 1/2 unit.
[7]Data may not add to totals shown because of independent rounding.

Table 10.—U.S. refinery production of gold

(Thousand troy ounces)

Raw material	1981	1982	1983	1984	1985
Concentrates and ores:					
Domestic	801	718	885	r760	620
Foreign	4	1	7	4	--
Old scrap[1]	1,610	1,444	1,380	1,310	1,215
New scrap	1,475	1,596	r1,590	r1,794	1,520
Total[2]	3,890	3,760	r3,863	r3,868	3,355

rRevised.
[1]Excludes upgrading of U.S. Government-owned gold (mostly coin gold) by the U.S. Assay Office, amounting to 2,476,628 ounces in 1981. Refining activity terminated in Sept. 1981.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Just over 3 million ounces of gold was consumed by domestic end-use industries in 1985, slightly less than that of 1984. Jewelry and the arts continued to be, as in years past, the principal end use, accounting for about 53% of overall consumption. Electronic products, specialty alloys, and aerospace applications absorbed about 34% of the total. Consumption in various dental applications increased slightly, accounting for nearly 13% of the total. Consumption in the fourth end-use category, small items for investment, continued to decline relative to earlier years, apparently in favor of other gold and nongold investment vehicles, and was negligible in 1985.

Sales of U.S. Department of the Treasury gold medallions and Olympic gold coins declined substantially, principally as a result of fulfillment of the minting requirements set forth in the enabling legislation.

Trading activity on the Nation's gold futures exchange markets declined for the third consecutive year, apparently to some extent as a result of the increasing popularity of trading in gold-based options, a declining rate of domestic currency inflation, and trading in more attractive investment opportunities in other markets, such as securities.

On July 10, the International Monetary Market in Chicago discontinued all gold futures trading activity. In October, members of Chicago's MidAmerica Commodity Exchange and the Chicago Board of Trade (CBOT) approved an affiliation agreement. The agreement called for the MidAmerica to remain a separate legal entity and a separate exchange and the CBOT to become the sole voting and equity member of the MidAmerica.

Table 11.—U.S. consumption of gold,[1] by end use

(Thousand troy ounces)

End use	1981	1982[2]	1983[2]	1984[2]	1985[2]
Jewelry and the arts:					
Karat gold	1,420	1,638	1,410	r1,466	1,418
Fine gold for electroplating	24	17	18	18	27
Gold-filled and other	286	301	237	225	198
Total[3]	1,730	1,954	r1,666	r1,709	1,643
Dental	314	358	360	363	394
Industrial:					
Karat gold	50	64	44	42	36
Fine gold for electroplating	528	389	344	415	326
Gold-filled and other	633	649	644	628	693
Total[3]	1,210	1,102	1,032	1,084	1,055
Small items for investment[4]	22	9	3	8	7
Grand total[3]	3,276	3,423	3,061	r3,164	3,100

rRevised.
[1]Gold consumed in fabricated products only; does not include monetary bullion.
[2]Data may include estimates.
[3]Data may not add to totals shown because of independent rounding.
[4]Fabricated bars, medallions, coins, etc.

STOCKS

Official.—Stocks of gold bullion, held by the Department of the Treasury, continued to decline slowly, reflecting, in part, material consumed to satisfy minting requirements of the Department's gold medallion and commemorative coin program.

Official gold reserves of the market economy countries, including stocks held by the International Monetary Fund (IMF) and the Bank for International Settlements, totaled 1.144 billion ounces at yearend, compared with 1.142 billion ounces at yearend 1984. IMF yearend stocks, 103.43 million ounces, were unchanged from stocks reported since 1980.

Commercial.—Stocks of refined gold held by industrial users at yearend were 16% lower than stocks on hand at the end of 1984. The sharpest decrease in inventories occurred during the first quarter, as users apparently began withdrawing material to meet anticipated demand later in the year. Yearend stocks of gold certified for delivery by the Commodity Exchange Inc., New York, the Nation's largest gold futures exchange, comprise nearly all U.S. futures exchange stocks; they declined about 9% from the yearend 1984 level.

Table 12.—Yearend stocks of gold in the United States

(Thousand troy ounces)

	1981	1982	1983	1984	1985
Industry	635	776	[r]623	[r]765	639
Futures exchange	2,449	2,303	2,530	2,359	[1]2,110
Department of the Treasury[2]	264,116	264,046	263,406	262,814	262,672
Earmarked gold[3]	350,640	348,555	341,402	337,873	377,399

[r]Revised.
[1]Commodity Exchange Inc. only.
[2]Includes gold in Exchange Stabilization Fund.
[3]Gold held for foreign and international official accounts at New York Federal Reserve Bank.

PRICES

The Engelhard Industries-London daily final price of refined unfabricated gold began the year at about $306 per troy ounce and remained at about that level for the following 8 weeks. On February 25, the price fell to $284, its lowest point since August 6, 1979. Subsequent domestic and international economic and political developments combined to drive the price to the year's high of $341 in August and to sustain it through yearend at around $320. The Engelhard Industries average for the year was $317.66 per troy ounce, compared with $360.66 per troy ounce in 1984.

Table 13.—U.S. gold prices[1]

(Dollars per troy ounce)

Period	Low	(date)	High	(date)	Average
1981	391.25	(Aug. 4)	599.25	(Jan. 6)	459.64
1982	276.75	(June 21)	481.00	(Sept. 7)	375.91
1983	374.65	(Nov. 21)	509.25	(Feb. 15)	424.00
1984	307.90	(Dec. 20)	405.85	(Mar. 5)	360.66
1985:					
January	298.15	(Jan. 28)	308.40	(Jan. 18)	303.19
February	284.65	(Feb. 25)	304.55	(Feb. 14)	299.22
March	287.65	(Mar. 1)	330.80	(Mar. 27)	304.34
April	317.15	(Apr. 4)	334.65	(Apr. 15)	325.31
May	310.00	(May 6)	326.90	(May 14)	316.46
June	312.40	(June 10)	325.80	(June 19)	316.89
July	308.65	(July 2)	327.90	(July 31)	318.20
August	320.20	(Aug. 6)	341.30	(Aug. 19 and 28)	330.46
September	316.65	(Sept. 18)	329.65	(Sept. 26)	323.18
October	322.65	(Oct. 1)	328.15	(Oct. 22)	326.24
November	322.35	(Nov. 8)	331.50	(Nov. 26)	325.64
December	315.90	(Dec. 11)	330.00	(Dec. 31)	322.76
Average	XX		XX		317.66

XX Not applicable.
[1]Engelhard Industries daily quotation.

FOREIGN TRADE

Net imports of gold continued to increase during most of 1985, probably in response to favorable currency exchange rates. With the exception of gold contained in waste and scrap products, imports of gold-bearing materials again exceeded exports, with total net imports for the year increasing 48% above the 1984 level. Net imports of refined bullion registered substantial gains over net imports of the previous 2 years; in terms of net value, however, the increase was marginal in comparison with that of 1984. Imports of gold-bearing ore and concentrates declined substantially from imports received during 1984, reflecting the precipitous decline during 1984 in imports of gold-bearing copper ore and concentrates. The rate of growth in net exports of waste and scrap slowed considerably from the rate in 1984.

Gold imported in bullion coins declined 26% to about 2.06 million ounces. Imports of South African Krugerrands declined 73% owing to a combination of factors, such as the Presidential banning order of October, the availability of domestic gold investment items, and a shift toward other forms of investment.

Table 14.—U.S. exports of gold, by country

Year and country	Ore and concentrates		Waste and scrap		Doré and precipitates		Refined bullion		Total[1]	
	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)
1981	3,827	$1,779	1,009,101	$485,794	186,493	$82,976	5,237,585	$2,501,337	6,437,006	$3,071,886
1982	3,092	1,028	1,149,821	427,846	180,297	69,264	1,637,184	590,947	2,970,394	1,089,086
1983	12,757	5,190	1,175,830	469,789	69,213	26,037	1,881,233	825,418	3,139,033	1,326,434
1984	3,298	545	1,422,849	503,237	72,470	24,502	3,482,473	1,284,718	4,981,090	1,813,002
1985:										
Belgium-Luxembourg	--	--	90,691	28,878	208	74	--	--	90,899	28,952
Canada	991	328	516,241	157,394	73,702	23,245	2,193,117	702,264	2,784,051	883,230
Colombia	--	--	710	220	--	--	15,042	4,563	15,752	4,783
Dominican Republic	--	--	--	--	--	--	2,124	703	2,124	703
France	241	40	170,538	54,399	--	--	462	106	171,241	54,545
Germany, Federal Republic of	--	--	25,533	7,869	6,499	2,079	3,932	1,198	35,964	11,146
Haiti	--	--	--	--	--	--	2,235	515	2,235	515
Hong Kong	--	--	19,300	5,790	28	17	66,468	20,344	85,796	26,151
Italy	10	3	2,675	847	141	35	1,930	603	4,756	1,488
Japan	--	--	38,959	11,278	6,267	1,611	35,742	11,498	80,968	24,386
Mexico	1,053	335	27	9	--	--	9,515	3,236	10,595	3,579
Panama	--	--	1,456	477	--	--	18,664	5,979	20,120	6,456
Spain	--	--	3,526	1,156	--	--	1,600	534	5,126	1,690
Sweden	--	--	25,700	8,181	2,522	833	--	--	28,222	9,014
Switzerland	110	55	430	112	3,537	1,026	338,406	110,293	342,483	111,486
United Kingdom	10	1	83,429	26,443	1,802	802	191,337	55,164	276,578	82,410
Uruguay	--	--	--	--	--	--	2,987	900	2,987	900
Other	33	10	932	359	1,068	427	4,748	1,534	6,781	2,332
Total[1]	2,448	771	980,147	303,413	95,774	30,147	2,888,309	919,433	3,966,678	1,253,764

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 15.—U.S. imports for consumption of gold, by country

Year and country	Ore and concentrates		Waste and scrap		Doré and precipitates		Refined bullion		Total[1]	
	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)
1981	102,746	$43,690	130,949	$56,153	253,980	$115,084	4,164,476	$1,942,560	4,652,151	$2,157,487
1982	202,410	69,528	85,584	27,786	394,667	145,571	4,237,669	1,650,719	4,920,330	1,893,604
1983	239,146	94,919	146,164	51,516	608,458	255,113	3,599,188	1,575,570	4,592,956	1,977,118
1984	202,787	69,061	357,119	122,483	1,277,146	461,763	6,031,550	2,293,606	7,868,602	2,946,914
1985:										
Argentina	--	--	--	--	230	83	28,583	9,343	28,813	9,425
Belgium-Luxembourg	1,408	1,066	--	--	37,019	10,441	145,401	46,372	183,828	57,880
Bolivia	--	--	106,732	35,725	23,050	7,263	26,445	8,167	156,227	51,155
Brazil	--	--	2,448	737	92	23	132,844	43,548	135,384	44,309
Canada	4,894	1,557	43,357	10,161	896,715	290,957	3,889,881	1,251,966	4,834,847	1,554,641
Chile	1,820	264	9,646	3,041	15,181	4,939	212,327	68,995	238,974	77,239
Dominican Republic	--	--	11,222	4,027	317,157	100,383	27,566	9,080	355,945	113,490
Germany, Federal Republic of	408	137	253	70	13,873	4,433	18,025	5,808	32,559	10,448
Mexico	6,600	2,152	13,310	4,539	5,386	1,730	7,248	2,343	32,544	10,765
Peru	--	--	834	255	16,663	5,410	33,155	10,726	50,652	16,391
Spain	3,255	948	--	--	--	--	25,250	7,910	28,505	8,858
Switzerland	11	4	--	--	46,558	14,806	301,645	97,689	348,214	112,498
United Kingdom	--	--	34,816	10,494	52,712	16,707	324,538	104,412	412,066	131,613
Uruguay	--	--	--	--	623	155	1,079,137	407,453	1,079,760	407,608
Venezuela	90	20	76,455	19,842	13,622	4,161	18,803	5,998	108,970	30,021
Yugoslavia	--	--	4,532	652	1,611	523	22,779	7,336	28,922	8,511
Other	18,581	5,478	63,282	17,605	20,576	6,215	67,350	22,330	169,789	51,628
Total[1]	37,067	11,628	366,887	107,147	1,461,068	468,227	6,360,977	2,109,475	8,225,999	2,696,478

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

Continuing a trend that began in 1980, world gold mine production increased again during 1985. About 45% of the world mine output came from the Republic of South Africa, with the remainder, in descending order of magnitude, from the U.S.S.R., Canada, the United States, Brazil, China, Australia, and 56 other countries. Gold is also produced in small quantities in a dozen or so other countries for which production data are not available.

Consolidated Gold Fields, in its annual summary of world gold supply and demand, reported that the supply of gold available to commercial purchasers in the market economy countries in 1985 was about 41.4 million ounces or nearly 5 million ounces less than that of 1984. Following 2 years during which central banks and government-controlled investment institutions, which together make up the official sector, were net sellers of gold to the market, the official sector in 1985 made net purchases amounting to over 4.3 million ounces.

Gold Fields estimated that consumption of gold in the commercial sectors of the market economy countries was about 39.6 million ounces, or essentially the same as that of 1984. Gold consumed in 1985 in the market economy countries was divided, in millions of troy ounces, with 1984 consumption in parentheses, between the following end-use categories: jewelry, 28.9 (26.6); electronics, 3.6 (4.0); dental, 1.7 (1.6); other industrial and decorative uses, 1.6 (1.8); medallions and unofficial coins, 0.4 (1.4); and official coins, 3.4 (4.2).[12]

A brief description and analysis of the salient features of the mineral industries, including gold, of Australia, Canada, and Oceania was published by the Bureau of Mines in 1985.[13]

Australia.—The resurgence in Australian gold production, which began in 1981, continued in 1985 with production exceeding 1.8 million ounces, up 46% over that of 1984 and greater than in any year since 1915. The year's comparatively high gold prices in terms of Australian dollars, and the income tax-free status of gold mining combined to further stimulate industry's interest and action. Again, as in recent years, Western Australia was the principal producing State and experienced the greatest gold exploration and mining activity.

Substantial depreciation of the Australian dollar in March and again in November 1985 served to increase the gap between U.S.-dollar-denominated gold prices and prices denominated in Australian dollars (A$). The price began the year at nearly A$370, compared with a London price of about US$308, peaked at A$510 in April then ranged from A$450 to A$500 for the rest of the year.

Highlights of Australian gold developments in 1985 were summarized by the Australian Bureau of Mineral Resources (BMR).[14] In addition to addressing developments at Australia's gold mines, the BMR noted that retreatment of old dumps for gold left by previous treatment was increasing; at least 53 dumps were being retreated, with the scale of the operations ranging from the Mount Morgan Ltd. and Anglo American Gold Pty. Ltd. 38,600-ounce-per-year venture in Queensland to smaller operations with individual annual capacities of 3,000 ounces or less. Throughout the country, at least 26 placer mines operated, most of them small; the total does not include many small 1- to 2-person operations. According to the BMR, out of the total funds directed toward mineral exploration in Australia exclusive of petroleum, about 40% was allocated to the search for gold.

April 4 marked the official opening of the new Kidston Mine, Australia's largest gold mine. The new mine is in the historic Oaks Goldfield approximately 180 miles northwest of Townsville in the State of Queensland. Ore production at the new open pit started in January, and the first gold was poured in February. The new mine, 70% owned by Placer Development Ltd. and 30% owned by various domestic interests, produced more than 206,000 ounces of gold during its first year of operation. At full production, Kidston was expected to yield 281,000 ounces of gold and 164,000 ounces of silver per year.

A significant gold discovery was made in early 1985 in Queensland's Drummond Basin about 35 miles south of Charters Towers and 90 miles southwest of Townsville, by Pajingo Gold Mines Pty. Ltd., a subsidiary of Battle Mountain Gold of Houston, TX. Initial drilling on the Pajingo Prospect reportedly produced several extremely high-grade intersections; one, for example, reportedly included 6.6 feet of core assaying 45.57 ounces of gold per ton. Subsequent drilling and examination of the ore body, designated as the "Janet A. Lode Zone," resulted in the identification of reserves bearing an estimated 500,000 ounces of gold and more than 1.8 million ounces of silver that should be minable using surface mining techniques. Six other areas, including the Janet B. Zone about 0.5 mile away from the Janet A. Zone, have been scheduled for investigation in the near future. The company has authority to prospect about 2,000 square miles in the Pajingo area. Nearby, another company, North Queensland Resources, reportedly held a small unexplored prospect designated as the "Highway gold prospect." Elsewhere in Queensland, the Mount Leyson gold deposit, a prospect held jointly by Noranda Pacific Ltd. (a joint venture of Noranda Australia, the Broken Hill Pty. Co. Ltd. (BHP), and the Electrolytic Zinc Co. of Australia Ltd.) and Pan Australia Mining Ltd., had reached the feasibility stage and was believed likely to begin production by 1987. Several other gold properties in the State were under investigation, with several targeted for production in the near future.

Western Mining Corp. Holdings Ltd. (WMCH) and its partner BP Australia Ltd. decided to develop the huge Olympic Dam project at Roxby Downs, South Australia. In addition to producing copper and uranium, the mine was expected to produce gold at a rate of about 96,000 ounces per year shortly before or following the mine's scheduled opening as a base metal producer in 1988.

In the Northern Territory, the Pine Creek gold mine of Renison Goldfields Consolidated Ltd. (RGC) and Enterprise Gold Mines NL began production in late October. The new mine at Pine Creek was to be operated by the partners' company, Pine Creek Consolidated Ltd., and was expected to produce 53,000 ounces of gold and 20,000 ounces of silver annually. In the Tanami area of the Northern Territory, North Flinders Mines Ltd. continued exploration and planning at its Granites project. The company planned to bring the new mine into production by July 1986 at an annual rate of about 65,000 ounces per year. Exploration reportedly identified five additional deposits that could add substantially to the project's established ore reserves. In other developments, Noranda Pacific continued exploration of a significant gold discovery made in 1984 at Coronation Hill. Drilling at the project in 1985 indicated a large reserve of ore minable by surface methods, while geological studies suggested that a much larger potential may exist. Platinum and palladium of unspecified quantity were reportedly associated with the discovery. Near yearend, Peko Mines, part of Peko-Wallsend Group Ltd., completed construction of surface and shaft-hoisting facilities at its Argo Mine (formerly Explorer 46) under development near Tennant Creek. Also near Tennant Creek, Nobles Nob gold mine ceased operation on January 14, after 37 years. Milling of stockpiled ore was expected to continue at least through midyear. Depletion of economic reserves was cited as a reason for the closure.

Developments in the State of Western Australia, which accounted for about 70% of Australia's production in 1985, continued to dominate the country's gold mining scene. At least six new mines began production during the year, and improvements were completed at numerous others; exploration was very active. WMCH's gold circuit at the Kambalda nickel operation produced 95,523 ounces for the fiscal year ending in September. The company also began heap leaching low-grade ore from the opencut at the Victory Mine. Production from WMCH's other Western Australian gold properties at Kalgoorlie, Lancefield, Mount Magnet, and Norseman, and not including production at affiliated Kalgoorlie Mining Associates (KMA) facilities, amounted to 223,964 ounces for the 12 months ending in September. Gold production by KMA at its Mount Charlotte and Fimiston operations amounted to 234,057 ounces during the fiscal year.

New mines that began operations in Western Australia during the year included the following: Esso Exploration and Production Australia Inc. and its partners dedicated the new 80,000-ounce-per-year Harbour Lights Mine at Leonora in July. AUR NL started treating ore from its Mount Martin and Good Hope Mines between Kalgoorlie and Kambalda. AUR poured its first gold in April; production was expected to be 10,000 to 15,000 ounces per year. Brunswick Oil NL began operations at its new open pit Galtee More Mine 5 miles northwest of Mount Magnet. Production was expected to be 45,000 ounces per year; a new 200,000-ton-per-year mill was scheduled for operation in early 1986. Endeavour Resources Ltd. commissioned its new 40,000-ounce-per-year Bluebird Mine and carbon-in-leach treatment plant near Meekatharra. Near Kalgoorlie, Windsor Resources NL and partners began production near yearend at the Mount Percy open pit. The new $9 million mine was expected to yield 39,000 ounces per year. The Paddington open pit mine of Pancontinental Mining Ltd., at Broad Arrow, 20 miles north of Kalgoorlie, was commissioned in May. The first gold was poured in June; annual production was expected to be 90,000 ounces. Finally, BHP's new Gimlet South, or Ora Banda Mine at Ora Banda, began production at an initial annual rate of 10,000 ounces.

At Western Australia's largest gold mine, the Telfer Mine, east of Nullagine, Newmont Holding Pty. Ltd. and BHP announced plans to increase the mine's production capacity from 140,000 to 190,000 ounces per year. The expansion program was scheduled for completion by September 1986.

Australia Mining NL announced in early 1985 that because of depletion of economic ore reserves the Mount Henry Mine at Norseman was placed in care-and-maintenance status pending the discovery of new reserves and/or an increase in the price of gold.

In August, the Government of Australia approved plans by the Western Australian government's Perth Mint to produce gold coins to compete in the international market with gold coins offered by other nations. The plans reportedly called for the minting of 200,000 to 500,000 coins of 99.99% purity ranging in weight from 0.10 to 1 troy ounce, to be marketed during the first half of 1986.

Brazil.—The gold rush under way in Brazil over the past several years continued to moderate, and development became more organized. At Serra Pelada, in the State of Pará, production dropped from a 1983 peak of about 400,000 ounces to an estimated 70,000 ounces in 1985; most of the estimated 30,000 to 40,000 independent miners, or "garimpeiros," who were working in the mine's enormous hand-dug pit during the peak years have since been drawn to the many other isolated gold rush camps scattered throughout the northern part of the country. Gold-bearing rivers such as the Tapajós and others flowing out of the Andes Mountains and along the frontier between Brazil and Bolivia continued to be the largest centers of garimpeiro activity.

Efforts were continued by the Government to develop a more accurate accounting of the country's gold production, especially that produced by garimpeiros who, attracted by premium gold prices offered outside of the country, reportedly sold their unreported production to smugglers, or simply used it as a medium of exchange in the frontier areas. Calls for official guidelines and policy directives aimed at achieving greater control over gold smuggling and objectionable garimpeiro mining practices were made on several occasions during the year by gold mining industry and Government representatives.

In the State of Minas Gerais, the Mining Div. of General Mining Union Corp. Ltd. (Gencor), of the Republic of South Africa, continued to develop its underground São Bento gold mine. The mine's new gold recovery plant was to incorporate a pressurized leaching system designed to maximize gold recovery from the highly refractory ore. Commissioning of the new mine was scheduled for the end of 1986. Production was expected to be about 60,000 ounces per year. At Paracatu, between Brazilia and Belo Horizonte, a large placer deposit reportedly containing 3 million ounces of gold, 1.4 million ounces of silver, and nearly 0.5 million ounces of platinum was discovered by RTZ Mineração Ltd., the Brazilian subsidiary of The Rio Tinto Zinc Corp. PLC, of the United Kingdom. The deposit, known as the Morro do Ouro, was the result of more than 4 years of exploration by RTZ. Reportedly at yearend, RTZ had formed a joint venture with Autram Mineração e Participações S.A. to proceed with development of the property. Production was scheduled to begin in 1987 at a rate of about 100,000 ounces of gold per year. Concurrently, Autram was reportedly involved with a Canadian partner, Treasure Valley Explorations, of Toronto, in developing a large placer deposit along the Teles Pires River in the State of Mato Grosso.

At Nova Lima, Mineração Morro Velho S.A. (MMV), an indirect subsidiary of the Anglo American Corp. of South Africa Ltd. (AAC), and its partner, the Bozzano Simonsen Group, moved closer to a targeted 1987 completion of an expansion program at its Raposos-Cuiaba project. The $160 million program was expected to increase the company's production capacity in the State by about 160,000 ounces, to 300,000 ounces per year. MMV also operates the old Morro Velho Mine near Nova Lima, where stratabound, sulfide-hosted gold has been mined since 1835, and the Jacobina Mine in the State of Bahia.

At the end of January, Cia. Vale do Rio Doce (CVRD), the Brazilian state mining company, produced the first gold from its new Araci Mine, also known as the Fazenda Brasileiro. Construction of the open pit mine, near Serrinha in the State of Bahia, was completed between January and September 1984 and is Brazil's first heap-leaching operation. About 16,000 ounces was expected to be produced annually. CVRD's plans to take over development of the Serra Pelada Mine in the State of Pará were reportedly postponed for several years to allow garimpeiros there to continue.

An investigation of the genesis and formation of gold deposits in the Precambrian shield of Brazil concluded that the best potential for future discoveries of lode gold deposits should be in greenstones and younger Precambrian conglomerates.[15] A genetic model was proposed that indicated repeated recycling of gold through geological time.

Canada.—Canadian gold production increased for the fifth consecutive year, reflecting the continuing momentum of both Canadian gold exploration and mine development.

Gold production in Ontario increased 13% during the year, and developments in that Province were highlighted by the opening of three large underground mines at Hemlo. Just 3 years from discovery and 2 years since construction began, the Golden Giant Mine at Hemlo poured its first 1,000-ounce bar of production gold. The Golden Giant Mine is owned by Noranda Mines Ltd. and its partners Golden Sceptre Resources Ltd. and Goliath Gold Mines Ltd. Production at the Golden Giant was expected to reach 330,000 ounces per year by 1988. At the end of May, Teck Corp. and its partner International Corona Resources Ltd. poured their first gold at the Teck-Corona Mine. Annual production at the new Hemlo facility was expected to be about 250,000 ounces by 1987. Nearby, Lac Minerals Ltd., of Toronto, brought its Page-Williams Mine on-stream in December. Production from this mine was to reach 200,000 ounces in 1986 and reportedly could rise to 400,000 ounces per year by 1989. Believed to be the most significant discovery in over 50 years in Canada, the Hemlo deposit may eventually increase Canadian production from its present 2.7 million ounces per year to nearly 3.5 million ounces.

At the Detour Lake Mine, 120 miles northeast of Timmins, Ontario, operations at the open pit were scheduled to end in 1986, and at about the same time, a 17-month shutdown was reportedly planned to accommodate changes in the mine's development plan. In midyear, Kidd Creek Mines Ltd., Toronto, announced a decision to expand crushing capacity and build a new gold recovery plant at its Kidd Creek copper-zinc-silver-gold mine at Timmins. The expansion was to accommodate production from the company's new Hoyle Pond and Owl Creek Mines. The Hoyle Pond Mine, near Timmins, was scheduled to begin production in early 1986 and was expected to produce about 45,000 ounces of gold per year. The Owl Creek open pit mine, which began production in 1982, is just west of Hoyle Pond and produces about 25,000 ounces of gold per year.

Other Canadian gold mines moving toward production in the near future include Sherritt Gordon Mines Ltd.'s new 70,000-ounce-per-year MacLellan Mine near Lynn Lake, Manitoba; Mascot Gold Mines Ltd.'s open pit project at Hedley, British Columbia; and Total Erickson Resources Ltd.'s Mount Skukum project, about 40 miles south of Whitehorse in the Yukon Territory. Corona's Cullaton Lake property in the Northwest Territories was closed, as was Teck's Lamaque Mine at Val d'Or, Quebec.

Although gold exploration activity was high throughout the gold-producing areas of Canada, it was especially high in the Maritime Provinces and in the Province of Quebec. Stimulated by the discovery near yearend by Teck Explorations Ltd. and its partners Golden Hope Resources Inc. and Golden Group Explorations Inc. of a small, high-grade gold, silver, copper, and zinc deposit near Casa Berardi, in Estrades Township, northwestern Quebec, numerous companies accelerated a rush to secure land positions in the area. Inco, one of the original companies that had been exploring in the area since 1981, touched off the rush when significant gold values were intersected during a drilling program along an extension of the main ore zone of its Golden Pond deposit, where Inco, with its partner Golden Knight Resources Ltd., had earlier begun an underground exploration program. At yearend, several dozen companies had secured land positions in the Casa Berardi area, and a few new gold strikes had reportedly been made. Investor interest, based largely on the results of preliminary drilling in the area, was reflected in a large early December increase in speculative trading activity on the Vancouver, British Columbia, stock exchange.

On the southwest coast of the island of Newfoundland, BP Resources Canada Ltd. continued to evaluate its Chetwynd gold deposit. By yearend, the company had completed 58 drill holes indicating preliminary reserves of about 1.6 million ounces of gold. A 9,500-ton heap-leach recovery test showing a 61% recovery rate was also conducted. Development of the property was expected to begin in 1986. Gold discoveries near the island's south coast, at White Bay on the north coast, and to the north in Labrador, also stimulated major claim staking and land acquisition in the Province of Newfoundland. The number of new claims staked reportedly exceeded 13,000, and more than 27,000 were reportedly in good standing at yearend. About 30 companies were involved in the new claim activity. Gold exploration activity was also reviving in the Provinces of New Brunswick and Nova Scotia, where new discoveries in recent years were prompting a reexamination of old goldfields and grassroots efforts in unexplored areas.

As a result of restrictions near yearend on the importation of South African Krugerrands by a number of countries, the Canadian Maple Leaf bullion coin market benefited significantly, and sales reached an all-time high, rising from 1 million ounces in 1984 to nearly 1.9 million ounces in 1985.

China.—The Government of China continued to formulate economic policies and provide incentives aimed at rapidly increasing the country's production of gold, which, as an export commodity, may be quickly liquidated to earn much-needed foreign exchange credits. At a gold mining conference in October, China's New Minister of Geology and Mineral Resources indicated that the Government planned to double the country's present annual output by 1990. To encourage greater production and discourage gold smuggling and hoarding, the Government began to maintain the price at levels in line with the world market price. A crackdown on gold smuggling was intensified during the year, and nearly 1,000 persons were reportedly fined or imprisoned. Gold was reportedly used as a medium of exchange for the purchase of luxury and restricted goods, such as television sets and drugs from outside the country.

The Government continued to step up its efforts to sell its gold production as fabricated products on both domestic and international markets. The popularity of Gold Panda coins minted in Shanghai by the China Mint Co., an affiliate of China's Central Bank, continued to grow, and the Government was reportedly continuing to encourage domestic fabrication of jewelry products in response to increasing demand by the Chinese people.

Reports of Chinese gold discoveries and new mine developments continue to increase every year. Gold was reportedly being mined in 400 Chinese counties. China's largest deposit, the Jiaojiashi gold mine in northern Shandong Province, was reportedly estimated to contain about one-third of the country's verified primary gold reserves. Information released on the discovery suggested that the deposit may be a large low-grade disseminated-type deposit.

Colombia.—Apparently stimulated by a 1984 Government decision to pay a 30% premium over world gold prices, gold production in Colombia registered a nearly 44% increase over that of 1984. Foreign and domestic participation in gold ventures throughout Colombia remained at a high level throughout the year. The Instituto Nacional de Investigaciónes Geológico-Mineras, an autonomous Government agency responsible for mineral exploration and preliminary mining studies, issued a report summarizing the most promising areas to prospect for new lode and placer deposits of gold and silver in Colombia. The area with the best potential for vein-type lode gold was reported to be the Cordillera Central because of extensive fracturing and fault structures; the volcanics on the western edge of the Cordillera were reported to be the most promising formations for discoveries of disseminated-type deposits. The promising placer zones detailed in the report offer the best prospect for discovery and increased gold output in the near term, with the Guaninía Zone near Brazil ranked as having the best potential for placer gold discoveries. The report included maps and a selected bibliography.[16]

Japan.—Interest in gold as an investment vehicle, as well as gold use in fabricated products, especially jewelry, continued to expand in 1985, and as a consequence, Japan moved closer to being one of the world's leading gold markets. Japanese interest and activity directed toward gold exploration and mine development also continued at a high level.

In July, Sumitomo Metal Mining Co. Ltd. began production at its rich Hishikari gold mine in Kagoshima Prefecture on Japan's southern island of Kyushu. The deposit, a classic epithermal (low-temperature) deposit characteristic of the Island Arc volcanic setting, was reportedly discovered in 1978 by an airborne electromagnetic survey conducted in an area previously thought not to host precious metals deposits. The grade of the ore under development was reportedly about 2.3 ounces per ton; 3.9 million ounces of reserves had been delineated by the time production began. Production costs for the planned 174,000-ounce-per-year operation were expected to be among the lowest in the world. Exploration in the Hishikari area by Japan's Metal Mining Agency reportedly led to the discovery of a gold prospect between Sumitomo's new mine and the Kushikiso gold mine of Mitsui Mining & Smelting Co. Ltd.

Initial assays of material returned from drilling a new well at a hot spring at Mount Aso, near the existing Hita gold mine in Kyushu's Oita Prefecture, reportedly showed about 0.6 ounce of gold per ton, plus silver and copper values.

Yatani Mining Co. Ltd., a subsidiary of Mitsubishi Metal Corp., reportedly discovered a high-grade gold occurrence in its Yatani lead and zinc mine, in the Yamagata Prefecture of northern Honshu.

Oceania.—This area has in recent decades yielded significant precious and base metals deposits, such as those developed in Papua New Guinea at Ok Tedi, on the mainland, and at Panguna, on Bougainville Island. Exploration over the past several years has resulted in the discovery of additional deposits, and discoveries announced during 1985 suggest that the rate of success is accelerating.

Interest was generated in 1985 by the release of a report detailing the discovery of anomalous gold values on the Island of Palau, along the Pacific Rim in the Caroline Islands north of New Guinea. According to the report, a brief reconnaissance of the island by the U.S. Geological Survey had resulted in the discovery of a large, as yet unassessed, epithermal gold system.[17]

In Papua New Guinea in the Enga Province of the Western Highlands, between Mount Hagen and Ok Tedi, exploration continued at the Porgera joint venture by Placer (P.N.G.) Pty. Ltd. and its partners Mount Isa Mines Ltd. and RGC. The partners had outlined a large reserve of gold- and silver-bearing ore, much of which is not recoverable by simple cyanide leaching. Metallurgical tests, however, demonstrated that a flotation and pressure oxidation process would be technically feasible. The partners planned to drive an exploration adit in 1986 to more fully evaluate the high-grade portion of the ore body. Placer also continued exploration at its gold and silver property on Misima Island, to the east of the mainland coast.

A partnership of Nord Resources Corp., Kennecott Explorations (Australia) Ltd., and Niugini Mining Ltd., exploring in the Tabar Islands group of Papua New Guinea, encountered encouraging results at three gold prospects on Tatau Island and at four prospects on Simberi Island, 5 miles to the north. To the southeast, in the Linetz-Lamond area of Lihir Island, the partners continued to evaluate a gold discovery announced in 1984. Preliminary diamond drilling results released at yearend 1985 reportedly indicate that a potential gold reserve of nearly 12 million ounces may exist. The partners were also exploring on the island of New Hanover, Woodlark Island, and in the Ramu River area of mainland Papua New Guinea. Also in Papua New Guinea, Esso PNG Inc. and City and Suburban Properties Ltd., of Sydney, Australia, were reported to be prospecting in the D'Entrecasteaux Island group of Milne Bay, in the Feni Islands, and on the island of New Britain, while Newmont Mining was reportedly prospecting in the Tanga Islands.

Activity increased in the Solomon Islands, with interest centering around the old gold deposits on Guadalcanal Island; Cyprus Minerals Co. was reportedly prospecting in the Gold Ridge area, while an Australian company, Zanex Ltd., was reportedly preparing to start mining a placer deposit on the Matepono River with its partner, a local company, Mavu Gold Development Ltd.

In 1985, 95% of the gold produced in Oceania came from two large mines in Papua New Guinea, the Panguna and Ok Tedi operations. At Panguna, on the Island of Bougainville, Bougainville Copper Ltd. produced more than 462,000 ounces of gold as a byproduct of its copper mining operations in 1985. The decline in gold production from the 1984 level of about 504,000 ounces reflected a continuing decline in the gold content of the ore mined; production of mined ore and concentrate had increased 7% over that of 1984.

On the mainland of Papua New Guinea, the new Ok Tedi gold and copper mine, which began production in 1984, produced an estimated 546,000 ounces of gold despite a 5-week hiatus beginning in February. The break in production stemmed from a disagreement between the Government of Papua New Guinea and the mine's owners concerning the time at which the second, or copper, development phase would begin, relative to the completion of the first mining phase—the extraction of the mine's gold-rich cap. An agreement was reached in March whereby the operators would accelerate preparations for the development of the copper production phase. The new mine is one of the largest gold mines in the world outside of the Republic of South Africa and the U.S.S.R. Situated at Mount Fulbian in the rugged Star Mountains near the border between Papua New Guinea and Indonesia, the mine was developed by two U.S. companies, plus a West German consortium and, later, included the Government of Papua New Guinea; the associates together make up Ok Tedi Mining Ltd. The location is perhaps one of the most inhospitable in the world today, with normal mean rainfall of 312 inches distributed over a rainy season lasting for 339 days per year.

Near the north mainland coast, New Guinea Goldfields Ltd. (NGG), controlled by RGC and Consolidated Gold Fields, produced about 11,000 ounces of gold and 7,800 ounces of silver from lode and placer mine operations at Wau. The company began construction of a new 440,000-ton-per-year mill and carbon-in-pulp plant that was scheduled for completion in early 1986.

Other gold-producing countries around the southern Pacific Rim include Indonesia, Fiji, and New Zealand. They registered production increases during the year of 7%, 24%, and 108%, respectively. Each also registered a substantial increase in gold exploration activity as well as development at new or existing operations.

Peru.—In May, the Government of Peru, responding to a need to attract investors to the country's gold mining industry by providing more flexibility in its gold mining laws, modified a number of regulations pertaining to gold mine investment and/or reinvestment programs. Reinvestment regulations were simplified and some burdensome aspects were removed altogether. Direct investment programs, where previously only reinvestment was permitted, were added and both kinds of programs together were structured to clarify investment incentives in the areas of minerals rights, exploration, equipment purchases, construction of infrastructure and access facilities, and installation of advanced recovery processes.

Philippines.—Gold production in the Philippines increased slightly in 1985. Despite gold rushes reportedly under way in several Provinces, some marginal gold and copper operations were forced to suspend work because of rising mining costs and low world metals prices.

The Benguet Corp., the country's largest gold producer, reported a drop in gold output from its five underground gold mines near Baguio City in Benguet Province and its open pit Dizon copper-gold mine in Zimbales Province. Production from the Baguio City mines amounted to 112,000 ounces compared with 114,000 ounces in 1984. During the year, the company began open pit mining at two mineralized areas associated with the deposit cut by the five underground operations. The company also acquired a controlling interest in the Ltogon Mine adjacent to its Acupan Mine. At the Dizon Mine and concentrator in San Marcelino, production of byproduct gold from the copper mining operations was 129,000 ounces, compared with 144,000 in 1984. In 1985, nearly 16 million tons of copper-gold ore plus waste rock were moved. The decline in gold production was a direct result of a 12% reduction in the gold content of the ore mined during the year plus a slight drop in gold recovered by the mill. Benguet also conducted extensive exploration and development work at its Paracale Gold project in Camarines Norte Province, and exploration for gold, copper, and other metals in various Philippine Provinces until financial limitations forced many projects to be suspended toward yearend.

Atlas Consolidated Mining and Development Corp. reported that 160,002 ounces of gold was produced at its operations on Cebu and Masbate Islands, compared with nearly 190,000 ounces in 1984. The heap-leaching plant at the Masbate Gold Operation (MGO), which began production in late 1984, produced 6,301 ounces of gold during its first full year of operation. Gold produced at MGO's open pit operation amounted to nearly 79,000 ounces, or slightly less than in 1984. Exploration by Atlas was held in abeyance during the year pending improvement in the outlook for its products.

Exploration for gold was conducted by a number of other companies operating in the islands. RGC continued drilling at its Tirad project, and prospecting on Bohol Island by Colfax Energy Ltd. and its partner Black Gold Oil & Gas Ltd. reportedly detected promising gold values.

Gold rushes were reported on the islands of Mindanao and Negros, where controls were imposed on the various operations following problems associated with unsafe working conditions and gold smuggling.

South Africa, Republic of.—Effective April 1, the mining tax surcharge paid by all domestic gold and diamond mines was increased by 5%, to 25%. A 34% decline in the value of the rand against the U.S. dollar, plus relatively stable dollar-denominated gold prices, combined to produce increased revenue for the country's gold mines.

From September 1983 through the end of 1984, the South African Reserve Bank had been paying for domestic gold mine production with dollars. Beginning in January 1985, this payment to the mines in dollars was reduced by one-half with the remaining one-half paid in rands, and by December, the bank reverted to paying for production exclusively in rands.

Superimposed on these and other internal developments, especially during the second half of the year, were actions taken by several foreign governments to ban the importation of Krugerrands and to impose restrictions on business-related activities with the Republic of South Africa.

In the meantime, labor strife continued to mount and manifest itself at some of the country's gold, coal, and platinum mines. On April 26, about 15,000 gold miners were fired following their participation in a reportedly illegal 24-hour strike for higher wages. The majority of the dismissed miners were employed at the Vaal Reefs Mine of AAC; concurrently, Anglovaal Ltd. fired a number of strikers at its Hartebeestfontein Mine. A strike by the National Union of Mineworkers (NUM) against selected South African gold and coal producers began on September 3, but was called off the following day when only a small percentage of NUM's estimated 150,000 members participated.

Of the nearly 21.6 million ounces of gold produced in the Republic of South Africa during the year, 20.5 million ounces was produced by the 33 mines that together represent the membership of the Chamber of Mines of South Africa. The remainder was recovered by small independent gold producers or as a byproduct of other mining sectors. The total ore milled by Chamber members, including ore milled by producers of byproduct and coproduct uranium, amounted to 115.3 million tons, averaging 0.18 ounce of gold per ton; in 1984, 111.5 million tons, averaging 0.19 ounce per ton, was milled. Working costs for South African gold mines in 1985 averaged[18] $155.27 per ounce and ranged from $87.69 per ounce at the Kloof Mine to $320.88 per ounce at East Rand Proprietary. Production by the six major mining groups was as follows, in million ounces: AAC, 7.7; Gold Fields of South Africa Ltd., 4.1; Gencor, 3.7; Rand Mines Ltd., 2.1; Johannesburg Consolidated Investment Co. Ltd. (JCI), 1.6; and Anglovaal, 1.2.

In terms of individual mine output, the largest South African gold mines, in millions of ounces of production, were Vaal Reefs with 2.6; Driefontein Consolidated with 2.1; Western Holdings, Buffelsfontein, and Western Deep Levels with about 1.2 each; and Harmony with just over 1.0. Estimates of fully developed or blocked-out gold ore reserves reported by the Chamber of Mines at the end of 1985 amounted to nearly 500 million tons, containing, on average, about 0.30 ounce of gold per ton. A comprehensive review of South African gold mining including historical and statistical details on production, labor, and mine financing was published in 1985.[19]

In an attempt to increase production and reduce working costs, AAC continued to seek approval of its previously announced plans to merge four of its gold mining companies in the Orange Free State to form Free State Consolidated Gold Mines Ltd., also known as Freegold. The merger, one that would create the world's largest single gold mine, producing about 3.6 million ounces and employing 105,000 people, had received Government approval by yearend but was yet to be approved by shareholders of the affected companies. Gold Field's Kloof Gold Mining Co. Ltd. announced plans to establish a new division, the Leeudoorn Div., to exploit recently discovered ore reserves near its existing operations in the Transvaal. A new main shaft and ventilation shaft connecting the existing workings with the new reserve area were under construction near yearend. Plans called for a doubling of milling capacity by the end of the century. Gencor announced that its new Beatrix Mine in the Orange Free State, which began production in late 1983, had attained its planned full production rate of more than 2.2 million tons of ore per year.

Exploration continued for new gold ore bodies and extensions to existing deposits in the Republic of South Africa. In the Orange

Free State, JCI and AAC completed their drilling and exploration program in the Theunissen District and reportedly decided to proceed with the sinking of two prospect shafts at the site, known as the Joel Prospect. In the Barberton region of the eastern Transvaal, Southland Energy Corp., a U.S. company, reportedly completed its first-phase exploration program at the old Makonjwaan and Imperial Mines. Favorable preliminary drilling results reportedly led the company to propose a broader program of exploration to several potential partners.

U.S.S.R.—Estimated net exports of gold from the U.S.S.R. and the centrally planned economy countries to the market economy countries were reported to have increased for the second consecutive year, rising from nearly 6.6 million ounces in 1984 to 6.8 million ounces or more in 1985.[20]

Table 16.—Gold: World mine production, by country[1]

(Troy ounces)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina	14,757	20,319	23,374	22,120	22,500
Australia	590,737	866,815	983,522	1,257,125	[3]1,832,590
Bolivia	66,372	40,146	49,217	40,827	30,000
Brazil[e 4]	1,200,000	1,500,000	1,750,000	1,750,000	2,000,000
Burundi	[e]100	[e]100	272	1,115	1,100
Cameroon	316	136	261	[e]250	250
Canada	1,672,893	2,081,230	2,363,411	[r e]2,638,000	2,747,000
Central African Republic	1,386	1,000	2,492	6,953	7,000
Chile	400,479	543,569	570,971	541,051	[3]554,281
China[e]	1,700,000	1,800,000	1,850,000	1,900,000	1,950,000
Colombia	529,214	472,674	438,579	799,889	1,150,000
Congo	48	83	267	101	150
Costa Rica[e]	20,000	27,000	30,000	35,000	35,000
Dominican Republic	407,813	[r]386,309	354,023	338,272	[3]337,150
Ecuador	[r]1,286	1,601	608	[e]1,000	1,000
El Salvador	3,883	3,300	650	285	280
Ethiopia[e]	[3]11,930	12,000	14,000	15,000	15,000
Fiji	[r]30,833	[r]45,750	40,124	48,515	[3]59,961
Finland	31,893	36,780	25,206	28,067	28,000
France	36,362	67,967	71,659	70,279	70,000
French Guiana	[e]4,000	5,231	8,038	10,127	12,000
Gabon[e]	550	550	550	[r]1,325	1,000
Germany, Federal Republic of	3,051	1,813	[e]1,900	[e]1,500	1,200
Ghana	341,000	331,000	276,000	287,000	[3]299,363
Guyana	19,263	7,347	4,607	11,131	[3]10,323
Honduras	1,579	1,711	2,151	2,784	2,500
Hungary[e]	60,000	50,000	30,000	20,000	20,000
India[5]	79,875	71,935	70,158	65,234	59,000
Indonesia[6]	[r]54,241	[r]71,878	76,888	78,677	84,500
Japan	99,242	104,136	100,921	103,519	[3]158,567
Kenya	100	21	100	600	600
Korea, North[e]	160,000	160,000	160,000	160,000	160,000
Korea, Republic of[5]	43,147	55,750	72,083	79,156	80,000
Liberia[e 7]	16,720	12,656	15,400	10,500	12,000
Madagascar[e]	110	110	110	[r]130	130
Malaysia:					
Peninsular Malaysia	5,691	[r]5,788	5,792	7,041	5,800
Sabah	[r]69,563	[r]84,614	82,662	82,012	82,000
Sarawak	67	[r]23	161	474	4,600
Mali[e]	16,000	13,000	13,000	16,075	16,000
Mexico[8]	198,594	214,349	198,177	270,998	285,000
Namibia	[e]6,000	7,395	7,459	6,302	[3]6,237
New Zealand	6,071	7,775	9,667	21,605	[3]45,011
Nicaragua	61,913	54,384	46,428	[r e]35,000	[3]24,491
Papua New Guinea	540,325	[r]589,258	579,407	[e]835,000	1,050,000
Peru	161,590	157,667	165,576	198,691	[3]223,447
Philippines	[r]758,306	[r]834,431	816,536	786,896	[3]809,735
Portugal	10,931	6,783	9,603	9,100	9,000
Romania[e]	65,000	65,000	65,000	65,000	65,000
Rwanda	1,204	286	623	240	250
Sierra Leone[9]	3,435	8,729	12,000	18,233	18,000
Solomon Islands	1,050	1,318	[e]1,100	2,572	3,000
South Africa, Republic of	21,121,157	21,355,111	21,847,310	21,906,619	[3]21,566,368
Spain	98,381	109,858	162,296	123,330	125,000
Sudan[e]	300	400	500	1,500	1,500

See footnotes at end of table.

Table 16.—Gold: World mine production, by country[1] —Continued

(Troy ounces)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Suriname	823	599	482	322	500
Sweden	[e]70,000	77,160	102,880	122,173	140,000
Taiwan[5]	56,695	71,770	52,361	37,794	30,600
Tanzania[e]	400	600	800	2,680	2,700
U.S.S.R.[e]	8,425,000	8,550,000	8,600,000	8,650,000	8,700,000
United States	1,379,161	1,465,686	[r]2,002,526	[r]2,084,615	[3]2,475,436
Venezuela	27,810	27,993	[e]33,200	[r e]50,885	72,900
Yugoslavia[5]	[r]115,164	[r]135,451	136,255	[e]140,000	145,000
Zaire	[r]65,169	[r]60,733	192,930	117,115	75,000
Zambia	10,545	13,439	10,160	12,185	11,600
Zimbabwe	371,000	426,000	453,373	478,306	480,000
Total	[r]41,250,525	[r]43,126,517	44,995,806	46,408,295	48,216,620

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 10, 1986.

[2]Gold is also produced in Bulgaria, Burma, Czechoslovakia, the German Democratic Republic, Guinea, Norway, Poland, Senegal, Thailand, and several other countries. However, available data are insufficient to make reliable output estimates.

[3]Reported figure.

[4]Officially reported figures are as follows, in troy ounces: Major mines: 1981—140,691; 1982—148,408; 1983—199,206; 1984—213,963; and 1985—not available. Small mines (garimpos): 1981—414,744; 1982—671,982; 1983—1,526,775; 1984—982,623; and 1985—not available.

[5]Refinery output.

[6]Excludes production from so-called "people's mines," but includes gold recovered as byproduct of copper mining.

[7]These figures are based on gold taxed for export and include gold entering Liberia undocumented from Guinea and Sierra Leone.

[8]Production series for Mexico revised since 1980 to reflect mine output data published for each State and municipality.

[9]Excludes estimates of gold produced in Sierra Leone, which is moved through undocumented channels for sale in Liberia.

TECHNOLOGY

Research directed toward the recovery of gold and other precious metals from primary and secondary sources was continued by the Bureau of Mines in 1985. The Bureau reported on the application of particle agglomeration technology to finely ground precious-metals-bearing tailings. It concluded that decreased leaching time and improved precious metals recovery made the technology cost effective.[21]

A procedure for selectively extracting platinum-group metals and gold from flotation concentrate from the Stillwater Complex (Montana) was devised by the Bureau. The two-stage leaching scheme, employing roasting followed by several leaching steps, extracted up to 99% of the gold, 97% of the platinum, and 92% of the palladium from the roasted concentrate. Techniques for recovering the precious metals from the pregnant solution were addressed.[22]

Gold and silver are commonly recovered from cyanide solution either by chemical precipitation onto zinc dust (the Merrill-Crowe process) or by electrochemical deposition onto a cathode fashioned of stainless steel wool. Chemical methods of processing the precious-metals-bearing steel zinc precipitates and steel wool cathodes were investigated by the Bureau. Leaching-precipitation experiments performed on the cathodes and precipitates recovered 99.9% of the gold as a gold-bearing residue. Treatment of the residue produced gold precipitates that ranged in fineness from 997 to 999 fine. The method was said to provide a viable technique for the smaller operator to produce high-purity gold without using pyrometallurgical refining methods.[23]

Hydrometallurgical procedures for concentrating precious metals from a mechanically processed metal fraction of obsolete military electronic scrap were tested by the Bureau. Included was a three-step process evaluation study of mechanical processing of general electronic scrap and two hydrometallurgical procedures for leaching high-tension-separated metallic concentrates obtained from the mechanical processing step. Process evaluation concluded that only mechanical processing is economically viable.[24]

The application of microbiology to gold exploration and processing was featured in several reports. Research at the U.S. Geological Survey suggested that the anomalous presence of aerobic spore-forming bacilli of the *Bacillus Cereus* group in stream and soil sediments may be a sensitive indicator of several types of concealed mineral deposits, including vein-type gold deposits. Preliminary tests suggest that measurement of the relative populations of certain soil bacteria may prove to be a more sensitive exploration tool than conventional geochemical techniques.[25]

A report on the use of biological leaching to pretreat or dissolve pyrite and liberate contained gold discussed the successful operation of a continuous bioleach circuit applied to gold-bearing concentrate from Placer Development's Porgera deposit in Papua New Guinea. Bioleach residues were cyanide-leached to extract gold and silver values. The features and advantages of biological oxidation as a pretreatment for refractory precious metal ores and concentrates were discussed.[26] Another report, detailing recent developments in gold processing, including the bioxidation process referenced above, discussed how the Homestake gold mine at Lead, SD, recently began treating its cyanide-bearing process wastewater with a technique utilizing a subspecies of the bacterium *Pseudomonas*. The bacteria degrade cyanide and thiocyanide, thereby reducing the quantity of weak-acid-dissociable cyanide in wastewater discharges to less than 50 parts per billion.[27] Japanese researchers reportedly found that ultrafine particles of gold, observed using a special technique, appeared to change shape as gold atoms moved around on the surface of the particles. This change in shape was reportedly caused by the fact that all of the gold atoms comprising the ultrafine particles moved in a manner to form various crystalline structures.[28]

A new prototype gas chromatography detector, developed by Professor Robert E. Sievers, University of Colorado, employs a gold catalyst to detect some atmospheric pollutants heretofore not readily detectable. The new detector, known as the Redox Chemiluminescence Detector, was reportedly capable of detecting substances such as formaldehyde, carbon monoxide, formic acid, and many others. It may, in addition, provide a new way to synthesize a variety of oxidation products, such as compounds useful in manufacturing plastics.[29]

A 4-year study conducted by the Mineral Industry Research Laboratory, at the University of Alaska, resulted in the development of a radiotracer technique for evaluating the fine gold recovery characteristics and performance of gravity concentrators. In the technique, fine particles of native gold, those small enough to pass through a 40-mesh screen, were weakly activated in a nuclear reactor then introduced into experimental separation devices. Process water, upon exiting the separation device, was piped into a compound water cyclone where concentration and recovery of the fine gold not captured by earlier separators was performed. By using gamma radiation detectors to measure the progress of the radioactive particles through various recovery stages, researchers were able to rapidly evaluate the effectiveness of the recovery technique employed and avoid the time-consuming and relatively inaccurate sampling and assaying steps previously required.[30]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Ounce refers to troy ounce.

[3]Federal Register. V. 50, No. 192, Oct. 3, 1985, p. 40325.

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Graphite

By Harold A. Taylor, Jr.[1]

No domestic amorphous graphite material was mined in 1985. All natural graphites, including crystalline flake, were in more than adequate supply as demand by industrial users tapered off from the previous year. Prices of the major imported graphites generally increased from those of 1984, except for the price of Sri Lankan graphite, which dropped 26%.

Production of manufactured graphite decreased 6% to 246,000 short tons valued at $628 million. Production of graphite fibers increased 38% to 1,902 tons valued at $112 million.

Domestic Data Coverage.—Domestic production data for synthetic graphite are developed by the Bureau of Mines from a voluntary survey of domestic producers, titled "Synthetic Graphite." Of the 38 operations to which a survey request was sent, 97% responded, representing 100% of the total production data shown in table 4 since the 2 nonrespondents were not included.

Table 1.—Salient natural graphite statistics

	1981	1982	1983	1984	1985
United States:					
Production ---short tons--	--	W	W	W	--
Apparent consumption[1] ---do----	54,315	W	W	W	42,578
Exports ---do----	11,344	10,335	9,435	7,096	10,159
Value ---thousands--	$4,433	$4,099	$3,455	$2,807	$3,830
Imports for consumption[1] ---short tons--	65,659	53,150	43,586	58,246	52,737
Value[1] ---thousands--	$19,093	$15,676	$11,921	$14,579	$16,186
World: Production ---short tons--	r649,093	r619,928	664,029	p685,507	e676,740

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Data do not include artificial graphite.

Legislation and Government Programs.—There were no acquisitions or disposals of strategic graphite in 1985.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. Substantial changes were proposed for the graphite goals: 13,996 tons of Madagascar crystalline flake, 5,059 tons of Sri Lankan amorphous lump, and 2,237 tons of crystalline graphite other than Madagascar and Sri Lanka would be in tier I, and 415 tons of Sri Lankan amorphous lump would be in tier II. Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

Production of graphite fibers made from pitch was considered for funding under title 3 of the Defense Production Act. The funding would be used for purchase guarantees for domestically produced graphite fiber made from pitch, or possibly for manufacturing technology or industrial modernization.

Table 2.—U.S. Government stockpile goals and yearend stocks of natural graphite in 1985, by type

(Short tons)

Type	Goal	National stockpile inventory
Madagascar crystalline flake	20,000	17,829
Sri Lanka amorphous lump	6,300	5,444
Crystalline, other than Madagascar and Sri Lanka	2,800	1,933
Nonstockpile-grade, all types	--	932

Source: General Services Administration. Inventory of Stockpile Materials as of Dec. 31, 1985.

DOMESTIC PRODUCTION

United Minerals Co. began producing sizable amounts of low-grade amorphous graphitic material by open pit mining from the claims of National Minerals Corp. near Townsend, MT, in 1982. Production had been tapering off, and ceased in 1985. Graphite Sales Inc. continued to make the material available. Other domestic deposits of graphite received little or no attention.

Output of manufactured graphite decreased 6% to about 246,000 tons, at 35 plants, with a likelihood of some unreported production for in-house use.

Production of all kinds of graphite fiber and cloth increased 38% to 1,902 tons.

Table 3.—Principal producers of manufactured graphite in 1985

Company	Plant location	Product[1]
Airco Carbon, a division of Airco Inc	Niagara Falls, NY	Anodes, electrodes, crucibles, motor brushes, refractories, unmachined shapes, powder.
Do	Punxsutawney, PA	
Do	St. Marys, PA	
Do	Ridgeville, SC	
Ashland Petroleum Co., Carbon Fibers Div	Ashland, KY	High-modulus fibers.
Avco Corp., Avco Specialty Materials Div	Lowell, MA	Do.
The Carborundum Co., Graphite Products Div.	Sanborn, NY	Motor brushes, unmachined shapes, cloth.
CCF Inc., Research Lab	Summit, NJ	High-modulus fibers.
Do	Rock Hill, SC	
Fiber Materials Inc	Biddeford, ME	High-modulus fibers and cloth.
Fiber Technology Corp	Provo, UT	Other.
BF Goodrich Co., Engineered Systems Div., Super Temp Operation.	Santa Fe Springs, CA	
Great Lakes Carbon Corp	Rockwood, TN	Anodes, electrodes, high-modulus fibers, unmachined shapes, other.
Do	Morganton, NC	
Do	Niagara Falls, NY	
Do	Ozark, AR	
Hercules Inc	Salt Lake City, UT	High-modulus fibers.
HITCO Materials Group, Owens-Corning Fiberglas Corp.	Gardena, CA	Cloth and high-modulus fibers.
Hysol Grafil Co	Sacramento, CA	High-modulus fibers.
Ohio Carbon Co	Cleveland, OH	Electric motor brushes, unmachined shapes.
Pfizer Minerals, Pigments & Metals Div	Easton, PA	Other.
Polycarbon Inc	North Hollywood, CA	Cloth.
Sigri Carbon Corp	Hickman, KY	Electrodes and other.
The Stackpole Corp., Carbon Div	Lowell, MA	High-modulus fibers, motor brushes, unmachined shapes, refractories, powder.
Do	St. Marys, PA	
Superior Graphite Co	Russellville, AR	Electrodes and other.
Do	Hopkinsville, KY	
Ultra Carbon	Bay City, MI	Other.
Union Carbide Corp., Carbon Products Div	Clarksburg, WV	Anodes, electrodes, unmachined shapes, motor brushes, powder, cloth, high-modulus fibers, other.
Do	Clarksville, TN	
Do	Columbia, TN	
Do	Fostoria, OH	
Do	Greenville, SC	
Do	Niagara Falls, NY	
Do	Yabucoa, PR	

[1]Cloth includes low-modulus fibers; electric motor brushes include machined shapes; crucibles include vessels.

Table 4.—U.S. production of manufactured graphite, by use

Use	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Synthetic graphite products:				
Anodes	4,680	$14,133	7,021	$19,813
Cloth and fibers (low-modulus)	223	17,979	316	27,235
Crucibles, vessels, refractories	W	W	W	W
Electric motor brushes and machined shapes	W	W	W	W
Electrodes	177,116	398,180	164,578	348,812
Graphite articles	--	39,895	--	36,365
High-modulus fibers	r1,160	r56,436	1,586	84,743
Unmachined graphite shapes	r12,848	r59,001	11,875	66,069
Other	r37,290	r36,235	38,900	38,690
Total	r233,317	r621,859	224,276	621,727
Synthetic graphite powder and scrap	29,911	6,668	22,100	5,970
Grand total	r263,228	r628,527	246,376	[1]627,696

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data do not add to total shown because of independent rounding.

Table 5.—U.S. production of graphite fibers

Year	Cloth and low-modulus fibers Quantity (short tons)	Cloth and low-modulus fibers Value (thousands)	High-modulus fibers Quantity (short tons)	High-modulus fibers Value (thousands)	Total Quantity (short tons)	Total Value (thousands)
1975	154	$10,600	52	$4,690	206	$15,290
1976	163	11,376	37	3,870	200	15,246
1977	136	8,800	49	4,330	185	13,130
1978	141	8,720	149	11,804	290	20,524
1979	169	10,089	194	13,031	363	23,120
1980	169	11,254	306	17,379	475	28,633
1981	216	15,293	409	21,759	625	37,052
1982	212	17,706	605	30,091	817	47,797
1983	188	14,217	739	33,854	927	48,071
1984	223	17,979	r1,160	r56,436	r1,383	r74,415
1985	316	27,235	1,586	84,743	1,902	111,978

rRevised.

There were a number of changes in ownership in the graphite industry, particularly among the graphite fiber producers. Horsehead Industries Inc. purchased Great Lakes Carbon Corp. BASF America Corp. purchased the Celanese Corp. graphite fiber operations and two subsidiaries that produce graphite fiber composite items for $135 million; the firm already makes the resins for the composites in Europe. Armco Inc. sold Owens-Corning Fiberglas Corp. its graphite fiber subsidiary, HITCO Materials Group, and two other high technology materials subsidiaries for $415 million. In December, Union Carbide Corp. announced plans to sell its graphite fiber operations to Amoco Minerals Co. in 1986. E. I. du Pont de Nemours & Co. Inc. was planning to enter the graphite fiber business with a pitch-based fiber based on Conoco Inc. technology. In 1985, the company purchased the graphite fiber research facilities and composite production operations of Exxon Corp.

Ashland Petroleum Co. announced plans to expand its plant at Catlettsburg, KY, from a capacity of 30 to 100 tons per year of pitch-based fiber.

A new trade association called Suppliers of Advanced Composite Materials Association (SACMA) was formed for graphite fiber and composite producing firms. SACMA expects to be active in standardizing test methods, compiling industry statistics, and dealing with issues related to the Export Control Act.

CONSUMPTION AND USES

Reported consumption of natural graphite decreased slightly to about 34,700 tons. The three major uses of natural graphite—refractories, foundries, and brake linings—accounted for 48% of reported consumption, compared with 61% in 1984.

Graphite fiber-reinforced, lightweight, concrete building panels have been developed in Japan. The panels are only one-third the weight of ordinary ones, which saves time and expense when handling them and allows a lighter structural steel frame to be used in the building. However, making the concrete for the panels is an exacting process, requiring the concrete to be vibrated rather than stirred.

A bonded carbon fiber material, Calcarb, was produced and sold by Consarc Engineering Ltd. of the United Kingdom for consumption as vacuum furnace insulation. The material can be made in many different forms, including boards and cylindrical sleeves. It is made by mixing 1/16-inch-long byproduct rayon fiber with a phenolic resin-water slurry, and heating the slurry to 900° C to convert the fiber to carbon. Advantages of Calcarb are its low thermal conductivity and expansion and great mechanical strength. Porous electrodes, catalyst supports, filters for fluids and molten metals, and aerospace applications were being examined as potential new markets for Calcarb.

Table 6.—U.S. consumption of natural graphite, by use

Use	Crystalline		Amorphous[1]		Total[2]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1984:						
Batteries	W	W	W	W	931	$1,563
Brake linings	1,156	$1,045	2,869	$2,496	4,025	3,541
Carbon products[3]	316	660	249	328	565	988
Crucibles, retorts, stoppers, sleeves, nozzles	1,953	1,858	(4)	6	1,953	1,864
Foundries[5]	2,337	1,285	4,804	1,810	7,141	3,095
Lubricants[6]	1,170	1,763	1,365	1,216	2,535	2,979
Pencils	1,557	2,121	356	257	1,913	2,378
Powdered metals	363	567	196	356	559	923
Refractories	W	W	W	W	10,461	4,200
Rubber	184	211	232	140	416	351
Steelmaking	326	142	1,739	798	2,065	940
Other[7]	299	498	2,306	2,123	2,605	2,621
Withheld uses	2,472	3,523	8,920	2,240	--	--
Total[2]	12,135	13,674	23,037	11,769	35,172	25,443
1985:						
Batteries	W	W	W	W	1,569	2,602
Brake linings	1,023	960	2,448	2,297	3,472	3,257
Carbon products[3]	379	843	206	173	585	1,016
Crucibles, retorts, stoppers, sleeves, nozzles	4,213	3,529	1	15	4,215	3,544
Foundries[5]	514	612	6,006	1,953	6,520	2,565
Lubricants[6]	1,025	1,478	2,586	2,327	3,611	3,805
Pencils	1,829	2,737	339	231	2,168	2,968
Powdered metals	348	520	226	451	574	971
Refractories	W	W	W	W	6,503	3,257
Rubber	217	249	289	170	506	419
Steelmaking	131	81	1,836	691	1,967	772
Other[7]	227	295	2,741	2,815	2,968	3,110
Withheld uses	3,216	4,342	4,855	1,517	--	--
Total[2]	13,123	15,647	21,534	12,641	34,657	28,288

W Withheld to avoid disclosing company proprietary data; included with "Withheld uses."
[1]Includes mixtures of natural and manufactured graphite.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes bearings and carbon brushes.
[4]Less than 1/2 unit.
[5]Includes foundry facings.
[6]Includes ammunition, packings, and seed coating.
[7]Includes paints and polishes, antiknock and other compounds, soldering and/or weld, electrical and electronic products, mechanical products, magnetic tape, small packages, industrial diamonds, and drilling mud.

While electric arc steelmaking capacity has continued to grow worldwide, graphite electrode consumption has not kept pace because of technological advances in electrode construction. The shrinking market for electrodes has led Union Carbide Corp. to suspend production at its new plant at Clarksville, TN. In addition, the Airco Carbon Div. of BOC Inc. shifted most of its production from its old plant in Pennsylvania to its new plant at Ridgeville, SC. While Great Lakes Carbon Corp. has kept all of its plants going except for a small one in California, the present electrode market has resulted in the shelving of expansion plans at its two newest plants.[2]

PRICES

Graphite prices are often negotiated between the buyer and seller, and are based on purity and other criteria. Therefore, published price quotations are given as a range of prices. Another source of information for graphite prices is the average customs value per ton of the different imported classes. However, it should be noted that these mainly represent shipments of unprocessed graphite.

The average prices of crystalline flake and other natural graphite imports were little changed in 1985, while the prices of other types dropped or rose significantly from those of 1984. The prices of crystalline flake increased by 5% to $536 per ton; Mexican amorphous graphite rose by 25% to $50 per ton; all types of Sri Lankan lump graphite dropped by 26% to $790 per ton; and other natural graphite (mostly fine crystalline flake and dust) dropped by 5% to $441 per ton.

Average prices for natural graphite at the point of consumption changed slightly in 1985. The price for crystalline graphite (mostly crystalline flake, some crystalline dust, and a little lump graphite) was $1,192 per ton, up 6% from that of 1984. The price for amorphous graphite (including small amounts of amorphous-synthetic graphite mixtures) was $587 per ton, up 15% from that of 1984.

Table 7.—Representative yearend graphite prices[1]

(Per short ton)

	1984	1985
Flake and crystalline graphite, bags:		
China	$54-$1,542	$54-$1,542
Germany, Federal Republic of	286- 3,084	227- 3,357
Madagascar	227- 726	227- 816
Norway	181- 816	--
Sri Lanka	272- 1,361	272- 1,361
Amorphous, nonflake, cryptocrystalline graphite (80% to 85% carbon):		
Korea, Republic of (bags)	82- 109	82- 113
Mexico (bulk)	64- 109	82- 109

[1]F.o.b. foreign port or border.

Source: Engineering and Mining Journal. V. 185, No. 12, Dec. 1984, p. 27., and v. 186, No. 12, Dec. 1985, p. 11.

FOREIGN TRADE

Exports of both natural and artificial graphite increased by 71%. Exports of graphite electrodes totaled 58,675 tons worth $88.1 million, of which 10,275 tons ($15.2 million) went to Canada, 7,210 tons ($10.0 million) to Venezuela, 5,443 tons ($5.2 million) to Norway, 5,117 tons ($9.9 million) to Brazil, 4,574 tons ($7.4 million) to the U.S.S.R., and the balance to other destinations.

Imports of natural graphite decreased 9% to 52,737 tons. Imports of natural graphite from Brazil and Sri Lanka gained by 153% and 85% respectively, while imports from Canada and Mexico dropped sharply to about the 1983 levels.

Table 8.—U.S. exports of natural and artificial graphite, by country

Country	Natural[1]		Artificial		Total	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
1984:						
Brazil	16	$4,896	153	$96,107	169	$101,003
Canada	3,490	1,162,208	1,725	643,558	5,215	1,805,766
Germany, Federal Republic of	103	39,307	147	59,853	250	99,160
Italy	16	9,402	21	20,134	37	29,536
Japan	201	262,934	529	742,514	730	1,005,448
Mexico	1,972	612,157	271	116,148	2,243	728,305
United Kingdom	252	136,464	155	111,990	407	248,454
Venezuela	301	177,294	36	37,102	337	214,396
Other	[r]745	[r]402,779	[r]1,189	[r]958,809	[r]1,934	[r]1,361,588
Total	7,096	2,807,441	4,226	2,786,215	11,322	5,593,656
1985:						
Brazil	49	22,879	783	992,413	832	1,015,292
Canada	4,065	1,366,750	1,240	592,536	5,305	1,959,286
Germany, Federal Republic of	2,002	711,818	707	319,315	2,709	1,031,133
Italy	1,174	205,953	164	91,765	1,338	297,718
Japan	226	318,799	2,671	800,694	2,897	1,119,493
Mexico	1,115	395,995	1,964	194,699	3,079	590,694
United Kingdom	212	133,984	186	141,121	398	275,105
Venezuela	241	152,561	98	74,390	339	226,951
Other	1,075	520,838	1,339	898,868	2,414	1,419,706
Total	10,159	3,829,577	9,152	4,105,801	19,311	7,935,378

[r]Revised.
[1]Amorphous, crystalline flake, lump or chip, and natural, not elsewhere classified.

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of natural graphite, by country

Country	Crystalline flake		Lump or chippy dust		Other natural crude and refined		Amorphous		Total[1]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983	7,034	$3,866	751	$870	10,124	$5,711	25,677	$1,474	[2]43,586	[2]$11,921
1984:										
Austria	--	--	--	--	--	--	32	7	32	7
Belgium-Luxembourg	1	2	--	--	--	--	--	--	1	2
Brazil	2,203	1,492	--	--	513	238	--	--	2,716	1,730
Canada	2,116	1,068	--	--	412	263	--	--	2,528	1,331
China	4,602	1,812	--	--	4,829	1,665	5,801	284	15,232	3,761
Denmark	--	--	--	--	(3)	2	--	--	(3)	2
France	362	213	--	--	80	45	--	--	442	258
Gambia	220	83	--	--	--	--	--	--	220	83
Germany, Federal Republic of	20	62	--	--	840	691	--	--	860	753
Hong Kong	--	--	--	--	897	214	--	--	897	214
India	77	38	--	--	332	211	--	--	409	249
Italy	--	--	--	--	1	6	--	--	1	6
Japan	182	131	--	--	273	291	--	--	455	422
Korea, Republic of	--	--	--	--	--	--	53	12	53	12
Madagascar	828	481	--	--	2,173	977	--	--	3,001	1,458
Mexico	--	--	--	--	1,943	995	25,922	1,025	27,865	2,020
Netherlands	(3)	(3)	--	--	3	1	--	--	3	1
Norway	4	7	--	--	150	61	--	--	154	68
Seychelles	--	--	--	--	9	16	--	--	9	16
Singapore	--	--	--	--	34	17	--	--	34	17
South Africa, Republic of	--	--	--	--	1,200	645	--	--	1,200	645
Sri Lanka	--	--	892	950	--	--	--	--	892	950
Sweden	--	--	--	--	28	59	--	--	28	59
Switzerland	--	--	--	--	3	5	--	--	3	5
Taiwan	--	--	--	--	901	268	--	--	901	268
United Kingdom	105	66	--	--	122	106	--	--	227	172
Zimbabwe	--	--	--	--	80	73	--	--	80	73
Total[1]	10,720	5,455	892	950	14,823	6,849	31,808	1,329	[2]58,246	[2]14,579

See footnotes at end of table.

Table 9.—U.S. imports for consumption of natural graphite, by country —Continued

Country	Crystalline flake		Lump or chippy dust		Other natural crude and refined		Amorphous		Total[1]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1985:										
Antigua	--	--	--	--	19	$8	--	--	19	$8
Belgium-Luxembourg	--	--	--	--	14	22	--	--	14	22
Brazil	1,775	$1,081	--	--	5,092	2,002	--	--	6,867	3,083
Canada	114	58	--	--	340	140	--	--	454	198
China	2,480	1,054	--	--	10,851	3,427	1,084	$74	14,415	4,555
France	--	--	--	--	110	103	--	--	110	103
Germany, Federal Republic of	48	25	--	--	907	934	--	--	955	959
Hong Kong	40	4	--	--	932	168	212	19	1,184	191
India	140	72	--	--	430	325	--	--	570	397
Japan	62	144	--	--	190	363	--	--	252	507
Liberia	--	--	--	--	33	42	--	--	33	42
Macao	19	12	--	--	--	--	--	--	19	12
Madagascar	1,169	675	--	--	1,819	1,405	--	--	2,988	2,080
Mexico	--	--	--	--	2,118	1,053	19,736	980	21,854	2,033
Netherlands	--	--	--	--	222	135	--	--	222	135
Norway	8	1	--	--	37	19	--	--	45	20
Sierra Leone	--	--	--	--	17	21	--	--	17	21
South Africa, Republic of	--	--	--	--	524	251	--	--	524	251
Sri Lanka	--	--	1,654	$1,307	--	--	--	--	1,654	1,307
Sweden	4	8	--	--	--	--	--	--	4	8
Switzerland	--	--	--	--	38	11	--	--	38	11
Taiwan	--	--	--	--	282	93	--	--	282	93
United Kingdom	40	25	--	--	(3)	16	--	--	40	41
Zimbabwe	--	--	--	--	175	108	--	--	175	108
Total[1]	5,899	3,161	1,654	1,307	24,152	10,646	21,032	1,073	[2]52,737	[2]16,186

[1]Data may not add to totals shown because of independent rounding.
[2]Data do not include artificial graphite.
[3]Less than 1/2 unit.

Source: Bureau of the Census.

The United States has the world's largest capacity for fabricating graphite fiber into composites and was the world's leading consumer and producer of all kinds of fiber-reinforced materials in 1985. However, the United States was much less dominant in the production of the graphite fiber consumed as a raw material to make the composites. The domestic graphite fiber capacity was about two-thirds of the Japanese capacity in 1982. Most of the polyacrylonitrile precursor used to make domestic graphite fiber (with the exception of fairly small amounts of fiber made from other materials) is now imported from Japan, although this is changing to some degree.

A U.S. Government study concluded that not only will the United States continue to encounter competition from Japan as it does now, but that it will encounter competition in graphite fiber from other foreign producers, mostly the Federal Republic of Germany and the United Kingdom. Japanese competition will broaden into fabricating the final materials. The authors expect that the United States and Japan will dominate world markets for graphite fiber during the 1990's although they will encounter increasing competition from European producers.[3]

Table 10.—U.S. imports for consumption of artificial graphite and graphite electrodes, by country

Country	Artificial graphite: Quantity (short tons)	Artificial graphite: Value (thousands)	Graphite electrodes: Quantity (short tons)	Graphite electrodes: Value (thousands)
1984:				
Australia	(1)	$25	(1)	$16
Belgium	(1)	27	998	1,915
Brazil	--	--	116	29
Canada	995	239	3,801	4,188
China	467	625	557	900
France	270	350	8,096	7,061
Germany, Federal Republic of	3,670	564	2,409	4,212
Israel	--	--	20	30
Italy	--	--	8,551	10,598
Japan	443	3,065	37,704	64,092
Mexico	--	--	15	15
Netherlands	7	110	6,164	2,021
Norway	--	--	42	10
Singapore	247	350	852	1,177
Spain	--	--	74	115
Sweden	--	--	54	27
Switzerland	4,332	6,454	269	233
Taiwan	1	9	20	60
United Kingdom	23	89	2,244	2,021
Other	--	--	2	15
Total[2]	10,456	11,906	71,988	98,735
1985:				
Australia	3	29	--	--
Austria	--	--	22	50
Belgium	13	50	1,404	2,719
Cameroon	20	29	--	--
Canada	1,117	422	2,625	3,770
China	211	278	153	230
France	454	575	2,946	4,640
Germany, Federal Republic of	906	2,217	6,730	8,780
India	212	226	--	--
Israel	--	--	20	44
Italy	53	102	3,386	4,989
Jamaica	5	33	--	--
Japan	964	5,200	36,736	64,752
Korea, Republic of	--	--	11	46
Netherlands	23	113	1,642	2,167
Singapore	--	--	1,473	2,195
South Africa, Republic of	2	13	1	2
Spain	--	--	7	10
Sweden	4	12	(1)	68
Switzerland	3,137	4,007	4,144	1,231
Taiwan	2	7	65	120
United Kingdom	118	535	931	1,097
Total[2]	7,241	13,847	62,296	96,913

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World demand and world supply of graphite were about the same as those of 1984. China announced the discovery of a very large graphite deposit, and the major graphite mine in Norway was closed because of a fire.

China.—Chinese sources announced that the largest graphite deposit discovered so far has been found in eastern Heilongjiang Province. It consists of 10 beds, each about 5,000 feet long, 1,000 feet thick, and 150 feet wide. Reserves were estimated to be 680 million tons averaging 12% carbon. Although Chinese sources did not specify the type of graphite, it was believed to be amorphous. The deposit can be accessed easily by roads and utilities. The local government decided to invite foreign tenders for development of the deposit. Some crystalline flake deposits have been discovered on the island of Hainan; preliminary investigation indicated that reserves were about 5.5 million tons averaging 3.7% carbon with a rate of recovery over 90%.

Finland.—Information on graphite mining and usage in Finland appeared in 1985, for the first time. What is called "energy graphite" in Finnish has been found in three different regions of Finland. About 20% graphite must be present to maintain combustion; it is burned in special fluidized bed boilers.

Germany, Federal Republic of.—Sigri GmbH announced the commissioning of a 1,100-ton-per-year-capacity graphite fiber plant based on polyacrylonitrile as a raw material.

Graphitwerk Kropfmuehl AG, the only West German miner of crystalline flake graphite, produced 18,700 tons of product at its Kropfmuehl plant and 8,800 tons of product at its Werk Wedel plant in 1984, of which 45% was exported. About one-half of its domestic sales were to the refractories industry for use in crucibles, continuous casting ware, and carbon-magnesite bricks. About one-third to one-half of the firm's raw material was mined domestically at Kropfmuehl, the balance coming from its mine in Zimbabwe.[4]

Japan.—Mitsubishi Chemical Industries Ltd. began building a 550-ton-per-year-capacity graphite fiber plant at Sakoide, Kagawa Prefecture, that will come onstream in late 1986. This supersedes earlier plans for a 1,100-ton-per-year-capacity plant. The plant will cost $10 million and use coal tar, which the firm produces, as a raw material. The graphite fiber was expected to be lower in cost than polyacrylonitrile-based graphite fiber. The firm also announced plans to develop graphite fiber composites.

The rapid growth of electric arc steelmaking in Japan, and therefore Japanese consumption of graphite electrodes, appeared to be coming to a halt. Accounting for a sizable fraction of Japan's total production, 28% in 1984, electric arc steelmaking will have trouble expanding further when the rest of the industry is in severe overcapacity and with increasing foreign competition from neighboring countries. The Ministry of International Trade and Industry has been pressing hard for a reduction in electric arc steelmaking capacity, with minimal industry response so far.[5]

Table 11.—Graphite: World production, by country[1]

(Short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina	2	13	22	16	20
Austria	26,243	26,953	44,553	48,269	44,000
Brazil (marketable)[3]	19,289	16,990	30,463	36,023	36,000
Burma[4]	1,568	308	220	258	220
China[e]	203,000	204,000	204,000	204,000	204,000
Czechoslovakia[e]	[r]55,000	[r]55,000	[r]55,000	[r]55,000	65,000
Germany, Federal Republic of	[5]9,024	[5]12,845	11,023	13,228	12,000
India (mine)[6]	80,240	57,735	43,615	42,975	44,000
Italy	3,897	3,538	2,534	--	--
Korea, North[e]	28,000	28,000	28,000	28,000	28,000
Korea, Republic of:					
Amorphous	37,533	29,033	35,903	62,014	55,000
Crystalline flake	928	691	766	2,541	2,200
Madagascar	14,698	[r]16,766	14,944	15,403	15,500
Mexico:					
Amorphous	45,351	37,886	47,034	43,923	44,000
Crystalline flake	1,270	1,989	1,828	1,855	1,900
Norway	9,552	8,213	8,888	10,508	2,500
Romania[e]	13,800	13,800	13,900	13,700	13,200
Sri Lanka	8,348	9,704	6,094	6,198	6,000
Thailand	1,984	694	95	([7])	--
Turkey	NA	3,704	5,297	([8])	NA
U.S.S.R.[e]	77,000	83,000	88,000	88,000	90,000
United States	--	W	W	W	--
Zimbabwe	12,366	9,066	21,850	13,596	13,200
Total	[r]649,093	[r]619,928	664,029	685,507	676,740

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 20, 1986.
[2]In addition to the countries listed, Namibia may have produced graphite during the period covered by this table, but output is unreported, and available general information is inadequate for formulation of reliable estimates of output levels.
[3]Does not include the following quantities sold directly without beneficiation, in short tons: 1981—17,988; 1982—6,758; 1983—12,278; 1984—2,902; and 1985—5,500 (estimated).
[4]Data are for fiscal year beginning Apr. 1 of that stated.
[5]Data presented represent estimated marketable product derived from raw graphite mined indigenously, assuming that marketable output equals one-half of officially reported raw graphite production.
[6]Indian marketable production is about 10% to 20% of mine production.
[7]Revised to zero.
[8]Revised to not available.

Norway.—On April 4, the processing plant of A/S Skaland Grafitverk was destroyed by a fire. The mine and warehousing area were unaffected. The firm continued its drilling and exploration program in the area and may move the mine a short distance for better access to the remaining ore. The firm tentatively has decided to build a new plant, which will be able to fabricate a much wider variety of products, including some high-purity, 99%-carbon product.

Spain.—The Government announced plans to set up a joint venture, Desarrollo de Nuevos Materiales, with the private sector, to develop and produce aramid and graphite fibers and fiber-reinforced composite materials.

Sri Lanka.—The Sri Lanka State Mining and Mineral Development Corp. and the Moriroko Co. Ltd. of Japan were negotiating an agreement to rehabilitate and work two abandoned graphite mines, one at Pussehena and one at Sigambalptitya.

TECHNOLOGY

A review of the development of graphite fiber composite technology indicates that fabrication has become simpler and less expensive. There has been a fivefold reduction in cost for many graphite fibers over the last decade, and an average drop in cost of fiber to one-half its former level in the same period. Although the bulk of composite structures and parts for aerospace uses are now made using prepreg tape and hand layup, production is expected to incorporate less labor-intensive, lower cost techniques such as automated material placement, filament winding, pultrusion, and thermoforming. Newly sophisticated aerospace requirements reportedly are going to lead to higher performance fiber and resin systems to improve the damage tolerance of composites, for example, such fiber forms as 2-D and 3-D woven fabrics and braided structural subelements.[6]

When toxicological, epidemiological, and environmental sampling data on graphite fibers were examined along with the results of related studies of other fibrous materials, graphite fibers were shown to present little or no chronic health risk to people under present conditions of manufacture and use. Health effects appear to be limited to temporary skin irritations and upper respiratory tract irritations. Use of the fibers has grown in recent years, mostly because of the environmental health hazards associated with asbestos fibers.[7]

The environmental stability of several kinds of intercalated graphite fiber was investigated. The degree of environmental stability of this new conductive kind of graphite fiber will determine whether or not it can be used commercially. Four types of graphite fiber were tested; fibers intercalated with bromine, with iodine monochloride, with ferric chloride, and with cupric chloride. All four types were unstable under conditions where water was absorbed from the air, but stable under conditions of high vacuum, such as found in space. When all the other tests were considered, bromine intercalated fiber appeared to be most stable.[8]

Some experiments at Rice University with laser vaporization of graphite yielded a stable 60 carbon atom molecule, which was given the name "buckminsterfullerene." The name was chosen because of its hypothetical structure; it seems to most closely resemble a truncated icosahedron or two geodesic domes attached at the base—soccerball shaped. The technique used to synthesize this material was laser vaporization of solid graphite into a pulsed high-density helium flow. The same researchers also discovered similarly shaped molecules composed of carbon atoms with a lanthanum atom at the center. If the molecule is stable in the condensed phase, it probably would have some unique chemical properties. So far, the molecule appears to be rather inert. This serendipitous discovery was the result of research into the formation of lengthy carbon chains in interstellar space.[9]

Sumitomo Electric Co. perfected a technique for the mass production of large industrial diamonds from graphite. The graphite was subjected to ultrahigh pressure in the range of 50,000 to 60,000 atmospheres at a temperature of 1,400° C to 1,600° C for 100 hours. Until now, only small-sized diamonds have been mass produced. The firm plans to underprice natural diamond slightly for sales mainly to the semiconductor and precision toolmaking industries.[10]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Metal Bulletin Monthly. Present Imperfect-Future Uncertain. Changes and Challenges at Great Lakes Carbon. No. 176, Aug. 1985, pp. 9-19.

[3]U.S. Department of Commerce, International Trade Administration, Nonferrous Metals Division. A Competitive Assessment of Selected Reinforced Composite Fibers. Sept. 1985, 48 pp.

[4]Robbins, J. The Industrial Minerals of West Germany. Ind. Miner. (London), No. 219, Dec. 1985, pp. 41-42.

[5]Metal Bulletin Monthly. Electric Arcs Challenge to the Integrated. No. 174, June 1985, pp. 43-46.

[6]Tenney, D. R., and H. B. Dexter. Advances in Composites Technology. NASA Tech. Memo. 86353, Jan. 1985, 32 pp.

[7]Dahlquist, B. H. Evaluation of Health Aspects of Carbon Fibers. Air Force Inst. of Tech., Wright-Patterson AFB, OH, 1984, 60 pp.; NTIS AD-A151 563/4 WEP.

[8]Gaier, J. R., and D. A. Jaworske. Environmental Stability of Intercalated Graphite Fiber. Nat. Aeronaut. and Space Admin., Cleveland, OH, May 1985, 16 pp.; NTIS N85-26992/6/WMS.

[9]Baum, R. M. Laser Vaporization of Graphite Gives Stable 60-Carbon Molecules. Chem. and Eng. News, v. 63, No. 51, Dec. 23, 1985, pp. 20-22.

[10]Industrial Minerals (London). Synthetic Diamond Breakthrough. No. 213, June 1985, p. 10.

Gypsum

By Lawrence L. Davis[1]

The gypsum industry, spurred by lower interest rates and pent-up demand for housing, with 1.7 million public and private housing unit starts in 1985, ended the year with record-high shipments of gypsum wallboard, 19.5 billion square feet, an increase of 7%. Output of crude gypsum and calcined gypsum also increased. Sales of gypsum products increased slightly to 25 million short tons valued at $2.4 billion. Imports for consumption of crude gypsum increased 11% to about 10 million tons. Total value of gypsum product exports decreased 12% to $26 million.

Domestic Data Coverage.—Domestic production data for gypsum are developed by the Bureau of Mines from a survey of U.S. gypsum operations. Of the 130 operations to which the annual survey request was sent, all responded, representing 100% of the total production shown in tables 1 and 2.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Active mines and plants[1]	113	109	111	113	116
Crude:					
Mined	11,497	10,538	12,884	14,319	14,726
Value	$98,101	$89,131	$101,361	$113,671	$114,229
Imports for consumption	7,593	6,718	8,031	8,904	9,922
Byproduct gypsum sales	696	697	760	780	779
Calcined:					
Produced	11,687	11,243	13,902	15,450	15,982
Value	$243,140	$196,488	$270,136	$320,518	$366,581
Products sold (value)	$1,196,236	$1,121,775	$1,605,605	$2,274,261	$2,418,296
Exports (value)	$35,434	$29,550	$32,088	$29,852	$26,419
Imports for consumption (value)	$51,720	$53,646	$87,880	$169,667	$155,422
World: Production	r83,970	r79,847	86,718	p86,767	e89,220

eEstimated. pPreliminary. rRevised.

[1]Each mine, calcining plant, or combination mine and plant is counted as one establishment; includes plants that sold byproduct gypsum.

DOMESTIC PRODUCTION

The United States remained the world's leading producer of gypsum, accounting for 17% of the total world output.

Crude gypsum was mined by 39 companies at 67 mines in 21 States. Production increased 3%. Leading producing States, in descending order, were Texas, Michigan, Iowa, Oklahoma, California, and Nevada. These six States produced more than 1 million tons each and together accounted for 65% of total domestic production. Stocks of crude ore at mines and plants at yearend were 3 million tons.

Leading companies were U.S.G. Corp., 12 mines; National Gypsum Co., 7 mines; Georgia-Pacific Corp., 6 mines; Celotex Corp., a subsidiary of Jim Walter Corp., and Genstar Gypsum Products Co., 3 mines each; and Weyerhaeuser Co., 1 mine. These 6 companies, operating 32 mines, produced

79% of the total crude gypsum.

Leading individual mines, in descending order of production, were U.S.G.'s Plaster City Mine, Imperial County, CA; U.S.G.'s Sweetwater Mine, Nolan County, TX; U.S.G.'s Alabaster Mine, Iosco County, MI; U.S.G.'s Shoals Mine, Martin County, IN; National Gypsum's Tawas Mine, Iosco County, MI; Weyerhaeuser's Briar Mine, Howard County, AR; U.S.G.'s Southard Mine, Blaine County, OK; National Gypsum's Sun City Mine, Barber County, KS; Georgia-Pacific's Acme Mine, Hardeman County, TX; and Republic Gypsum Co.'s Duke Mine, Jackson County, OK. These 10 mines accounted for 41% of the national total. Average output per mine for the 67 U.S. mines increased 6% to 219,800 tons.

Gypsum was calcined by 14 companies at 71 plants in 30 States, principally for the manufacture of gypsum wallboard and plaster. Calcined output increased 3% in tonnage and 14% in value. Leading States, in descending order, were Texas, California, Florida, Iowa, and New York. These 5 States, with 24 plants, accounted for 41% of the national output.

Leading companies were U.S.G., 22 plants; National Gypsum, 18 plants; Georgia-Pacific, 9 plants; Genstar, 5 plants; and Celotex, 4 plants. These 5 companies, operating 58 plants, accounted for 82% of the national output.

Leading individual plants were, in descending order of production, U.S.G.'s Jacksonville plant, Duval County, FL; U.S.G.'s Plaster City plant, Imperial County, CA; U.S.G.'s Sweetwater plant, Nolan County, TX; Weyerhaeuser's Briar plant, Howard County, AR; National Gypsum's Tampa plant, Hillsborough County, FL; U.S.G.'s Stony Point plant, Rockland County, NY; U.S.G.'s Shoals plant, Martin County, IN; National Gypsum's Medicine Lodge Plant, Barber County, KS; Georgia-Pacific's Acme plant, Hardeman County, TX; and Genstar's Las Vegas plant, Clark County, NV. These 10 plants accounted for 27% of the national production. Average calcine production for the 71 U.S. plants was 225,100 tons, a slight increase.

The following companies sold a total of 779,000 tons of byproduct gypsum, valued at $6 million, principally for agricultural use, but some for gypsum wallboard manufacturing: Allied Chemical Corp. and J. R. Simplot Co., both in California; Occidental Petroleum Corp. in Florida; Kemira Inc. in Georgia; SCM Pigments Div. of SCM Corp. in Maryland; and Texasgulf Inc. in North Carolina. Approximately 22% was of nonphosphogypsum origin, compared with 19% in 1984. Some byproduct gypsum was mixed with natural gypsum and commercially used in the manufacture of wallboard at U.S.G.'s Baltimore, MD, plant using byproduct gypsum obtained from SCM Pigments Div.'s plant in Baltimore.

Gypsum wallboard plant capacity increased 4% to 21.63 billion square feet. Total wallboard shipments were 19.5 billion square feet, indicating a 90% utilization of operating capacity. Shipments were a new record-high, a 7% increase compared with that of 1984.

One new gypsum mine was opened during the year. Eagle Gypsum Ltd.'s Eagle Mine in Eagle County, CO, produced gypsum for use as a cement set retarder.

Thomas Peck & Sons Inc. operated its mine near Nephi, UT, on an intermittent basis because of excessive fugitive dust emissions during the dry summer months and flooding problems in the wet months. The gypsum was used for cement production at portland cement plants in Juab and Salt Lake Counties.

At yearend, Piedmont Energy Inc. of Salt Lake City, UT, purchased Houston-based Standard Gypsum Corp., a gypsum importer with facilities at Tampa, FL.[2]

A new company, Atlantic Gypsum Co. Inc., was planning a $34 million gypsum importing, processing, and wallboard manufacturing facility at Port Newark, NJ. The plant, to be fed by at least 250,000 tons per year of imported gypsum, was expected to begin operation in the spring of 1987.[3]

Winn Rock Inc.'s Winnfield Mine in Winn Parish, LA, the only anhydrite mine in the United States, produced rock mainly for road construction, but some was sold for use as a cement set retarder.

Reflecting sporadic markets for crude gypsum sold for cement or agricultural use, several gypsum mines remained closed during the year. CalMat Co.'s Shoveler Annex Mine in Imperial County, CA, was idle. Ernest W. Munroe, Joe C. Lackey, Colorado Lien Co., all in Colorado, were dormant. E. J. Wilson & Sons' Lidy Hot Springs Mine in Lemhi County, ID, remained inactive but shipped some gypsum from stockpile for agricultural use. Walter Fisk's Lovelock Mine in Pershing County, NV, was inactive. Raymond Schweitzer Gypsum Co.'s Calumet Mine in Canadian County, OK, and Walton Gypsum Co.'s Okeene Mine in Blaine County, OK, remained dormant.

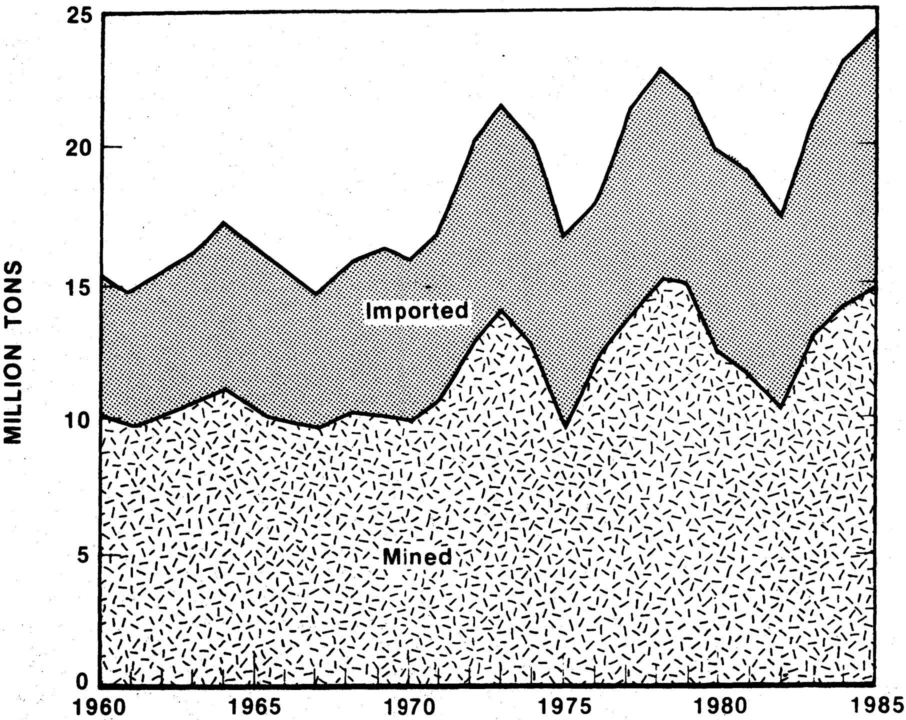

Figure 1.—Supply of crude gypsum in the United States.

Table 2.—Crude gypsum mined in the United States, by State

State	1984			1985		
	Active mines	Quantity (thousand short tons)	Value (thousands)	Active mines	Quantity (thousand short tons)	Value (thousands)
Arizona	4	261	$2,332	4	251	$1,926
Arkansas, Kansas, Louisiana	5	1,465	9,577	5	1,365	7,740
California	10	1,382	12,443	8	1,332	12,201
Colorado, Idaho,[1] Montana, South Dakota, Washington	7	428	3,576	7	375	3,086
Indiana, New York, Ohio, Virginia	5	1,844	14,330	5	1,870	14,832
Iowa	6	1,527	12,421	6	1,639	13,682
Michigan	5	1,534	10,304	5	1,772	11,883
Nevada	4	1,192	8,860	4	1,207	8,942
New Mexico	3	318	1,622	3	350	1,570
Oklahoma	6	1,549	13,485	6	1,595	12,548
Texas	7	2,166	19,431	7	1,981	17,299
Utah	4	277	2,671	4	413	4,033
Wyoming	3	376	2,618	3	576	4,488
Total[2]	69	14,319	113,671	67	14,726	114,229

[1]1984 only.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Calcined gypsum produced in the United States, by State

State	1984			1985		
	Active plants	Quantity (thousand short tons)	Value (thousands)	Active plants	Quantity (thousand short tons)	Value (thousands)
Arizona and New Mexico	3	382	$8,770	3	404	$10,016
Arkansas, Louisiana, Oklahoma	6	1,600	30,318	6	1,664	34,905
California	6	1,519	35,364	6	1,606	41,325
Colorado and Utah	3	352	7,010	3	354	8,164
Delaware and Maryland	3	783	16,695	3	732	17,165
Florida	3	1,160	25,774	3	1,185	27,974
Georgia	3	702	15,940	3	740	18,161
Illinois, Indiana, Kansas	6	1,405	25,765	6	1,445	28,862
Iowa	5	1,173	22,931	5	1,168	26,589
Massachusetts, New Hampshire, New Jersey, Pennsylvania	5	789	17,387	5	820	20,084
Michigan	4	500	9,446	4	571	12,217
Montana, Washington, Wyoming	5	701	17,195	5	705	19,951
Nevada	3	779	13,877	3	825	16,674
New York	4	986	19,627	4	1,046	24,408
North Carolina and Virginia	3	628	12,835	3	672	15,676
Ohio	3	404	9,425	3	432	9,998
Texas	6	1,587	32,157	6	1,614	34,412
Total[1]	71	15,450	320,518	71	15,982	366,581

[1]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Apparent consumption, production plus net imports plus industry stock changes, of crude gypsum, including byproduct gypsum, increased 5% to 25.4 million tons. Net imports provided 33% of the crude gypsum consumed. Apparent consumption of calcined gypsum increased 4% to 15.9 million tons.

Yearend stocks of crude gypsum at mines and calcining plants were 3 million tons. Of this, 46% was at calcining plants in coastal States.

Of the total gypsum products sold or used, 5.6 million tons, 23%, was uncalcined. Of the total uncalcined gypsum, 76% was used for portland cement, and 21% was used in agriculture. Of the total calcined gypsum, 96% was used for prefabricated products and 4% for industrial and building plasters. Of the prefabricated products, based upon surface square feet, 67% was regular wallboard; 22% was fire-resistant type X wallboard; 3% was 5/16-inch mobile home board; 5% was lath, veneer base, sheathing, and predecorated wallboard; and 3% was miscellaneous board including water- and/or moisture-resistant board. Of the regular wallboard, 83% was 1/2-inch and 11% was 5/8-inch. In descending order, the leading sales regions for prefabricated products were the South Atlantic, Pacific, and West South-Central, which accounted for 54% of the total.

Table 4.—Gypsum products (made from domestic, imported, and byproduct gypsum) sold or used in the United States, by use

(Thousand short tons and thousand dollars)

Use	1984		1985	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland cement	4,286	41,046	4,256	38,623
Agriculture[1]	1,326	18,671	1,180	16,377
Fillers and miscellaneous	125	6,597	132	6,448
Total	5,737	66,314	[2]5,567	61,448
Calcined:				
Building plaster:				
Regular base coat	155	15,356	149	15,027
Poured gypsum cement and concrete	4	365	2	192
Veneer plaster	89	12,680	102	15,190
Gauging plaster and Keene's cement	23	3,030	26	3,561
Other	9	1,201	8	1,105
Total	280	[2]32,633	[2]288	35,075
Industrial plaster	453	45,866	510	55,426
Prefabricated products[3]	17,572	2,129,448	18,320	2,266,348
Total calcined	18,305	2,207,947	[2]19,117	2,356,849
Grand total	24,042	2,274,261	[2]24,684	[2]2,418,296

[1]Includes most of 779,603 tons of byproduct gypsum in 1984 and most of 778,515 tons in 1985.
[2]Data do not add to total shown because of independent rounding.
[3]Includes weight of paper, metal, or other materials, and some byproduct gypsum.

Table 5.—Prefabricated gypsum products sold or used in the United States

Product	1984			1985		
	Thousand square feet	Thousand short tons[1]	Value (thousands)	Thousand square feet	Thousand short tons[1]	Value (thousands)
Lath:						
3/8 inch	30,600	23	$4,282	27,800	21	$4,404
1/2 inch	1,500	1	202	1,750	2	237
Total[2]	32,100	24	4,484	29,550	22	4,641
Veneer base	408,270	470	50,882	428,860	435	58,167
Sheathing	337,720	325	49,773	349,860	328	52,389
Regular gypsumboard:						
3/8 inch	475,283	361	54,047	454,246	340	53,301
1/2 inch	10,490,118	9,262	1,135,688	10,851,776	9,539	1,134,940
5/8 inch	1,298,586	1,430	162,942	1,395,919	1,252	173,496
1 inch	61,600	126	13,513	79,900	142	18,532
Other[3]	162,370	125	18,880	276,220	180	31,898
Total[2]	12,487,957	11,304	1,385,069	13,058,061	11,453	1,412,168
Type X gypsumboard	4,040,744	4,677	507,100	4,387,049	5,015	546,862
Predecorated wallboard	127,110	134	41,013	134,650	129	45,346
5/16-inch mobile home board	853,850	615	87,704	651,549	489	64,567
Other[4]	25,930	23	3,423	483,420	448	82,209
Grand total[2]	18,313,681	17,572	2,129,448	19,522,999	18,320	2,266,348

[1]Includes weight of paper, metal, or other material.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes 1/4-, 7/16-, and 3/4-inch gypsumboard.
[4]Includes approximately 478,000 square feet of water- and/or moisture-resistant board in 1985.

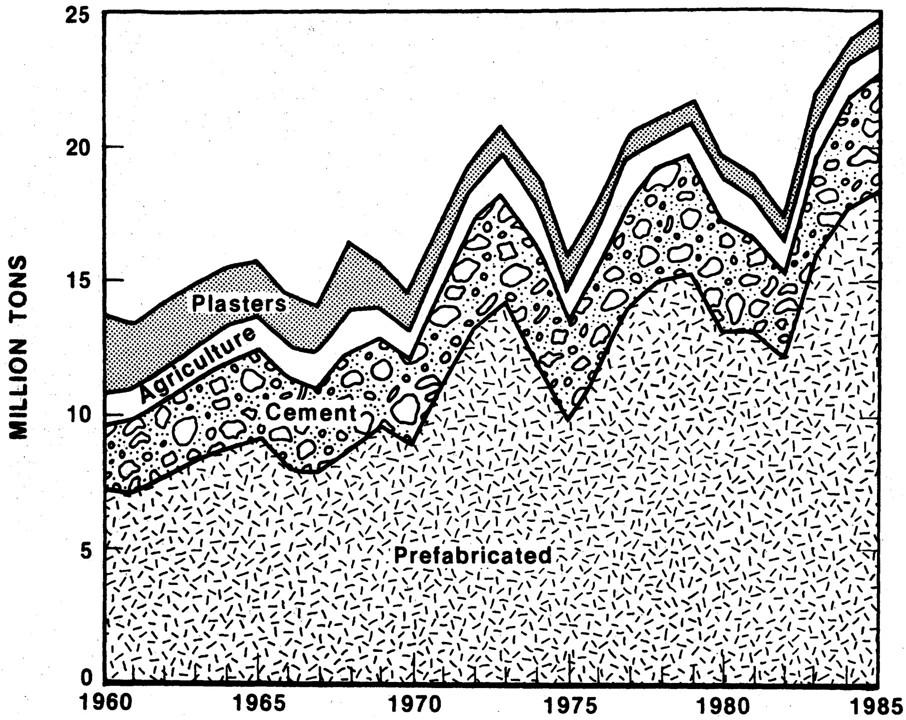

Figure 2.—Sales of gypsum products, by use.

ENERGY

Efficient production scheduling, superior insulation, and energy-saving processing equipment such as one-step drying and calcining continued to improve the utilization of energy per unit of wallboard as in the past few years. Energy consumption per thousand square feet of gypsum wallboard sales decreased slightly to 2.42 million British thermal units.

As reported by the Gypsum Association, fuel sources for the gypsum industry were natural gas, 84.5%; electricity, 6.5%; propane, 1.0%; No. 2 fuel oil, 2.8%; No. 4 and No. 6 fuel oil, 2.0%; and coal, 3.0%.

PRICES

On an average value per ton basis, crude gypsum decreased slightly to $7.76, calcined gypsum increased 13% to $23.53, and byproduct gypsum decreased 7% to $7.70.

The average value of gypsum products sold or used increased 4% to $97.97 per ton. Prefabricated products were valued at $123.71 per ton, industrial plasters at $108.68 per ton, building plaster at $121.79 per ton, and uncalcined products at $11.04 per ton.

Quoted prices for gypsum products were published monthly in Engineering News-Record. Prices in December, based on truck lots delivered to the job, showed a wide range. Regular 1/2-inch wallboard prices ranged from $97 per thousand square feet at Dallas and Denver to $268 at Boston. Average price in December for 20 cities was $173 per thousand square feet, with some minor discounts for prompt payment. This represented a slight increase compared with that of December 1984.

FOREIGN TRADE

The gypsum industry continued to rely on imports of crude gypsum rock for a significant fraction, 33%, of apparent consumption. Imports of crude gypsum, principally from Canada, 66%; Mexico, 22%; and Spain, 12%, increased 11% to 9.9 million tons. Spanish imports into the South Atlantic Coast and Gulf Coast States increased 31% to 1.2 million tons. Most of the imported crude gypsum was mined by subsidiaries of U.S. companies in Canada and Mexico.

Total value of gypsum and gypsum products imported was $155 million, a decrease of 8%. Gypsum wallboard imports, principally from Canada, 82%, were 786 million square feet, a 9% decrease. Total value of gypsum product exports to all countries was $26 million, a 12% decrease.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed, or calcined		Other manufactures, n.e.c. (value)[1]	Total value
	Quantity	Value		
1983	117	13,621	18,467	32,088
1984	131	12,711	17,141	29,852
1985	83	13,021	13,398	26,419

[1]Includes gypsum or plaster building boards and lath (TSUS 245.7000) and articles, n.s.p.f., of plaster of paris (TSUS 512.4500).

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude		Ground or calcined		Alabaster manufactures[1] (value)	Plasterboard[2] (value)	Other manufactures, n.s.p.f.[3] (value)	Total value
	Quantity	Value	Quantity	Value				
1983	8,031	56,960	4	305	1,922	26,200	2,492	[4]87,880
1984	8,904	73,965	11	392	3,300	86,962	5,048	169,667
1985	9,922	64,089	2	242	5,173	80,119	5,799	155,422

[1]Includes imports of jet manufactures, which are believed to be negligible.
[2]Includes gypsum or plaster building boards and lath (TSUS 245.7000).
[3]Comprised of statues and articles, n.s.p.f., of plaster of paris (TSUS 512.4100 and 512.4400) and gypsum cement, (TSUS 512.3100 and 512.3500).
[4]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption of crude gypsum, by country

(Thousand short tons and thousand dollars)

Country	1984		1985	
	Quantity	Value	Quantity	Value
Australia	15	160	16	130
Canada[1]	6,006	58,980	6,516	45,445
Jamaica	112	977	17	118
Mexico	1,837	7,392	2,162	9,896
Spain	922	6,312	1,207	8,052
Other	12	143	4	447
Total[2]	8,904	73,965	9,922	64,089

[1]Includes anhydrite.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

Production of gypsum from small deposits in the developing countries has been intermittent and often unreported. Total world production figures might be somewhat low because, in many countries, significant mine production was consumed captively in integrated industrial plants producing wallboard, plaster, and plaster products, and was unreported.

Canada.—Canada was the second largest producer of crude gypsum, accounting for 10% of the world total. Shipments increased 9% to 9.3 million tons, 75% of which came from Nova Scotia.

Canada exported 6.4 million tons of crude gypsum, almost 70% of its production. Over 99% of the exports were to the United States, principally to wallboard plants in the Atlantic and Gulf Coast States. Canada imported about 120,000 tons of crude gypsum, over 70% of which came from Mexico.

Production of wallboard products decreased because of a 4-month strike at Domtar Inc.'s plant at Caledonia, Ontario. As a result, exports to the United States decreased from the record high set in 1984. Wallboard imports increased greatly in 1985 because of reduced production and an increase in Canadian demand.

Domtar purchased the gypsum wallboard plants of Genstar Gypsum Ltd. at Edmonton, Alberta, and Saskatoon, Saskatchewan. Westroc Industries Ltd. announced that its Vancouver, British Columbia, plant would be closed. Westroc then purchased Genstar Gypsum's gypsum wallboard plant in Vancouver.[4]

The Gypsum Association in the United States, of which all Canadian gypsum wallboard manufacturers were members, announced that yearend Canadian wallboard capacity was 3.64 billion square feet, a slight decrease from that of 1984.

Finland.—Kemira Oy opened a plant to produce paper coating pigments using phosphogypsum. The plant, at Siilinjarvi, has a capacity of 55,000 tons per year.[5]

Germany, Federal Republic of.—The Federal Republic of Germany is one of Western Europe's major producers of crude gypsum and a world leader in specialty gypsum used in molding, dental, and pharmaceutical applications that require very high purity gypsum. The largest producer of crude gypsum is Gebr. Knauf Westdeutsche Gipswerke with a capacity of about 3.3 million tons per year from 11 mines in Bavaria and 6 others in Baden-Württemberg, Hessen, Saarland, and Lower Saxony. The second largest crude gypsum producer is Rigips Baustoffwerke GmbH, with numerous mines in Baden-Württemberg and two in Lower Saxony. Both companies produce building plaster and wallboard. Another 20 or so smaller companies produce gypsum retarders for the cement industry, building plasters, high-purity specialty plasters, and gypsum blocks.[6]

Libya.—Libya awarded a contract to develop a 220,000- to 330,000-ton-per-year gypsum mine and to construct export facilities at a port east of Tripoli. Most of the crude gypsum was expected to be exported to Scandinavia and Europe and the remainder used to supply domestic demand for plaster and wallboard products.[7]

Thailand.—Fueled by rapid growth in building construction in the Bangkok area, gypsum production, used mainly by the cement industry, increased about 13%. Exports, mainly to Taiwan and Malaysia, increased slightly. Exports faced increased competition from Australia and India.[8] Major gypsum deposits are in the northern Provinces of Pichit and Nakhon Sawan and the southern Provinces of Nakhon Si Thammarat and Surat Thani. The largest producers in the north are Thai Gypsum Co. Ltd. and its affiliate Thai Gypsum Products Co. Ltd. with a combined capacity of 330,000 tons per year of crude gypsum. In the southern Province of Surat Thani, Taksin Sahakarn Co. Ltd. is the largest producer, while in Nakhon Si Thammarat Chokpana Co. Ltd. and S. K. Minerals are the principal producers.[9]

Table 9.—Gypsum: World production, by country[1]

(Thousand short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Afghanistan	[r][e]3	[2]3	[r][e]3	[r][e]3	3
Algeria[e]	220	220	275	275	275
Angola[e]	22	22	22	[r]22	22
Argentina	739	679	637	625	585
Australia	1,932	2,054	1,664	678	1,100
Austria[3]	882	802	828	816	830
Belgium[3]	170	--	--	--	--
Bolivia	1	1	[e]1	[e]1	1
Brazil	659	750	613	544	610
Bulgaria	386	414	425	433	435
Burma[4]	34	29	38	43	[2]43
Canada (shipments)[3]	7,744	6,600	8,275	8,550	9,300
Chile	[r]262	[r]99	73	185	[2]216
China[e]	3,700	3,900	4,700	5,300	5,500
Colombia	[r]328	309	247	287	300
Cuba[e]	143	140	145	145	145
Cyprus	[r]44	[r]33	35	24	25
Czechoslovakia	845	875	935	928	840
Dominican Republic	[2]225	[e]230	[e]230	[e]230	255
Ecuador	[2]2	[e]2	[e]2	[e]2	2
Egypt	1,047	1,026	795	[e]800	800
El Salvador[e]	7	6	5	5	4
Ethiopia	5	4	[e]5	[e]5	5
France[3]	6,839	6,657	6,111	5,954	6,000
German Democratic Republic[e]	[r]397	[r]397	[r]397	[r]397	397
Germany, Federal Republic of (marketable)[3]	2,122	1,897	2,739	[e]2,400	2,200
Greece	694	756	[r][e]760	[r][e]760	750
Guatemala	32	31	43	28	27
Honduras[e]	22	22	[r]25	25	25
India	1,045	1,070	1,145	1,519	[2]1,239
Iran	[2]6,600	[e]5,500	[e]6,000	[e]5,500	5,500
Iraq[e]	190	190	190	330	330
Ireland	[r]396	409	388	358	360
Israel	46	46	46	46	46
Italy	1,702	1,472	1,530	1,393	1,400
Jamaica	206	118	119	[e]200	220
Japan[5]	6,765	7,014	6,443	[e]6,700	6,900
Jordan	58	44	45	121	120
Kenya[3]	--	(6)	1	[r][e]2	2
Korea, Republic of[5]	[e]700	[e]800	[e]1,000	[2]558	[2]873
Laos	45	[e]70	[e]80	90	120
Lebanon	10	6	6	[e]6	3
Libya	198	193	198	198	198
Luxembourg	1	(6)	[e](6)	[e](6)	(6)
Mauritania[e]	[2]2	6	4	1	1
Mexico	2,635	2,251	3,261	2,347	3,100
Mongolia[e]	35	35	35	35	35
Morocco	439	463	485	[e]500	500
Nicaragua	[e]33	22	13	[e]10	[2]9
Niger[e]	3	3	3	3	3
Pakistan	[r]349	[r]365	351	413	475
Paraguay	11	7	4	7	6
Peru	[2]386	[e]400	[e]400	[e]400	400
Philippines[5]	122	121	122	124	124
Poland[3]	[2]1,445	[e]1,430	[e]1,430	[e]1,430	1,490
Portugal	268	262	275	[r][e]265	275
Romania[e]	1,800	1,800	1,800	2,000	1,700
Saudi Arabia	386	400	[e]550	331	330
Sierra Leone	--	--	4	4	4
South Africa, Republic of	612	590	571	590	[2]505
Spain	5,829	5,564	6,195	5,914	5,800
Sudan[3]	[r][e]9	[r][e]9	[e]9	[2]9	[2]7
Switzerland[e]	95	[r]85	85	85	90
Syria	88	[e]90	186	220	220
Taiwan[5]	7	2	3	2	2
Tanzania[e]	13	13	13	13	13
Thailand	596	831	838	1,224	1,380
Tunisia[e]	80	80	[r]88	[r]95	100
Turkey	100	[e]100	83	64	66
U.S.S.R.[e][5]	5,400	5,400	5,400	5,400	5,400
United Kingdom[3]	3,245	3,021	3,271	3,459	[2]3,389
United States[7]	11,497	10,538	12,884	14,319	[2]14,726
Uruguay	(8)	135	167	82	110
Venezuela	241	175	226	158	[2]147

See footnotes at end of table.

Table 9.—Gypsum: World production, by country[1] —Continued

(Thousand short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Vietnam[e]	17	30	30	30	30
Yemen Arab Republic	[e]22	24	26	27	27
Yugoslavia	737	705	687	[r e]720	750
Total	[r]83,970	[r]79,847	86,718	86,767	89,220

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 8, 1986.
[2]Reported figure.
[3]Includes anhydrite.
[4]Data are for years beginning Apr. 1 of that stated.
[5]Includes byproduct gypsum. (In the case of Japan, byproduct gypsum was virtually all the gypsum consumed during 1981-85.)
[6]Less than 1/2 unit.
[7]Excludes byproduct gypsum.
[8]Revised to zero.

TECHNOLOGY

Windsor Gypsum Co. began construction of a gypsum wallboard plant near Tatum, TX, close to the Martin Lake powerplants of Texas Utilities Co. The raw material feed for the wallboard plant will be high-quality synthetic gypsum from the flue gas desulfurization system of the powerplants. This would be the first U.S. wallboard plant designed and constructed solely on the basis of a synthetic gypsum feed.

The Bureau of Mines conducted pull and creep tests on roof bolts anchored with gypsum plaster. Results showed that 2-foot bolts anchored with the gypsum plaster, which was allowed to cure for 10 minutes, sustained pull test loads equal to the ultimate strength of the bolt steel, about 37,000 pounds.[10]

The Bureau of Mines investigated possible high-volume uses of waste phosphogypsum. Admixtures of phosphogypsum, fly ash, and lime that could produce a coarse aggregate suitable for road construction were studied. Use of cement, cement-kiln dust, clays, oxychlorides, phosphogypsum asphalt, and silica were also investigated. It was found that a mix containing 7% grade AC-20 asphalt and 93% aggregate composed of 20% dried phosphogypsum, 30% sand, and 50% limestone met Florida Department of Transportation specifications for a type III surface course mix, a sand-asphalt hot mix for patching, and an ABC-1 base course mix. Thus, phosphogypsum could be used in asphalt-concrete mixes for surface or base courses or for patching, but none of the various mixes could meet specifications for wearing or friction courses.[11]

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[1]Physical scientist, Division of Industrial Minerals.
[2]Rock Products. V. 89, No. 1, Jan. 1986, p. 36.
[3]Page 8 of work cited in footnote 2.
[4]Stonehouse, D. H. Gypsum and Anhydrite. Can. Miner. Yearbook 1985, pp. 30.1-30.8.
[5]Griffiths, J. Kemira Mica-Utilising Resources. Ind. Miner. (London), No. 219, Dec. 1985, p. 81.
[6]Robbins, J. The Industrial Minerals of West Germany. Ind. Miner. (London), No. 219, Dec. 1985, pp. 23-24.
[7]Industrial Minerals (London). No. 219, Dec. 1985, p. 12.
[8]U.S. Embassy, Bangkok, Thailand. State Dep. Telegram 24749, May 28, 1986, sec. 17 and 18.
[9]Rachdawong, S. Industrial Minerals of Thailand. Ind. Miner. (London), No. 221, Feb. 1986, pp. 40-41.
[10]Hansen, J. S., and S. J. Gerdemann. Pull and Creep Tests on Gypsum-Bonded Roof Bolts. BuMines RI 8937, 1985, 36 pp.
[11]May, A., J. R. Cobble, and J. W. Sweeney. Assessment of Phosphogypsum as a Constituent of Aggregate Material. BuMines RI 8939, 1985, 21 pp.

Helium

By William D. Leachman[1]

Grade-A helium (99.995% or better) sales volume in the United States by private industry and the Bureau of Mines was 1,444 million cubic feet (MMcf) in 1985.[2] Grade-A helium exports by private producers were 439 MMcf, for total sales of 1,883 MMcf of U.S. helium. The Bureau's price, f.o.b. plant, for Grade-A helium was $37.50 per thousand cubic feet (Mcf). The price of Grade-A helium gas sold by private producers was about $36 per Mcf at the end of the year, and the price of liquid helium averaged $55 per Mcf gaseous equivalent with some producers posting surcharges to these prices.

Domestic Data Coverage.—Domestic production data for helium are developed by the Bureau of Mines from records of its own operations as well as the "High-Purity Helium" survey, a single, voluntary canvass of private U.S. operations. Of the six operations to which a survey request was sent, 100% responded, and those data plus data from the Bureau's operations represent 100% of the total production shown in table 2.

Legislation and Government Programs.—The Government's program for storage of private crude helium in the Government's helium storage facilities at the Cliffside Field near Amarillo, TX, was critical in supplying helium for the private helium market. Private helium production in 1985 was not sufficient to provide for the private market because one of its crude helium separation plants suspended operations in April. Private crude helium previously stored under contract with the Government was returned to the owners for purification as needed to provide for private industry's demand.

DOMESTIC PRODUCTION

In 1985, 11 privately owned domestic helium plants were operated by 8 companies. Seven privately owned plants and one Bureau of Mines plant extracted helium from natural gas. Both private and Bureau plants use cryogenic extraction processes. Pressure-swing adsorption is used for helium purification at two newer private helium plants and at the Bureau's plant. Cryogenic purification is used by other producers. The Bureau and all six private plants that produce Grade-A helium also liquefy helium. They are Air Products and Chemicals Inc., Hansford County, TX; Navajo Refined Helium Co., Shiprock, NM; Kansas Refined Helium Co., Otis, KS; and Union Carbide Corp., Linde Div., in Bushton, Elkhart, and Ulysses, KS.

The volume of helium recovered from natural gas decreased in 1985 because one of the larger private crude helium plants shut down in April and did not resume operation owing to the declining market for natural gas and natural gas liquids. All of the natural gas processed for helium extraction came from the gasfields in Kansas, New Mexico, Oklahoma, and Texas.

The Bureau of Mines' 500-liter-per-hour helium liquefier was modified in 1985 to increase its efficiency. The control system was changed, and a wet-expansion engine was installed to increase its output. The modifications and new equipment increased liquefaction capacity about 30%, with an increase of only 11% in operating costs. The Federal demand for liquid helium continues to grow as national defense, space, and energy research and development projects using liquid helium increase.

Table 1.—Ownership and location of helium extraction plants in the United States in 1985

Category and owner or operator	Location	Product purity
Government-owned:		
Bureau of Mines	Masterson, TX	Crude and Grade-A helium.[1]
Do	Keyes, OK	Helium tank car maintenance only.[2]
Private industry:		
Air Products and Chemicals Inc	Hansford County, TX	Grade-A helium.[1]
Cities Service Cryogenics Inc	Scott City, KS	Crude helium.[3]
Cities Service Helex Inc	Ulysses, KS	Crude helium.
Kansas Refined Helium Co	Otis, KS	Grade-A helium.[1]
Navajo Refined Helium Co	Shiprock, NM	Do.
Northern Helex Co	Bushton, KS	Crude helium.
Phillips Petroleum Co	Dumas, TX	Do.
Do	Hansford County, TX	Do.
Union Carbide Corp., Linde Div	Bushton, KS	Grade-A helium.[1]
Do	Elkhart, KS	Do.
Do	Ulysses, KS	Do.

[1]Including liquefaction.
[2]Tank car maintenance relocated to Masterson, TX, in May 1985. Keyes plant deactivated.
[3]Output is piped to Ulysses, KS, for purification.

Table 2.—Helium recovery in the United States[1]

(Thousand cubic feet)

	1981	1982	1983	1984	1985
Crude helium:					
Bureau of Mines:					
Total storage	-257,799	-350,235	-275,714	-314,969	-411,681
Private industry:					
Stored by Bureau of Mines	452,880	113,261	282,018	506,092	487,576
Withdrawn	-304,987	-724,113	-729,134	-605,935	-956,462
Total private industry storage	147,893	-610,852	-447,116	-99,843	-468,886
Total crude helium	-109,906	-961,087	-722,830	-414,812	-880,567
Stored private crude helium withdrawn from storage and purified by the Bureau of Mines for redelivery to industry	-80,208	-51,234	-65,015	-49,057	-5,339
Grade-A helium:					
Bureau of Mines sold	240,880	305,071	241,733	294,460	397,446
Private industry sold	1,014,543	939,496	1,120,955	1,342,961	1,485,662
Total sold	1,255,423	1,244,567	1,362,688	1,637,421	1,883,108
Total stored	-190,114	-1,012,321	-787,845	-463,869	-885,906
Grand total recovery	1,065,309	232,246	574,843	1,173,552	997,202

[1]Negative numbers denote net withdrawal from the Government's underground helium storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.

Table 3.—Summary of Bureau of Mines helium plant operations

(Thousand cubic feet)

	1983	1984	1985
Grade-A supply:			
Inventory at beginning of period[1]	20,368	22,400	18,163
Helium recovered: Exell plant[2]:	308,780	339,280	387,795
Total	329,148	361,680	405,958
Grade-A disposal:			
Sales	241,733	294,460	397,446
Redelivered to private producers	65,015	49,057	5,339
Inventory at end of period[1]	22,400	18,163	3,173
Total	329,148	361,680	405,958

[1]At Amarillo and Exell helium plants.
[2]Includes 65,015 Mcf purified for private industry in 1983, 49,057 Mcf in 1984, and 5,339 in 1985.

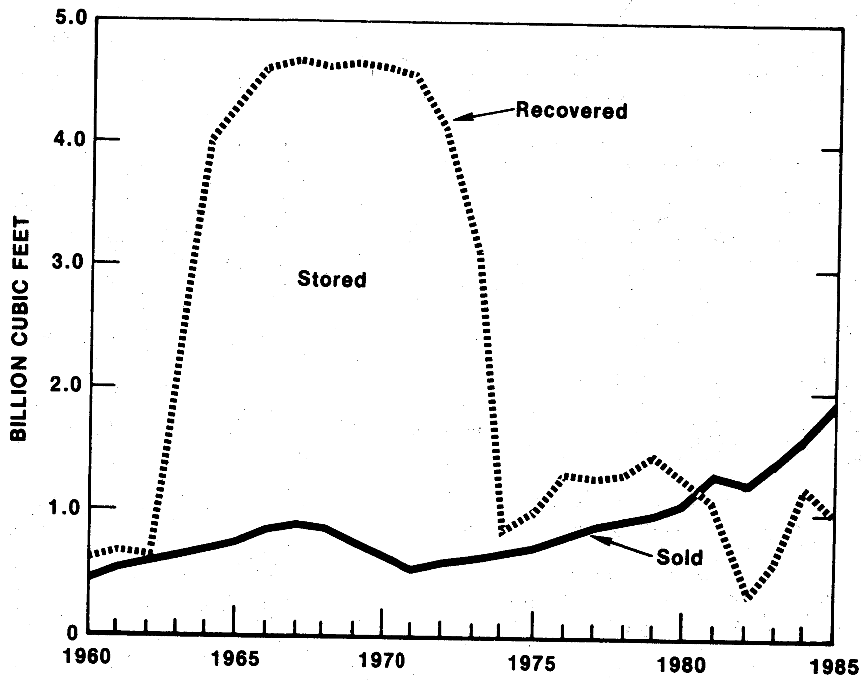

Figure 1.—Helium recovery in the United States, 1960-85.

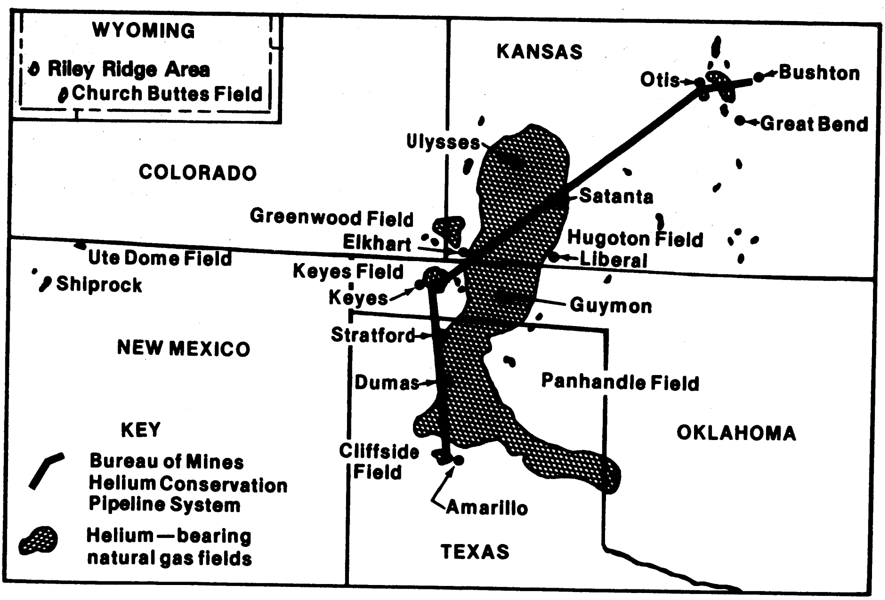

Figure 2.—Major U.S. helium-bearing natural gas fields.

CONSUMPTION AND USES

The major domestic end uses of helium were cryogenics, welding, and pressurizing and purging. Minor uses included synthetic breathing mixtures, chromatography, leak detection, lifting gas, heat transfer, and controlled atmospheres. The Pacific and Gulf Coast States were the principal areas for helium demand.

Nine more successful space shuttle launches were made by the National Aeronautics and Space Administration (NASA) in 1985 using Bureau helium. The *Discovery* space shuttle was launched four times, the *Challenger* and *Atlantis* orbiters were each launched twice, and the *Columbia* made one flight. Each space shuttle launch requires about 7.5 MMcf of helium for purging and pressurizing. Helium demand for space activity is increasing and is expected to increase more when the U.S. Department of Defense's space shuttle facilities at Vandenburg Air Force Base, CA, become operational.

The Federal agencies purchase their major helium requirements from the Bureau of Mines. Direct helium purchases by the U.S. Department of Energy, the U.S. Department of Defense, NASA, and the National Weather Service constituted most of the Bureau's Grade-A helium sales. All of the remaining sales to Federal agencies were through private helium distributors, who purchased equivalent volumes of Bureau helium under contracts described in the Code of Federal Regulations (30 CFR 602). Some of the private distributors also have General Services Administration helium supply contracts. These contracts make relatively small volumes of helium readily available to Federal installations at reduced freight charges.

Table 4.—Total sales of Grade-A helium in the United States

(Million cubic feet)

Year	Volume
1981	866
1982	867
1983	995
1984	1,245
1985	1,444

Table 5.—Bureau of Mines sales of Grade-A helium, by purchaser[1]

(Thousand cubic feet)

	1983	1984	1985
Federal agencies:			
Department of Defense	105,372	117,047	120,225
Department of Energy	32,821	34,599	37,731
National Aeronautics and Space Administration	37,674	49,323	103,144
National Weather Service	874	752	909
Other	2,957	4,052	7,604
Total	179,698	205,773	269,613
Federal agency sales supplied by private contract helium distributors[2]	59,059	86,434	124,299
Commercial sales	2,976	2,253	3,534
Grand total	241,733	294,460	397,446

[1]Table identifies Federal purchaser, who may redistribute the helium to another Federal helium user.
[2]Purchased from the Bureau of Mines by commercial firms and redistributed to Federal installations under contract authority of 30 CFR 602.

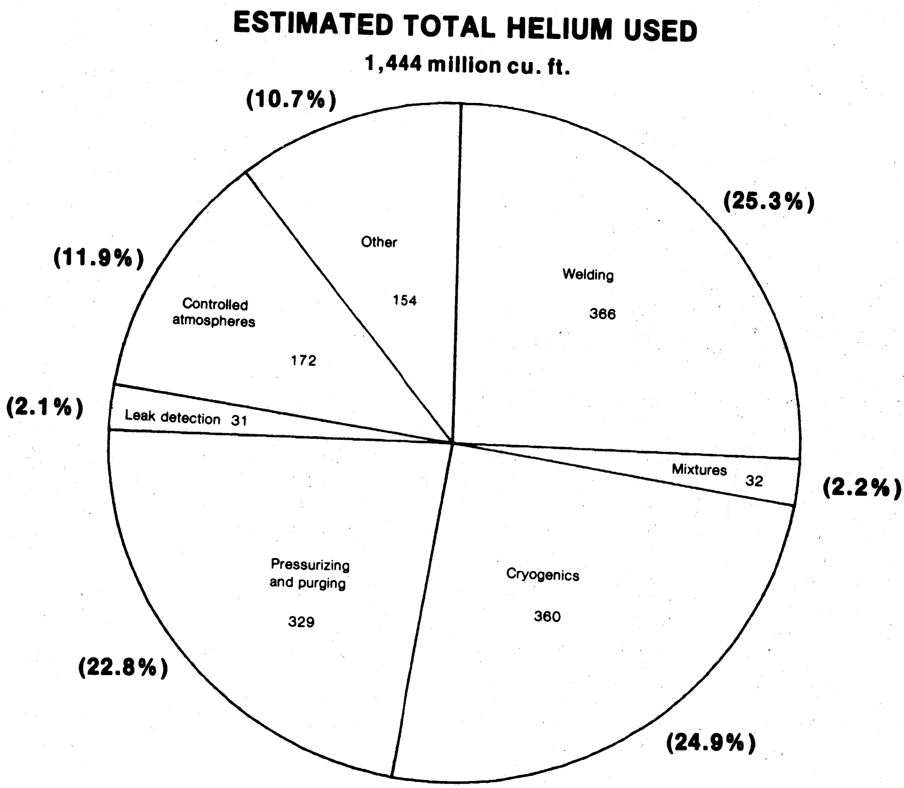

Figure 3.—Estimated helium consumption in the United States in 1985, by end use (million cubic feet).

STOCKS

The volume of helium stored for future use in the Bureau of Mines helium conservation storage system, which includes the conservation pipeline network and the Cliffside Field near Amarillo, TX, totaled more than 37 billion cubic feet (Bcf) at yearend. The conservation storage system contains crude helium purchased by the Bureau under contract, Bureau helium extracted in excess of sales, and privately owned helium stored under contract. During 1985, 488 MMcf of private helium was delivered to the Bureau's helium conservation storage system and 962 MMcf was withdrawn, for a net decrease of 474 MMcf of private helium in storage.

Table 6.—Summary of Bureau of Mines helium conservation storage system[1] operations

(Thousand cubic feet)

	1983	1984	1985
Helium in conservation storage system at beginning of period:			
Stored under Bureau of Mines conservation program	35,787,375	35,511,661	35,196,692
Stored for private producers under contract	3,475,638	2,963,507	2,814,606
Total	39,263,013	38,475,168	38,011,298
Input to system:			
Net deliveries from Bureau of Mines plants[2]	-275,714	-314,969	-411,681
Stored for private producers under contract	282,018	506,091	487,576
Total	6,304	191,122	75,895
Redelivery of helium stored for private producers under contract[2]	-794,149	-654,992	-961,801
Net addition to system[2]	-787,845	-463,870	-885,906
Helium in conservation storage system at end of period:			
Stored under Bureau of Mines conservation program	35,511,661	35,196,692	34,784,996
Stored for private producers under contract	2,963,507	2,814,606	2,340,396
Total	38,475,168	38,011,298	37,125,392

[1]Crude helium is injected into or withdrawn (-) from the Government's underground helium storage facility, a partially depleted natural gas reservoir in Cliffside Field near Amarillo, TX.

[2]Negative numbers denote net withdrawal from storage.

RESOURCES

Domestic measured and indicated helium resources as of January 1, 1985 (the latest figures available), are estimated to be 504 Bcf. The total identified helium resources are about 20 Bcf more than reported in 1984. This change is due to the identification of additional helium reserves in the Pecos Slope area of New Mexico and an increase in the undefined indicated category. The resources included measured reserves and indicated resources estimated at 240 and 29 Bcf, respectively, in natural gas with a minimum helium content of 0.3%. The measured reserves included 38 Bcf stored in the Bureau of Mines' helium conservation storage system. Measured helium resources in natural gas with a helium content of less than 0.3% are estimated to be 44 Bcf. Indicated helium resources in natural gas with a helium content of less than 0.3% are estimated to be 191 Bcf. Approximately 89% of the domestic helium resources under Federal ownership are in the Riley Ridge area and the Church Buttes Field in Wyoming, and in the Cliffside Field in Texas.

Most of the domestic helium resources are in the midcontinent and Rocky Mountain regions of the United States. The measured helium reserves are in approximately 95 gasfields in 11 States. About 92% of these reserves is contained in the Hugoton Field in Kansas, Oklahoma, and Texas; the Keyes Field in Oklahoma; the Panhandle and Cliffside Fields in Texas; and the Riley Ridge area in Wyoming. The Bureau of Mines analyzed a total of 381 natural gas samples from 27 States during 1985 in conjunction with a program to survey and identify possible new sources of helium.

TRANSPORTATION

All Grade-A gaseous helium sold by the Bureau was shipped in cylinders, special railway tank cars, or highway tube semitrailers. Liquid helium was shipped in dewars and semitrailers from the Exell helium plant. Private industrial gas distributors shipped helium as gas or liquid. Much of the private helium was transported in liquid form by semitrailers to distribution centers, where a portion was gasified and compressed into trailers and small cylinders for delivery to the end user.

PRICES

The Bureau of Mines price, f.o.b. plant, for Grade-A helium was increased from $35 to $37.50 per Mcf effective October 1, 1982. The $37.50-per-Mcf price remained in effect throughout 1985. Private producers' price for Grade-A helium was about $36 per Mcf at yearend. The price of liquid helium averaged $55 per Mcf gaseous equivalent, plus possible surcharges.

FOREIGN TRADE

Exports of Grade-A helium, all by private industry, increased by 12% in 1985 to 439 MMcf (table 7). Over 62% of the exported helium was shipped to Europe. Belgium-Luxembourg, France, and the United Kingdom, collectively, received more than 94% of the European helium imports. About 25% of the U.S. helium exports went to Asia, 4% to South America, 3% to Central America, 2% to North America, 1% to the Middle East and Australia-New Zealand, and less than 0.5% each to Africa and the Caribbean. The shipments of large volumes of helium to Western Europe were attributed to helium's use in breathing mixtures for diving and for welding in the exploration for North Sea oil and gas. Liquid helium is also being used in significant quantities in cryogenic research and superconducting equipment. Although no helium was imported in 1985, import tariffs on helium decreased 0.2% on January 1, 1985, to 4.0%. Future decreases are planned, with the import tariff finally reaching 3.7% on January 1, 1987.

Table 7.—U.S. exports of Grade-A helium

(Million cubic feet)

Year	Volume
1981	389
1982	378
1983	368
1984	392
1985	439

Source: Bureau of the Census.

WORLD REVIEW

World production of helium, excluding the United States, was estimated to be 100 MMcf, most of which was extracted in Poland. The remainder was attributed to centrally planned economy countries.

TECHNOLOGY

Magnetic resonance imaging (MRI) continues to gain acceptance in the medical field. About 125 units were installed during the year, which doubled the units in operation at the end of 1984. MRI utilizes a superconducting magnet cooled by liquid helium to produce a magnetic field. The patient is placed in the magnetic field, where molecules in the body align themselves with magnetic field lines. Radio waves are then beamed through the patient causing a different molecular alignment. When the radio waves are turned off, the molecules oscillate as they attempt to swing back to their prior magnetic alignment. This oscillation generates extremely weak radio waves that are received and analyzed by computer to obtain an image of the inside of the body. MRI and computer-assisted tomography (CAT) scans are now being utilized extensively at U.S. clinics. MRI offers several advantages over older methods of imaging, such as X-rays, as there are no harmful effects associated with this procedure.

Commissioning of Fermi National Accelerator Laboratory's (FNAL) Tevatron/Tevatron 1 is proceeding with the first experiment scheduled for 1986. When the collider begins to function, it will be the highest energy accelerator in the world. If the Tevatron operates as designed, the focus of particle research will shift from the European Center for Nuclear Research (CERN) in Geneva, Switzerland, which presently has the highest energy accelerator, to FNAL in

Batavia, IL. Tevatron/Tevatron 1 is the world's first liquid-helium-cooled superconducting particle accelerator. The Government-owned, contractor-operated project at Batavia, IL, is a major advance in high-energy physics research, and the total system design is a major engineering achievement. The use of superconductivity technology means that less electricity is required, reducing energy requirements, while intense and extremely steady magnetic fields are achieved. This application of superconductivity for the Tevatron demonstrates its commercial value and the reliability of large helium liquefiers and refrigerators. The liquid helium that cools the magnets is supplied by a 5,000-liter-per-hour central helium liquefier coupled to 24 satellite helium refrigerators. It roughly doubles the world's helium liquefying capacity.

Researchers have begun final preparation for a 2-year test program aimed at developing large superconducting magnets for fusion power reactors of the future. Installation of the final magnet in Oak Ridge National Laboratory's International Fusion Superconducting Magnet Test Facility completed the assembly work with testing scheduled to begin in 1986. The facility is designed to simultaneously test six 45-ton, 6- by 10-foot, D-shaped, helium-cooled superconducting electromagnets under conditions simulating a tokamak fusion reactor (a doughnut-shaped chamber for confinement of ionized gas in a magnetic field). The international program includes three magnets from the United States and one each from Japan, Switzerland, and Euratom (a consortium of European countries engaged in atomic research). The test program will allow the U.S. Department of Energy to select the best design for future liquid-helium-cooled superconducting magnets, which will be used in the final nuclear fusion reactor design.

Other technologies that are presently evolving and require helium's unique properties are (1) superconducting magnets used to separate weakly magnetic materials, (2) helium-neon lasers used to detect gas leaks, (3) helium ions used to treat tumors, (4) infrared mapping of infrared emissions in and beyond our galaxy, (5) helium pillow to analyze thermonuclear airbursts, (6) "Strategic Defense Initiative" equipment, such as lasers and surveillance, and (7) new lighter-than-air activities.

High-field design, liquid-helium-cooled superconducting magnets were selected for the proposed "Superconducting Super Collider." Actualization of this project could have an impact on helium usage.

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[1]Chemical engineer, Helium Field Operations, Amarillo, TX.

[2]All helium volumes herein reported at 14.7 pounds per square inch absolute and 70° F.

Iodine

By Phyllis A. Lyday[1]

Reported domestic consumption of iodine decreased during 1985. Three producers of crude iodine supplied less than one-half of domestic demand; the remainder was imported. Excess from the National Defense Stockpile remained unavailable for sale but could be bartered for other materials needed to meet goals.

Domestic Data Coverage.—Domestic production data for iodine are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the three operations to which a survey request was sent, two responded, representing an estimated 88% of the total production. Production data are withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—The National Defense Stockpile contained 7.4 million pounds of crude iodine valued at $47 million in inventory at yearend. The stockpile goal remained at 5.8 million pounds.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, iodine would be categorized in tier II, and the goal would be 5.5 million pounds of crude iodine. At yearend, this proposal was under consideration by Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The Federal Emergency Management Agency (FEMA) published a notice to provide guidance to State and local agencies responsible for radiological emergency planning and preparedness regarding the distribution of potassium iodide (KI) for use as a thyroidal blocking agent by the general public in the vicinity of nuclear powerplants.[2] The U.S. Department of Health and Human Services delegated responsibility to the Food and Drug Administration (FDA) to provide guidance to State and local governments on the use of radioprotective substances and prophylactic use of KI to reduce the radiation dose to specific organs, including dosage and projected radiation exposures at which such drugs should be used. Recommendations were that KI could be used during radiation emergencies by people who are likely to receive more than 10 to 20 rad to the thyroid. KI at recommended doses could block at least 90% of radioiodine absorption if the first dose is given shortly before or immediately after exposure to radioiodine, and the drug could block 50% of radioiodine uptake if the first dose was administered within 4 hours after exposure. State and local officials were responsible for establishing a system for informing the public how to use KI, report side effects of the drug, and get treatment for any adverse reactions. FEMA took the position that the predistribution or stockpiling of KI for use by the general public should not be required.

The Federal Radiological Preparedness Coordinating Committee of FEMA published advisory guidelines to State and local governments who, within the limits of their authority, should consider the recommendations in the development of emergency plans and in determining appropriate actions to protect the general public. In summary, the policy recommends the stockpiling or distribution of KI during emergencies for emergency workers and institutionalized persons, but does not recommend requiring predistribution or stockpiling for the general public.[3]

The FDA proposed amending regulations providing for the safe use of elemental iodine, KI, and isopropanol as components of a sanitizing solution produced by the Diversey Wyandotte Corp. for use on food-contact surfaces.[4]

The FDA continued to list Red No. 3 dye, erythrosine, on the provisional list of color additives. Red No. 3 contains 58% iodine by weight and has a grape-like color used in carbonated soft drinks, powdered drinks, gelatin desserts, icings, and pet foods. Although under pressure by one citizens group, the FDA declined to make a final decision on the provisional list until all the relevant issues were considered. Amendments to the Food, Drug, and Cosmetic Act of 1960, the Delaney Clause, required that all permanently listed dyes be proven safe. The FDA announced that a decision on the provisional status was expected to be made in 1986.[5]

DOMESTIC PRODUCTION

The Dow Chemical Co. continued to recover iodine from mineral-rich brines as a byproduct of bromine and other salts such as sodium, magnesium, and calcium-magnesium compounds. Dow's iodine production decreased during 1985 because of a planned shutdown of brine operations by 1986.

North American Brine Resources operated three miniplants at Dover and Hennessey in Kingfisher County, OK. The plants were located at oilfield reinjection disposal sites. Iodine of 95% purity was produced. Plant capacity was between 260,000 and 350,000 pounds per year. North American was a joint venture among Godoe USA Inc., a wholly owned subsidiary of United Resources Industry Co., 50%; Beard Oil Co., 40%; and Inorgchem Development Inc., a wholly owned subsidiary of Mitsui & Co. USA Inc., 10%.

Woodward Iodine Corp., a subsidiary of Asahi Glass Co. of Japan, produced iodine from brines using the "blowing-out" process. Iodine purity was greater than 99.8%. Plant capacity was reported at 2 million pounds per year.

CONSUMPTION AND USES

An accurate iodine end-use pattern was not available because intermediate compounds were marketed before reaching their ultimate end uses. The downstream uses of iodine continued to be animal feed supplements, catalysts, pharmaceuticals, sanitary and industrial disinfectants, stabilizers, inks and colorants, photographic equipment, and other uses. Other uses included production of high-purity metals, motor fuels, iodized salt, smog inhibitors, and lubricants. Iodine also had application in cloud seeding and radiopaque diagnosis in medicine.

Deepwater Chemical Co. Inc., sole producer of calcium iodide in the United States, reported a stable market of less than 111,000 pounds.[6]

The U.S. International Trade Commission (ITC) publication, "Synthetic Organic Chemicals, 1984," reported that the Sterling Organic Div. of Sterling Drug Inc. and Mallinckrodt Inc. were the only domestic producers of roentgenographic contrast media used in X-rays. Substances listed as being produced were meglumine diatrizoate, sodium diatrizoate, iopanoic acid, meglumine iothalamate, meglumine, sodium tyropanoate, and an "other" category. These substances contained between 47% and 67% iodine by weight. Sterling discontinued the production of radiopaque compounds in June 1984 and began importing compounds for domestic sales that occurred throughout 1985.

Radioactive iodine-125 was shipped by New England Nuclear Products, an E. I. du Pont de Nemours & Co. Inc. subsidiary, to Daiichi Pure Chemicals Co. Ltd., its exclusive distributor in Tokyo, Japan. Isotopes were used in university and hospital research.

Modern day rainmakers used silver iodide and sometimes dry ice as a nucleating agent to "seed clouds" by attracting cloud droplets to produce rain. About 25,000 pounds of silver iodide was used throughout the world for cloud seeding, including about 1,000 pounds in the United States. The amount used varied but averaged between

10 and 50 grams per cloud seeding. Deepwater Chemical was the sole supplier.

The ITC reported in "Synthetic Organic Chemicals, 1984," that 357,000 pounds of Red No. 3 was sold at a value of $5.2 million. The four companies reporting production were H. Kohnstamm & Co. Inc., Sterling Drug, McCormick & Co. Inc., and Warner-Jenkinson Co.

Several major companies that consume iodine were for sale during 1985. Mallinckrodt, a specialized chemicals and medical products company, was the largest domestic consumer of crude iodine and had been acquired by Avon Products Inc. in 1982 for $715 million. Uniroyal Chemical Co., a subsidiary of Uniroyal Inc., was also for sale. The subsidiary manufactured agricultural and industrial chemicals, specialized rubber and plastic products, and other specialty chemicals. Such catalysts as titanium tetraiodide and diethylaluminum iodide were used to produce stereospecific polybutadiene and polyisoprene, major synthetic rubbers.

Table 1.—U.S. consumption of crude iodine, by product

Product	1984 Number of plants	1984 Consumption (thousand pounds)	1985 Number of plants	1985 Consumption (thousand pounds)
Reported consumption:				
Resublimed iodine	4	161	6	191
Potassium iodide	8	1,281	8	1,077
Sodium iodide	6	122	5	145
Other inorganic compounds	15	1,286	28	1,248
Ethylenediamine dihydroiodide	r6	1,137	5	1,199
Other organic compounds	22	1,540	16	1,312
Total	[1]29	5,527	[1]27	5,172
Apparent consumption	XX	W	XX	W

rRevised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Nonadditive total because some plants produce more than one product.

PRICES

In April, the major suppliers of crude iodine increased prices about 14 cents per pound to $5.72 per pound for truckload quantities; smaller quantities were reported at $6.35 per pound. Silver iodide for cloud seeding was about $2.00 per gram. The quoted yearend U.S. prices for iodine and its primary compounds were as follows:

	Per pound[1]
Calcium iodate, FCC drums, f.o.b. works	$5.50
Calcium iodide, 50-kilogram drums, f.o.b. works	9.07
Iodine, crude, drums	$5.60- 5.72
Iodoform, N.F., 300-pound drums, f.o.b. works	24.00
Potassium iodide, U.S.P., granular, crystals, drums, 1,000-pound lots, delivered	10.72- 12.39
Resublimed iodine, U.S.P., granular, 100-pound drums, works	14.21- 14.59
Sodium iodide, U.S.P., crystals, 300- to 500-pound lots, drums, freight equalized	14.72

[1]Conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiations and/or somewhat different price quotations.

Source: Chemical Marketing Reporter. V. 228, No. 25, Dec. 16, 1985, pp. 40-48.

FOREIGN TRADE

The U.S. Department of the Treasury began charging a duty of 6.7 cents per pound on iodine of 99.9% or greater purity in September 1984. Treasury decided to take Japanese-produced iodine imported under item 415.25, Tariff Schedule of the United States (TSUS), and classify it under the provisions for resublimed iodine in item 415.27, TSUS. This decision was based on the various filtering, separating, and heating procedures that used sulfuric acid, hydrochloric acid, and chlorine. Although the product was not resublimed, Treasury considered it to be something other than crude because of further processing. Under the similitude provision, item 798.00, TSUS, it was classified "a nonenumerated product most resembling as to use the product resublimed iodine at the same rate of duty as that applicable to as resublimed iodine."[7]

At yearend 1985, the collection of the duty caused delays in the delivery of iodine while the U.S. Customs Service sent samples to laboratories for analysis. The duty rate during 1985 on crude and resublimed iodine was $0.00 and $0.065 per pound, respectively.

Table 2.—U.S. imports for consumption of crude iodine, by type and country

(Thousand pounds and thousand dollars)

Type and country	1984 Quantity	1984 Value[1]	1985 Quantity	1985 Value[1]
Iodine, crude:				
Belgium	--	--	21	174
Canada	--	--	1	3
Chile	1,176	r5,304	1,651	8,105
Japan	3,711	r19,404	3,299	18,479
Mexico	179	93	--	--
United Kingdom	(2)	r2	--	--
Total[3]	5,067	r24,803	4,971	26,761
Iodine, potassium:				
Belgium	(2)	3	3	17
Canada	(2)	r1	1	3
Germany, Federal Republic of	3	r26	6	30
India	24	r124	12	64
Italy	7	7	2	3
Japan	25	r138	41	226
United Kingdom	4	r45	2	54
Total[3]	63	r344	67	396
Iodine, resublimed:				
Canada	r(2)	r1	--	--
Germany, Federal Republic of	--	--	(2)	4
Japan	(4)	(4)	408	2,158
Mexico	--	--	1	13
Sweden	r1	r9	2	17
Total[3]	1	r10	410	2,193
Grand total[3]	5,131	r25,158	5,448	29,350

rRevised.
[1]Declared c.i.f. valuation (1984 value previously published as custom value).
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.
[4]Revised to zero.

Source: Bureau of the Census.

WORLD REVIEW

Chile.—María Elena and Pedro de Valdivia, the only remaining nitrate mines in the world, were owned by the Sociedad Química y Minera de Chile (SOQUIMICH). Final products included sodium nitrate, potassium nitrate, sodium sulfate, and iodine. From each 2,000 pounds of caliche ore mined, 75 pounds of potassium nitrate, 13 pounds of sodium sulfate, and 0.2 pound of iodine were produced.[8] María Elena employed about 1,800 workers, and Pedro de Valdivia employed about 2,000 workers.

SOQUIMICH announced the completion of a new iodine plant at yearend 1985 with a capacity between 440,000 and 550,000 pounds per year. Potential iodine reserves were estimated at 300 million pounds of economically recoverable iodine in ore surrounding the existing mining operations, and another 440 million pounds in overburden and waste dumps close to the plants.[9] In addition to the new plant, SOQUIMICH had developed a new mineral fertilizer byproduct, "astrakanite," or bloedite, a magnesium-sodium hydrous sulfate, utilizing residues that were disposed of in the playa for 30 years from the Coya Sur evaporation ponds that concentrate the iodide liquor leached from the nitrates.

Japan.—Japan led the world in production of iodine in 1985. Japan produced wet, propane-butane-rich, and dry, methane-rich natural gas, but all of the iodine produced in Japan occurred in the brines in the dry type of gasfields. Production was from various strata buried with natural gas between 1.7 and 24 million years ago. The natural gas reservoirs were found within the sedimentary basin of the marine Kazusa Group of Late Pliocene to Middle Pleistocene in sediments deposited in water about 600 feet or more in depth. The group is distributed over an area of about 12,000 square kilometers. The major iodine-producing area was the southern Kanto Gasfields, which extend into Chiba, Tokyo, and Kanagawa Prefectures. Iodine was produced in the Niigata and Nakajo Gasfields in Niigata Prefecture, on the Sea of Japan side of central Japan, and the Sadowara Gasfield in Miyazaki Prefecture, southern Kyushu. The occurrence of iodine was confirmed in gasfields in southern Okinawa, the Oshamambe, Hokkaido, and the Ishikawi, Honshu.[10]

U.S.S.R.—At the Neftechala iodine-bromine plant in Azerbaidzhan, construction of the first stage of renovation was reported completed. At the Nebit-Dag iodine-bromine plant in Turkmens S.S.R. (Turkmenistan), an experimental facility was planned to study extraction of coproduct boron, calcium, magnesium, and sodium compounds from the brines during 1986-90. It was reported that the brines contain 250 grams per liter combined of these various elements.[11]

Table 3.—Crude iodine: World production, by country[1]

(Thousand pounds)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Chile	5,926	5,723	6,158	5,866	5,700
China[e]	1,000	1,000	1,000	1,000	1,000
Indonesia	[r]55	64	55	55	55
Japan	15,128	15,829	16,034	16,098	[3]15,986
U.S.S.R.[e]	4,400	4,400	4,400	4,400	4,400
United States	W	W	W	W	W
Total[4]	[r]26,509	27,016	27,647	27,419	27,141

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through June 17, 1986.
[2]In addition to the countries listed, New Zealand also produces elemental iodine, but production data are not available, and available information is inadequate for formulation of reliable estimates of output levels.
[3]Reported figure.
[4]Excludes U.S. production.

TECHNOLOGY

The National Oceanic and Atmospheric Administration reported in 1984 that there were 32 domestic cloud-seeding projects covering 66,120 square miles. Cloud seeding was accomplished in two ways. In the first method, silver iodide, dissolved by ammonium iodide, was sprayed into a cloud through a propane flame, usually from the wing of an airplane flying through or just below a cloud. In the second method, an aluminum canister containing a pyrotechnic mixture of silver iodide, silver iodate oxidizer, aluminum, and magnesium was used. The canister, attached to an airplane wing, was ignited electrically, thus releasing the iodide particles. The canister could also be dropped through the cloud.[12]

Recent experiments demonstrated the silver ions diffuse rapidly when a potential was applied across a silver mercury iodide solid electrolyte. At temperatures less than 50° C, silver mercury iodide existed in an ordered structure. At temperatures equal to and above 50° C, the cations demonstrated a disordered structure. Although details differ from one compound to another, most crystalline inorganic electrolytes followed a similar temperature pattern described from silver mercury iodide. Each had a low-conductivity phase in which ions were ordered in a subset of lattice sites. Over some higher temperatures, the ions became disordered among the sites and conductivity was high. This predictable behavior has guided solid-state chemists searching for new high-conductivity solid electrolytes. High-conductivity solid electrolytes have revolutionized conventional concepts of ionic compounds and have potential in high-energy-density battery and fuel cells and lasers.[13]

An organic material, named ET-iododibromide, that becomes superconducting at 2.8 kelvin (K) and ambient pressure has been produced. The transition temperature is twice as high as the level achieved by earlier organic superconductors at ambient pressure. Evidence indicates that this compound can become superconducting at 4 K under different pressure conditions.[14]

The 28th biennial Kirkpatrick Chemical Engineering Achievement Award was bestowed on Tennessee Eastman Co. for pioneering a coal-based acetic anhydride process that offers lower costs using a rhodium, methyl iodide, and lithium catalyst. The firm was the first to manufacture an industrial chemical that used a second-generation coal-gasification process to produce acetic anhydride, a key raw material.[15]

Studies of two strains of chickens genetically susceptible to autoimmune thyroiditis indicate a direct link between the rising incidence of autoimmune thyroiditis in chickens and their consumption of large amounts of iodine. The research can be applied to similar incidents of autoimmune thyroiditis in Americans and their consumption of large amounts of iodine. When iodine concentrates in the thyroid, it is incorporated into thyroglobulin molecules, altering the shape of the molecules and probably increasing their immunogenicity. This may account for the initiation of autoimmune disease.[16]

Iodophors, carriers of iodine, are the least expensive way to sterilize water. Starch and iodine solutions are capable of annihilating bacterial flora, yeasts, and molds. Polyvinyl alcohol and iodine are also other common antiseptic bases. In addition, the same type of starch and iodine solution can be used to preserve fruit for several months.[17]

Energy-efficient lamps containing iodine in metal halide compounds were developed specifically for the Statue of Liberty by General Electric Co.'s Lighting Business Group. The lamps are activated by passing current through a quartz tube and exciting the metal halides to higher energy levels. The colors depend on the chemical makeup of the iodine compounds. The expected consumption of 17.9 kilowatt hours per year will result in a savings of over 50% of the cost of the electricity.[18]

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[1]Physical scientist, Division of Industrial Minerals.
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Iron Ore

By Peter H. Kuck[1]

U.S. production of iron ore declined slightly in 1985, as the recovery of the basic industries sector from the 1982-83 recession began to slow. Demand for pellets from the iron and steel industry leveled off in midyear compared with 1984 levels, but firmed in the fourth quarter. The domestic ore industry suffered from excess production capacity and was forced to schedule a number of shutdowns ranging from 4 to 15 weeks as well as production cutbacks. One mine was closed and the future of several others was uncertain. Both the ore and steel industries underwent more restructuring as part of the continuing struggle since 1982 to reduce production costs and improve efficiency. Production of usable ore in 1985 was about 56% of productive capacity. Yearend stocks of iron ore at U.S. docks and furnace yards were at their lowest levels in more than 30 years.

In the rest of the world, iron ore production and trade were slightly higher in 1985 as consumption stabilized in both the European Communities (EC) and Japan. New markets for ore from market economy countries continued to grow in China, the Republic of Korea, Taiwan, Eastern Europe, and the Middle East. Nevertheless, worldwide overcapacity remained a serious problem for most producers and was expected to worsen when the 34-million-ton-per-year[2] Carajás project in Brazil, the 7.4-million-ton-per-year Kudremukh project in India, and the 4.9-million-ton-per-year San Isidro Mine in Venezuela are brought into full production. International iron ore prices firmed, while ocean freight rates for spot charterings, in constant dollars, declined to their lowest levels in 7 years.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Iron ore (usable,[1] less than 5% manganese):					
Production	73,174	35,433	37,562	51,269	48,751
Shipments	72,181	35,756	44,596	50,883	49,411
Value	$2,915,239	$1,491,809	$1,944,988	$2,247,686	$2,076,730
Average value at mines dollars per ton	$40.39	$41.72	$43.61	$44.17	$42.03
Exports	5,546	3,178	3,781	4,993	5,033
Value	$244,685	$150,522	$182,744	$239,257	$240,557
Imports for consumption	28,328	14,501	13,246	17,187	15,771
Value	$947,977	$470,847	$445,731	$529,065	$452,240
Consumption (iron ore and agglomerates)	104,385	63,916	70,629	72,514	70,575
Stocks, Dec. 31:					
At mines[2]	12,734	12,129	[3]4,122	[3]5,265	[3]5,951
At consuming plants	36,203	29,923	25,494	24,017	21,290
At U.S. docks	6,571	5,750	3,174	2,942	2,404
Manganiferous iron ore (5% to 35% manganese):					
Shipments	156	28	30	79	18
World: Production	r844,606	r768,011	726,399	p817,428	e845,251

eEstimated. pPreliminary. rRevised.

[1]Direct-shipping ore, concentrates, agglomerates, and byproduct ore.

[2]Excludes byproduct ore.

[3]These stocks are not comparable to those of previous years owing to the reclassification of some stocks from the usable to the byproduct category.

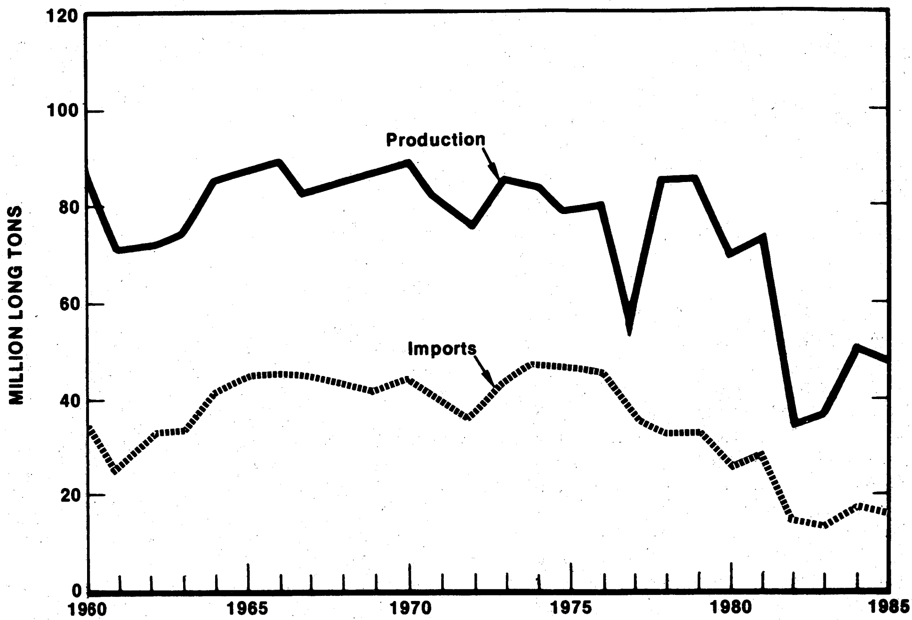

Figure 1.—U.S. iron ore production and imports for consumption.

Domestic Data Coverage.—U.S. production data for iron ore are developed by the Bureau of Mines from three separate voluntary surveys of domestic operations. The annual "Iron Ore" survey (1066-A) provides the basic data used in this report. Of 55 addressees to whom the 1066-A form was sent, 52 responded, representing 78.3% of total production shown in tables 1 through 4. Production for nonrespondents to the annual survey was estimated from monthly surveys (1066-M), using data from railroad reports and reported production levels in prior years, supplemented by employment data, mine inspection reports, and information from consumers. Consumption data were mostly provided by the annual "Blast Furnace and Steel Furnace" survey (1067-A). Data coverage for this survey is reported in the "Iron and Steel" chapter.

EMPLOYMENT

Statistics on employment and productivity in the U.S. iron ore industry in 1985, shown in table 2, were derived from quarterly employment data supplied by the Mine Safety and Health Administration (MSHA) of the U.S. Department of Labor, and from production data derived from Bureau of Mines surveys. Both sets of data were obtained from producers' reports.

The statistics include production workers employed at mines, concentrators, and pelletizing plants, and in repair and maintenance shops, but do not include 1,014 persons engaged in management, research, or office work at mines and plants. Employees engaged in ore preparation, such as sintering, at blast furnace sites are not included. Because employment data reported to MSHA are primarily for safety analysis, hours spent by salaried employees in mines or plants may be included by operators in the total number of hours worked at individual mines or plants. This has resulted in understatement of calculated productivity by 10% to 25% for some operations, but its effect on others is not known. If company reporting practice is consistent, however, comparison of productivity from 1 year to the next should be reasonably valid.

Average quarterly employment decreased slightly compared with that of 1984, with total hours worked and output of usable ore decreasing by 16% and 5%, respectively. In the Lake Superior district, which accounts for the bulk of U.S. output, average productivity for usable ore was only 14% higher than that of 1984 but 59% higher than that of 1981. The significant gain since 1981 is the result of drastic reductions in employment made by the principal producers in 1982, which have allowed the potential productivity of highly mechanized operations to be increasingly realized. The concentration of production in large-scale taconite operations of the Lake Superior district was an important contributing factor.

DOMESTIC PRODUCTION

A leveling off of demand from the iron and steel industry in midyear was largely responsible for the 5% decline in iron ore production from the 1984 level of 51.3 million tons. A small increase in demand from Canada helped moderate the decline. Output of usable ore in the first half of the year was 8% lower than that in the comparable period of 1984, shipments were down 6%, and production of pig iron decreased 10%. In August, demand began to recover and, during the last 5 months of the year, monthly production of pig iron was above 1984 levels. Several mines and pelletizing plants were closed for periods of 4 to 15 weeks during the second half of the year. By December 1, four of the eight taconite operations in Minnesota had been shut down for an indefinite period, and one had been permanently closed. The patterns of production, shipments, and plant closings were similar to those experienced in 1984 and reflected a continuing weakness in demand for domestic iron and steel. Total output of usable ore was equivalent to about 56% of installed production capacity on January 1.

Iron ore was produced by 19 open pit mines and 1 underground mine. Fifteen mines produced ore for the iron and steel industry but only 2 mines were operated throughout the year and only 1 of the 2 produced at its rated capacity. One taconite mine and associated pelletizing plant remained idle, while one large, permanently closed "natural ore" mine shipped pellets and concentrates from stocks. Installed production capacity for usable ore at yearend was estimated at 86 million tons per year, including 82 million tons of capacity for pellets. Effective production capacity for pellets was at least 15 million tons less than installed capacity.

An average of 3.1 tons of crude ore was mined in 1985 for each ton of usable ore produced. This ratio does not take into account the tonnage of waste rock or overburden removed. The ratio of total materials mined to usable ore produced was probably greater than 5 to 1. Low-grade ores of the taconite type mined in Minnesota and Michigan accounted for 97.9% of total crude ore production. U.S. production of pellets totaled 47 million tons in 1985, 96% of usable ore output. Average iron content of usable ore produced was approximately 64.2%, while that of usable ore shipped was 63.8%.

Inland Steel Co. combined the activities of its former Raw Materials Department (iron ore, coal, limestone, and fleet operations) with those of its coke, ironmaking, and materials control operations to form a new Materials and Energy Group. The company continued to restructure its iron ore operations in order to reduce costs and match the downsizing of its steelmaking operations. Inland Steel retained its wholly owned Minorca Mine and pelletizing facilities at Virginia, MN, along with its shares in the Empire Mine at Palmer, MI, and the Wabush Mines operations in Labrador and at Pointe Noire, Quebec. However, the Butler Taconite project, in which Inland Steel has 38% ownership, was permanently closed on June 29.

The closure of the Butler Taconite project at Nashwauk, MN, was the first permanent shutdown among the eight taconite operations on the Mesabi Range. Butler Taconite had an annual production capacity of 2.7 million tons of pellets. The decision to close was precipitated by the bankruptcy filing in April of Wheeling-Pittsburgh Steel Corp., which owned 24.5% of the venture. The remaining 37.5% share was held by The M. A. Hanna Co. (formerly Hanna Mining Co.), which managed the project. With the closure of Butler Taconite, Hanna no longer has ownership in any operating U.S. iron mine. As recently as 1980, Hanna was among the leading iron ore producers and merchants in the United States. However, the company continues to manage the National Steel Pellet Co. project at Keewatin, MN. Hanna is also manager and a major shareholder of the Iron Ore Co. of Canada, the largest iron ore producer in Canada, as well as a major shareholder in Minerações Brasileiras Reunidas S.A.

(MBR), the second largest iron ore producer in Brazil.

Minnesota produced 72% of the national output of usable ore in 1985. Production of pellets totaled 33.4 million tons, equivalent to about 53% of installed production capacity of the State's eight taconite plants. The remainder of the output consisted of hematite concentrates produced from "natural" ores by LTV Steel Co. and Rhude & Fryberger Inc. Pittsburgh Pacific Co. shipped 29,000 tons of concentrates recovered from stockpiled ores. All of the taconite plants were operated in 1985 but most were idle for part of the year.

National Steel Pellet was operated throughout the year, except for a 21 day period in April and produced 4.4 million tons of pellets, a level slightly lower than that of 1984. However, in mid-December, the company announced that it would close for a total of 3 months in 1986 because of a planned cutback to 4.0 million tons.

Butler Taconite was operated from March 4 until June 29, when it was permanently closed. During the 4-month period, the operation produced about 960,000 tons of pellets. Approximately 450 employees were affected by the closure.

Reserve Mining Co., a joint venture of Armco Inc. and LTV Steel, recalled an additional 145 employees on January 6 and restarted the second of eight pelletizing lines at its Silver Bay plant. Ore was provided by the Peter Mitchell Mine at Babbitt. The company had been operating only one of its lines since September 1984 when production was cut and 200 employees were laid off. Both lines remained in operation until June 30, when Reserve shut down both Silver Bay and Babbitt for 4 weeks and temporarily laid off 1,000 employees. The company produced only 3.2 million tons during the year, slightly less than 33% of capacity.

Erie Mining Co. resumed production of pellets at Hoyt Lakes on March 3, after a 3-month shutdown, and produced 5.0 million tons before being shut down again on November 30.

Hibbing Taconite Co. was operated from March 17 to October 26 and produced 5.1 million tons of pellets, about 18% less than in 1984.

The Minntac facility of United States Steel Corp. was operated from January 13 to June 30 and from July 28 to December 1, producing about 9.9 million tons of pellets or 53% of installed capacity. The pelletizing plant operated only three of its seven production lines, as in 1984. The work force varied from 1,450 to 1,700 and was somewhat smaller than before owing to streamlined operations.

Oglebay Norton Co. suspended production at Eveleth Mines on June 30 for 15 weeks because of reduced demand for pellets. Only 735 of the 750 laidoff workers were recalled when operations were resumed on October 13. Because of the summer shutdown, Eveleth produced only 3.0 million tons, 50% of capacity. A 380,000-ton production run was made at Eveleth Mines' Fairlane plant using the organic compound "Peridur" as a substitute pellet binder. These lower silica pellets were used by two of the operation's partners in closely monitored blast furnace trials with encouraging results.

The Minorca Mine of Inland Steel Mining Co. was operated from February 24 to June 29 and from August 4 to November 16, producing 1.9 million tons of pellets. Approximately 405 workers were laid off when the mine and pelletizing facilities were temporarily shut down in November. The shutdown was triggered by cutbacks in steel production at Inland Steel's Indiana Harbor Works, which uses Minorca pellets exclusively. Only five of the nine blast furnaces at Indiana Harbor were running at the end of December.

More than 4,500 employees were out of work in Minnesota at yearend as a result of the permanent closure of Butler Taconite and the temporary shutdowns in the fourth quarter of four other taconite plants.

Michigan produced 26% of the national output of usable ore in 1985. Production consisted entirely of pellets produced from ores mined at the Empire and Tilden Mines in Marquette County. Both mining ventures are managed and partially owned by the Cleveland-Cliffs Iron Co. (CCI). The company's wholly owned Republic Mine remained idle throughout the year. Production of pellets totaled 12.5 million tons, of which 6.9 million tons was produced at the Empire plant and 5.6 million tons was produced at Tilden. The Empire facility was operated all year except for a 7-week period between September 1 and October 20 and produced at 86% capacity. The average operating rate at Tilden was only 70%. CCI was forced to suspend all operations at the Tilden Mine and temporarily lay off 850 employees after a fire extensively damaged the mine's main conveyor system on June 12. On July 7, 300 workers were called back and assigned to stripping operations and maintenance. Full operations were resumed on July 29.

In Missouri, Pea Ridge Iron Ore Co. produced about 1.1 million tons of iron ore products, including 1.03 million tons of self-fluxing olivine pellets, from magnetite ore produced at its underground mine near Sullivan. The mine and plant, wholly owned by St. Joe Minerals Corp., were operated throughout 1985.

In Wyoming, Universal Equipment Co. purchased the Atlantic City iron mine from U.S. Steel. The sale included iron ore processing facilities, mining equipment, water rights, and a 76-mile railroad line from the mine to Winton Junction near Rock Springs. Universal Equipment will mine the site for road construction materials. U.S. Steel halted mining operations at Atlantic City in October 1983 and officially closed the mine on April 1, 1984.

CONSUMPTION AND USES

Consumption of iron ore was about 3% less than that of 1984, owing to decreased demand from the iron and steel industry. Consumption for ironmaking and steelmaking totaled about 63.7 million tons, including 54.7 million tons in blast furnaces, 8.3 million tons in sintering plants, 0.2 million tons each in steelmaking furnaces and for production of direct-reduced iron (DRI), and 0.3 million tons for miscellaneous and unspecified purposes. Consumption of iron ore for manufacture of cement, heavy-medium materials, pigments, and miscellaneous products was approximately 1.2 million tons.

In the iron and steel industry, monthly consumption of ore averaged 5.3 million tons, compared with 5.5 million tons in 1984. The decrease in consumption occurred mainly in the first half of the year. Between January 31 and June 30, the number of operating blast furnaces actually increased from 49 to 53 to meet the traditional seasonal increase in demand for pig iron. Monthly consumption during the 6 months averaged 5.5 million tons and reached a peak of 6.0 million tons in May. In June, however, demand for ore began to slide. By September, monthly consumption had fallen to 4.9 million tons and remained low for the rest of the year. Consumption of ore for the second half averaged 5.1 million tons, with only 43 blast furnaces operating at the end of October. During the last 2 months of 1985, 4 additional blast furnaces were brought on-line, bringing the total at yearend up to 47.

Consumption of iron ore and agglomerates reported by integrated producers of iron and steel totaled 69.4 million tons, including 50.8 million tons of pellets, 16.5 million tons of sinter, and 2.1 million tons of natural coarse ore. Of the primary ore consumed, an estimated 72% was of domestic origin, 14% came from Canada, and 14% came from other countries.

Estimated consumption of other materials in sintering plants included 3.0 million tons of mill scale, 1.4 million tons of flue dust, 3.6 million tons of limestone and dolomite, 1.3 million tons of slag and slag scrap, and 0.8 million tons of coke breeze. Other iron-bearing materials charged directly to blast furnaces included about 74,000 tons of manganiferous iron ore, 1.2 million tons of steel-furnace slag, 0.3 million tons of mill scale, and 1.0 million tons of slag scrap.

STOCKS

Stocks of iron ore and agglomerates reported at U.S. mines, docks, and consuming plants at yearend continued to decline in 1985 and were at their lowest level in more than 30 years. The decline of 8% in total stocks from that of 1984 was due primarily to a reduction of stocks of imported ore at U.S. docks and furnace yards. Stocks reported at these facilities at yearend included 18.5 million tons of domestic ores, 3.0 million tons of Canadian ores, and 2.2 million tons of other foreign ores. Mine stocks at yearend were about 13% higher than those of 1984, as the quantity of ore shipped from most Minnesota mines was less than production.

End-of-month stocks reported at mines peaked at 13.4 million tons in April and declined to 6.0 million tons at yearend, while stocks of ore reported at consuming plants ranged from a low of 13.8 million tons in March to a high of 21.3 million tons in December. As in previous years, these variations were principally caused by the seasonal nature of ore shipping on the Great Lakes.

Stocks of unagglomerated concentrates reported at pelletizing plants totaled 331,000 tons at yearend. This material is not included in mine stocks of usable ore reported in the accompanying tables because it is considered an intermediate product. Also, mine stock data after 1983 do not include byproduct ore, owing to the change in classification reported in this publication in 1983; data for previous years remain unchanged to avoid disclosing company proprietary information.

TRANSPORTATION

Vessel shipments of iron ore from U.S. ports on the upper Great Lakes totaled 44.2 million tons, about 4% less than those of 1984. Nearly 90% was destined for U.S. consumers and the rest was destined for Canada. Shipments of iron ore through the St. Lawrence Seaway to U.S. ports on the Great Lakes totaled approximately 4.8 million tons and accounted for about 30% of U.S. imports. The balance of imports, about 11.0 million tons, was shipped through ports on the east and gulf coasts.

Ore shipments from four of the seven U.S. ports on the upper Great Lakes declined from the levels of 1984, with the largest decrease at Superior, WI. Shipments from Two Harbors, Taconite Harbor, and Marquette increased. Tonnage shipped from each port in 1985 was as follows:

Port	Date of first shipment	Date of last shipment	Total tonnage (thousand long tons)
Duluth, MN	Apr. 2	Dec. 15	6,133
Two Harbors, MN	Apr. 3	Dec. 21	8,719
Silver Bay, MN	Apr. 7	Dec. 14	3,426
Taconite Harbor, MN	Apr. 5	Dec. 21	4,972
Superior, WI	Apr. 5	Dec. 22	8,506
Marquette, MI	Apr. 3	Jan. 4	5,071
Escanaba, MI	Mar. 28	Dec. 26	7,385
Total			44,212

Source: Lake Carriers Association, 1985 Annual Report.

The number of vessel shipments from all seven ports totaled 1,283, indicating an average cargo of 34,460 tons. Individual cargoes of 60,000 tons or more were loaded at six of the ports during the year, although the average shipment from individual ports ranged from 24,264 tons at Marquette to 60,107 tons at Silver Bay. Relatively high water levels in Lakes Michigan and Superior permitted record loadings of iron ore at Escanaba and Silver Bay. The largest cargo shipped during the year was 69,701 tons, an all-time high for the Great Lakes, loaded on Bethlehem Steel Corp.'s 1,000-foot carrier *Lewis Wilson Foy* at Escanaba for delivery to Indiana Harbor. A record high cargo of 64,188 tons was loaded on Oglebay Norton's *Columbia Star* at Silver Bay for transit through the Soo Locks to Toledo, OH. Previous records were about 68,000 tons at Escanaba and 63,000 tons at Silver Bay, both set in 1983.

Lake freight rates for iron ore, in effect since April 1984, were as follows, per ton: from the Head of the Lakes to lower lake ports, $7.41; from Marquette to lower lake ports, $6.11; from Escanaba to Lake Erie ports, $5.64; and from Escanaba to lower Lake Michigan ports, $4.45.

Published bulk vessel freight rates from the Gulf of St. Lawrence to Lake Erie and Lake Michigan were $5.00 and $7.00 per ton, respectively. Freight rates for self-unloading vessels were $1.50 per ton higher. These rates may include toll charges on the St. Lawrence Seaway, which amount to about $1.24 per ton.

The collapse of a 150-foot section of the west wall of Lock 7 in the Welland Canal blocked shipping on the St. Lawrence Seaway between Lakes Erie and Ontario from October 14 to November 7. By the time repairs were made and the lock was reopened, 118 vessels were waiting for transit, including 12 carrying iron ore from eastern Canada to U.S. lake ports. Although the closure did not cause significant shortages of iron ore at U.S. blast furnaces, and all waiting vessels were locked through by November 12, the delay called attention to the vulnerability of Seaway shipping to damage or obstruction of each of the many locks, bridges, or narrow channels that control navigation along the 1,340-mile route between Duluth and Montreal.

The principal issues concerning U.S. lake shipping in 1985 were proposed construction of a second Poe-class lock at Sault Ste. Marie, and proposed taxes (user charges) on shippers to recover the costs of operation and maintenance of shipping facilities and most of the costs of new construction, which historically have been paid by the Federal Government.

As a result of the construction of 13 self-unloaders with a length of at least 1,000 feet in the last 14 years, and the retirement of smaller vessels, about one-third of the vessels in the U.S. Great Lakes fleet (comprising more than one-half of the fleet's carrying capacity) must use the Poe Lock to transit the St. Mary's River Canal. A malfunction of this lock could seriously disrupt lake shipping and increase costs. The cost of converting the aging and narrow Sabin and Davis Locks into a new Poe-sized lock was estimated to be $227 million. The U.S. Army Corps of Engineers, which has studied the problem for many years, issued a feasibility report on March 29 recommending construction of a second lock that could accommodate all vessel sizes in the fleet.

Although the Lake Carriers' Association advocated construction of the new lock at Sault Ste. Marie, it was opposed to the imposition of user charges. The Office of Management and Budget has proposed that the Congress levy both Port User Charges and U.S. Coast Guard User Charges. The port tax would be used to defray the costs of channel dredging and other harbor maintenance, while the Coast Guard tax would help pay for icebreaking, navigational aids, and vessel documentation. The proposed port tax alone could cost lake shippers more than $4 million annually; charges for new construction would greatly increase this figure. According to the Association, taxes of this magnitude would be an unfair burden on the lake shipping industry. Although the Association remains adamantly opposed to the proposed Coast Guard tax, it has reluctantly agreed to work with the Congress and the Administration to develop an equitable port charge in the form of an ad valorem tax on cargo that would be assessed only once and paid by the shipper. Proponents of the user charges feel that costs of shipping facilities should be largely borne by the shippers instead of by the Federal Government.

Published railway freight rates for pellets from mines to upper lake shipping ports increased in Minnesota in 1985 but were essentially unchanged in Michigan, compared with rates in late 1984. On April 1, the rate for pellets from the western Mesabi Range to the Allouez docks at Superior, WI, was raised from $4.87 to $4.96 per ton. On June 3, the rate was increased an additional $0.03 to $4.99. For pellets from the Marquette Range of Michigan, the rates to Presque Isle and Escanaba were $2.40 and $2.68 per ton, respectively. Dock charges at Duluth, Superior, and Escanaba ranged from 64 to 92 cents per ton. At Lake Erie ports, ore transfer charges from rail-of-vessel or dock receiving area direct into railway cars ranged from about $0.96 to $1.15 per ton, up slightly from those of 1984. Most rail rates from lower lake ports to consuming districts were also unchanged; the volume rate from Lake Erie ports to the Pittsburgh and Wheeling districts was $10.16 per ton. Single-car rates for ore imported through east coast ports to inland consuming points were mostly unchanged. The rate to Pittsburgh from Baltimore and Philadelphia remained at $14.93 per ton. All-rail rates from mines to consuming points rose in several instances. However, the volume rates to Granite City, IL, from the Mesabi Range and from Pea Ridge, MO, were unchanged at $18.82 and $6.41 per ton, respectively. The published volume rate to Geneva, UT, from the Mesabi Range was $41.03 per ton. All-rail shipments of pellets from Minnesota by the Duluth, Missabe and Iron Range Railway and connecting lines totaled 1.5 million tons; the greater part of this tonnage was shipped to Geneva, UT, from the Minntac plant.

Published nominal ocean freight rates for iron ore from eastern Canada to U.S. east coast ports were $3.50 to $3.75 per ton, but spot rates quoted for cargoes of 50,000 to 60,000 tons ranged from $1.85 to $3.80 per ton. A few shipments reported from Brazil to east coast ports indicated freight rates of $4.50 to $5.50 per ton.

PRICES

Producers' published prices for Lake Superior iron ores in the first 7 months of 1985 were unchanged from those quoted in August 1983. The pellet prices thus ranged from 80.5 cents to 86.9 cents per long ton unit (ltu) of iron, natural, delivered rail-of-vessel at lower lake ports, with the lower price quoted by Pickands Mather & Co. and the higher price quoted by CCI, Hanna, Oglebay Norton, and U.S. Steel. The range in unit price was equivalent to approximately $50.71 to $54.75 per long ton of pellets containing 63% iron.

Late in 1984, Mineral Services Inc. (MSI) of Cleveland, OH, began offering pellets at a published price of 66 cents per ltu, on the same basis as the producers' prices. Although the source of pellets was not identified, the company said that at least 2 million tons per year would be available. This was the first time that a nonproducer had publicly quoted a price for Lake Superior pellets since commercial pellet production began in the district in 1955. The MSI price was equivalent to about $41.58 per ton of pellets containing 63% iron.

On August 1, 1985, Pickands Mather effectively lowered its pellet price while changing its price base from the traditional "lower lake port" to "upper lake port," thus transferring charges for lake freight and some handling operations to the buyer. The new quotation was 59.4 cents per ltu of iron, natural, delivered to hold of vessel at upper lake port. Although not specified by the company, the net reduction in price appeared to be about 12%, taking into account published lake freight rates and unloading charges. Inland Steel Mining later adopted the new price base and began quoting an identical price.

On August 16, U.S. Steel switched its price base from natural ltu to dry ltu. The new, effectively lower, price of Minntac pellets was 72.5 cents per dry ltu of iron, delivered rail-of-vessel at lower lake ports. Three weeks later, on September 1, MSI lowered its pellet price from 66 cents to 58 cents per natural ltu of iron, delivered at lower lake ports. At yearend, there were at least three different published price bases being used by Lake Superior producers. The range of prices was approximately equivalent to $37.12 to $55.62 per ton of pellets containing 64% iron, delivered rail-of-vessel at lower lake ports. The departures from traditional pricing and individual price cuts were believed to reflect declining production costs as well as increasing competition between domestic and foreign producers in the U.S. market.

Published prices for other Lake Superior ores, per ton, basis 51.5% iron, natural, delivered rail-of-vessel at lower lake ports, remained as follows: Mesabi non-Bessemer ore, $30.03 for coarse ore and $31.53 for fines; and manganiferous ore, $32.78. CCI continued to quote a price of $28.75 for Old Range non-Bessemer ore, based on rail and lake freight rates and handling charges in effect on April 27, 1981. These prices were not very significant because most Mesabi non-Bessemer ore was produced and consumed by LTV Steel, and little or none of the other grades of ore was produced. Pellets made up more than 98% of ore shipped from the Lake Superior district.

Prices for most Canadian and other foreign ores marketed in the United States were not available. The published price of Wabush pellets, f.o.b. Pointe Noire, Quebec, remained at 63.5 cents per ltu. The average f.o.b. value of all Canadian ores imported by the United States, as determined from data compiled by the Bureau of Census, was $38.01 per long ton. Data from this source indicated average f.o.b. values of $14.05 per ton for Liberian ores and $19.42 per ton for Brazilian ores. Other sources indicated that most imported Canadian ore consisted of pellets; Liberian ores consisted of fines and washed lumpy ore; and about two-thirds of the ore imported from Brazil consisted of pellets. F.o.b. value data for Venezuelan ores were not determinable, because much of the ore was apparently valued on a c.i.f. basis.

Published f.o.b. prices for DRI were also unchanged from those quoted in 1984, and were as follows, per metric ton: at Georgetown, SC, $125 to $135; at Contrecoeur, Quebec, $115; and at Point Lisas, Trinidad, $120. The apparent f.o.b. value of some shipments of DRI imported from Venezuela ranged from about $75 to $102 per long ton.

FOREIGN TRADE

U.S. exports of iron ore were only slightly higher than those of 1984, because of a leveling off of demand from the Canadian steel industry. Virtually all exports consisted of pellets shipped via the Great Lakes to Canadian steel companies that are partners in U.S. taconite projects in Minnesota and Michigan. Consumption of iron ore at Canadian blast furnaces totaled 13.3 million tons, an amount identical to that of 1984.

U.S. imports of iron ore decreased 8% in 1985, partially reversing the 1984 gain of 30%. Tonnage decreased by 1.4 million tons compared with that of 1984. A sharp decline of ore imports into the Cleveland and Baltimore customs districts accounted for essentially all of the decrease. Imports from Canada fell 24% from the 1984 level, but still accounted for more than one-half of total U.S. imports. Imports from Liberia and Venezuela rose 26% and 36%, respectively, while those from Brazil were unchanged. Brazil, the next largest supplier after Canada, retained its 16% share of U.S. imports.

On December 20, 1984, Pickands Mather, Oglebay Norton, CCI, and the United Steelworkers of America petitioned the U.S. International Trade Commission (ITC) for countervailing duties on imports of iron ore pellets from Brazil. The petitioners said that subsidies granted by the Brazilian Government allow Brazilian pellets to be delivered to U.S. consumers for at least 30% less than pellets produced in the United States, causing injury to the U.S. iron ore industry and particularly to U.S. merchant producers. Cia. Vale do Rio Doce (CVRD), through its U.S. subsidiary, Rio Doce America Inc., responded for Brazil.

U.S. imports of iron ore from Brazil in 1984 totaled 2.5 million tons, including an estimated 1.8 million tons of pellets. The pellet imports equaled an estimated 4% of U.S. consumption, but the petitioners stated that this quantity was equivalent to about 30% of the amount available for sale by U.S. merchant producers. CVRD claimed that it did not need subsidies to compete in the U.S. market because the high grade of its ore allowed pellets to be made in Brazil for about $20 per ton less than what it cost U.S. producers. CVRD also stated that 75% of its 1984 pellet sales in the United States were under long-term contracts to U.S. Steel and Armco, and that about one-half of the remainder was sold in areas of the United States where U.S. pellets could not compete because of high transportation costs. Armco is the principal shareholder in Eveleth Mines, a Minnesota producer operated by Oglebay Norton. U.S. Steel operates the largest pelletizing facility in Minnesota.

On January 28, 1985, the ITC unanimously agreed there was a reasonable indication that imports of Brazilian pellets were materially injuring U.S. pellet producers. The case was referred to the U.S. Department of Commerce on February 4 for investigation of the alleged subsidies granted to Brazilian producers and for recommendation of a countervailing duty. On March 19, Commerce recommended that an ad valorem duty of 5.15% be imposed on Brazilian pellets. This recommendation automatically returned the case to the ITC for a final decision. However, the countervailing duty investigation was suspended on May 29, following agreement by CVRD and the Government of Brazil to eliminate all benefits determined by Commerce to constitute subsidies on exports of pellets to the United States. The suspension agreement would have eliminated imposition of any countervailing duty, as well as any further action on the matter by Commerce or the ITC.

The countervailing duty investigation was unexpectedly reopened in mid-June at the request of CVRD. On December 18, the Government of Brazil formally notified Commerce of CVRD's withdrawal from the suspension agreement. The trade case was still active at the end of 1985.

WORLD REVIEW

World production, trade, and consumption of iron ore increased slightly in 1985, compared with the levels of 1984, as output of iron and steel stabilized in most industrialized countries and in many developing countries as well after recovering from the 1982-83 recession. World trade was estimated at 360 million long tons, of which about 85% was oceanborne. Brazil was the leading exporter, followed by Australia, with each country shipping more than 87 million tons to world markets. Japan remained the principal importer, receiving 123 million tons in 1985, while countries of the EC imported about 118 million tons.

World production of pellets was estimated at 195 million tons, about 80% of installed capacity. Several pelletizing plants were reactivated because of declining fuel costs, while most others operated close to rated capacity owing to relatively improved demand from their principal markets. A new plant was completed in Bahrain, while others were under construction in India, the Republic of South Africa, and Turkey.

World output of DRI was estimated at slightly more than 10.8 million tons, about 51% of installed capacity, as low prices for ferrous scrap continued to limit production. About 51% of the total output was produced in Mexico, Venezuela, and other countries in Latin America. New direct-reduction (DR) plants were completed in Iran, Malaysia, the Republic of South Africa, and the

U.S.S.R., while others were under construction in at least seven countries.

Most negotiations of 1985 iron ore prices under Japanese and Western European contracts with foreign producers were completed by mid-August. Overall, compared with 1984 prices, prices for lump ore and fines increased 1.5% to 6%, while prices for pellets declined slightly. Japanese prices for fines from Canada, Chile, and Peru were unchanged, while prices for Indian ores were increased despite an earlier agreement to maintain them at 1984 levels. Price declines for Peruvian pellets and for South African ores destined for Japan ranged from 4% to nearly 7%, possibly because of the relatively high alkali content of the ores. The price increases for lump ore and fines, which together made up about 85% of Japanese imports, were similar to those negotiated between producers and Western European buyers earlier in the year. Negotiations in both consuming regions were protracted, as buyers were determined to hold prices down because of the strength of the U.S. dollar (in which prices are quoted), and producers held out for increased prices because of stronger demand, especially for lump ore and pellets. On an f.o.b. (shipping port) basis, most 1985 prices apparently ranged from about $15 to $17.50 per long dry ton (ldt) for fines, $16 to $20.50 per ldt for lump, and $22.50 to $25.50 per ldt for pellets. Delivered prices (at receiving port) were about $2 to $9 higher, depending on ocean freight costs. The Japanese contract prices listed below are f.o.b., in U.S. cents per dry ltu of iron unless otherwise indicated:

Country and producer	Ore type	Prices	
		FY 1984	FY 1985
Australia:			
Hamersley Iron Pty. Ltd. and Mount Newman Mining Co. Pty. Ltd.	Lump ore	30.87	31.55
Do	Fines	26.67	27.05
Cliffs Robe River Iron Associates	do	23.67	24.05
Savage River Mines Ltd	Pellets	38.30	37.10
Brazil:			
Cia. Vale do Rio Doce and Minerações Brasileiras Reunidas S.A.	Lump ore	24.27	24.65
Minerações Brasileiras Reunidas S.A	Fines	24.94	25.33
Samarco Mineração S.A	Pellet fines	20.25	20.46
Cia. Nipo-Brasileira de Pelotização (Nibrasco).	Pellets	37.31	36.25
Canada: Iron Ore Company of Canada (Carol Lake).	Fines	23.37	23.37
Chile: Cía. Minera del Pacífico S.A. (El Algarrobo).	Pellets	38.80	37.60
India:			
Minerals and Metals Trading Corp. (Bailadila).	Lump ore	30.06	30.73
Do	Fines	25.86	26.23
Liberia: LAMCO Joint Venture Operating Co	do	22.20	23.30
Peru: Empresa Minera del Hierro del Perú S.A.	Pellets	30.80	29.50
South Africa, Republic of:			
South African Iron and Steel Industrial Corp. Ltd.	Lump ore	[1]27.19	[1]25.86
Do	Fines	[1]23.89	[1]22.26

[1]Price per dry metric ton unit.

Source: TEX Report (Tokyo), v. 17, Nos. 4009 and 4013, Aug. 2, and 9, 1985.

Australia.—Shipments of iron ore by Australian producers in 1985 totaled about 94 million tons, including 87 million tons for export and 7 million tons for domestic consumption. Actual exports totaled about 84 million tons, of which 82% was destined for Japan and other Asian countries and 18% was destined for Western Europe. Exports consisted of about 58% sinter fines, 39% lump ore, and 3% pellets. Shipments by individual producers follow, in million tons: Hamersley Iron Pty. Ltd., 38.6; Mount Newman Mining Co. Pty. Ltd., 28.5; Cliffs Robe River Iron Associates, 14.9; The Broken Hill Pty. Co. Ltd. (BHP), 5.2; Goldsworthy Mining Ltd., 4.5; and Savage River Mines Ltd., 2.6.

In June, Mount Isa Mines Holdings Ltd. completed the sale of its 20% interest in Goldsworthy Mining to Renison Gold Fields Ltd., one of its partners in the venture. As a result of this sale, ownership will be shared between Renison Gold Fields (58.3%) and BHP (41.7%). Goldsworthy Mining operates the Shay Gap and Sunrise Hill iron mines in the Pilbara region of Western Australia. The company recently installed a pilot beneficiation plant at its Mount Goldsworthy Mine, where mining was suspended in December 1982, to test the feasibility of upgrading 100 million tons of marginal reserves containing 58.0% to 60.7% iron that occur at five deposits in the area.

In December, BHP Minerals Ltd. acquired the 25% and 30% interests in the Mount Newman Joint Venture held, respectively, by AMAX Iron Ore Corp. and Pilbara Iron Ltd. The two acquisitions raised BHP's equity in the venture from 30% to 85%. The joint venture mines the 1.1-billion-ton Mount Whaleback ore body and the 153-million-ton Marra Mamba No. 29 ore body in the southeastern corner of Western Australia's Hamersley Iron Province. AMAX will no longer act as sales agent outside Australia for Mount Newman and has agreed to transfer this function to BHP as well, effectively withdrawing from the world iron ore market. Earlier in the year, BHP shut down its mine on Cockatoo Island in Yampi Sound, northeast of the Pilbara coast. The mine, which shipped 31 million tons of ore during its 33-year life, will continue to ship stockpiled material over the next 2 years.

Bahrain.—The pelletizing plant of Arab Iron & Steel Co. (AISCO) shipped about 700,000 tons of pellets during its first year of operation. The Bahraini facility is the world's first merchant pelletizing plant to be based wholly on imported iron ore. The $310 million plant, commissioned in November 1984, has a production capacity of 4 million tons of pellets per year and uses a grate-kiln pelletizing system fueled by natural gas from local oilfields. It is a joint venture of Arab organizations and the public sectors of Bahrain, Kuwait, Saudi Arabia, and the United Arab Emirates, and was built to produce pellets for DR plants along the Persian Gulf and in Southeast Asia. Difficulty in finding buyers for AISCO's product has forced management to adopt a 30-day-up and 30-day-down production schedule. Saudi Iron & Steel Co. has reportedly placed an order for 60,000 tons to be delivered in 1986 to its DR plant at Jubail. However, the ongoing war between Iran and Iraq has completely disrupted markets in the rest of the region, forcing AISCO to seek out customers in the EC, Turkey, and northern Africa.

Brazil.—Shipments of iron ore for export and domestic consumption rose to record-high levels for the second year in a row. Exports totaled about 91 million tons, 4% more than those of 1984, while net shipments for domestic consumption increased more than 55% to 34 million tons. Exports included about 45 million tons to Europe and 27 million tons to Japan. Total shipments of pellets were estimated at about 20 million tons.

CVRD produced 73.7 million tons of iron ore products and exported 50.6 million tons. CVRD also exported 18.9 million tons for other companies, including about 8.7 million tons of pellets for its joint ventures at Tubarão with Japanese, Italian, and Spanish companies, 7.4 million tons of ore products for Ferteco Mineração S.A., and 2.8 million tons for S.A. Mineração da Trindade (SAMITRI). Most of CVRD's production came from the Caue and Conceição Mines near Itabira. Minas da Serra Geral S.A., owned 51% by CVRD, sold about 10.3 million tons of ore from the Capanema Mine for beneficiation at the Timbopeba plant and shipment to the Tubarão steelworks.

CVRD's huge $5 billion Carajás project in the State of Pará was more than 80% completed by yearend.[3] The N4E Mine began shipping trial amounts of ore in midyear, and was scheduled to reach full production capacity of 35 million tons per year, averaging 66.13% iron, in July 1987. About 12 million tons of overburden already had been removed at the N4E project site. The $1.3 billion, 550-mile-long railroad between the mine and São Luis on the coast of Maranhão was inaugurated on February 28, 1985, with the first cargoes of iron and manganese ores being transshipped to the old port of Itaqui. A total of 539,000 tons of iron ore was exported through Itaqui during the year. The new marine terminal at nearby Ponta da Madeira was almost completed and was scheduled to open in January 1986. The terminal will be able to accommodate vessels with a carrying capacity of 280,000 tons.

MBR, Brazil's second largest producer, shipped 15.1 million tons of ore in 1985, including 13.1 million tons for export. Most of the ore was produced at the Aguas Claras Mine, southeast of Belo Horizonte in the Minas Gerais Iron Ore Quadrangle. Empreendimentos Brasileiros de Mineração S.A. owns 51% of MBR, while Hanna has an indirect interest of 34% through the St. John d'el Rey Mining Co. PLC. Another 5% is indirectly held by Bethlehem Steel.

Ore shipments by other producers, in million tons, follow: Ferteco (sales), 8.6; SAMITRI, 8.9; Samarco Mineração S.A., 6.7; Cia. Siderúrgica Nacional, 4.8 (estimated); William H. Mueller S.A., 1.1; and Empresa de Mineração Esperanca S.A., 0.2.

Canada.—Shipments of iron ore products totaled 40.2 million tons, compared with 40.7 million tons in 1984. Exports totaled about 24.7 million tons, of which 57% was destined for EC countries and 29% was destined for the United States. Domestic consumption was estimated at 14.8 million tons.

Shipments of ore by individual producers, in million tons, follow: Iron Ore Co. of Canada, 14.9 including 8.3 of pellets, 4.8 of concentrates, and 1.8 of direct-shipping ore; Quebec Cartier Mining Co., 15.6, including 8.9 of concentrates and 6.7 of pellets; Pickands Mather, 6.0 of pellets including 5.5 from Wabush Mines; Cliffs of Canada Ltd. (for Dofasco Inc.), 2.1 of pellets from the Adams and Sherman Mines; and Inco Ltd., 0.09 of pellets from stockpile. The Algoma Steel Corp. Ltd. shipped 1.4 million tons of superfluxed sinter from Wawa, Ontario, to its steelworks at Sault Ste. Marie. Feed to the sinter plant included 1.6 million tons of siderite ore produced at the MacLeod underground mine.

Stelco Inc. took steps to permanently close its Griffith Mine and pelletizing plant near Red Lake, Ontario. The mine produced only 475,000 tons of pellets, 50% of capacity in 1985 and is operated for Stelco by Pickands Mather.

China.—China was expanding the iron and steel complexes at Panzhihua near Dukou in Sichuan Province, Maanshan in Anhui Province, and Handan in Hebei Province as part of its seventh 5-year plan (1986-90). Construction of new steelmaking facilities and modernization of existing plants was in progress at each of three sites and was expected to be completed by 1995. Panzhihua and Maanshan both have their own titaniferous magnetite mines and are major producers of vanadiferous slags that average 17% vanadium pentoxide. The Panzhihua blast furnace operations also produce a titaniferous slag containing 12% to 14% titanium dioxide. This second type of slag is used as feed for the Zunyi titanium sponge plant in Guizhou.

The Panzhihua complex would have an annual production capacity of 2.8 million tons of pig iron when the new 1,350-cubic-meter blast furnace is completed. The present plant reportedly was producing 1.5 million tons of pig iron annually with its three existing blast furnaces. The project would include the construction of a new sinter plant, a hot rolling mill, and two coke oven batteries. According to Xinhua, an official Chinese news agency, the Panzhihua deposit contains more than 10 billion tons of iron ore and accounts for 93% of the country's titanium reserves and 87% of its vanadium reserves. An earlier report stated that the iron mine had only 1.03 billion tons of ore grading 33.2% iron, 11.6% titanium dioxide, and 0.3% vanadium pentoxide. The 10-year expansion program was expected to raise raw steel production capacity from 1.75 million metric tons per year to 2.5 million tons per year, making Panzhihua the largest iron and steel center in southwestern China.

A new 2,500-cubic-meter blast furnace and a new sinter plant would also be installed at Maanshan. Existing plans called for the 30% to 50% iron ore at Maanshan to be blended with Australian ore as feed for the new sinter plant. The existing open hearth furnaces were to be replaced by either oxygen converters or electric arc furnaces. One of the first improvements would be the construction of a new oxygen plant for the steel mill. Maanshan has an annual raw steel capacity of 1 million tons and employs 60,000 workers.

Guinea.—A recently completed, $500,000 study to examine the most economical means of developing the Mifergui-Nimba Co. iron deposit found that the deposit would require a $267 million investment for a 10-million-ton-per-year operation. An 11-mile rail line would be built to haul the ore from its location on the Liberian border to the existing railway of the LAMCO Joint Venture Operating Co. (LJV) inside Liberia. The Guinean ore could then be processed along with LJV's ore and shipped an additional 167 miles to the Liberian Port of Buchanan for export. The port facilities can currently handle vessels with a carrying capacity of 80,000 tons. The results of the study were being reviewed by both the Government of Guinea and the Mifergui-Nimba shareholders. The study was funded by the International Bank for Reconstruction and Development (World Bank) and carried out by Granges International Mining and U.S. Steel. According to the World Bank, a follow-on study was being undertaken to assess the economic viability of the project and the marketability of the ore.

Development of the deposit could extend the life of LJV's Nimba Mine by permitting the company to mix its diminishing, lower grade Liberian ore with the richer Guinean ore. Furthermore, Nigeria, an investor in Mifergui-Nimba, could benefit from access to West African ore that might be more economic because of lower ocean shipping costs.

Hungary.—The Ministry of Industry announced that the Rudabanya Mine, near Miskolc in Borsod-Abauj-Zemplen County, would be closed on January 22, 1986. Production at the country's only active iron mine declined from 434,000 tons in 1983 to 306,000 tons in 1985. The grade of the Rudabanya ore traditionally has been low and reportedly has fallen to a point where beneficiation is no longer economical. The mine has been able to satisfy only a minor part of Hungarian demand.

India.—Production, exports, and consumption of iron ore increased in 1985 compared with 1984 levels. Exports totaled 28.4 million tons and domestic consumption was estimated at 13.5 million tons. Exports included 19.2 million tons to Japan, 2.9 million tons to the Republic of Korea, and 2.5 million tons to Romania. Shipments from Goa totaled 13.7 million tons, and shipments from east coast ports by the National Mineral Development Corp. totaled 7.5 million tons.

The 3-million-ton pelletizing plant of Kudremukh Iron Ore Co. Ltd. (KIOC) at the Port of Mangalore was completed in June and was undergoing testing. The plant will receive concentrates through a 42-mile pipeline from the Kudremukh Mines in the Western Ghats. Commissioning was delayed by a miners' strike that lasted from September 3 to November 2. The opening ceremony has been rescheduled for April 1, 1986. The first pellets are to be shipped to Malaysia for feed in DR plants. KIOC shipped about 1.6 million tons of pellet feed in 1985, most of which went to Japan. The company has signed a contract with AISCO to supply 6.5 to 8.3 million tons of concentrates to Bahrain between April 1985 and March 1989.

Minerals and Metals Trading Corp. of India was seeking financial assistance for a $90 million port expansion and channel dredging project at Paradip. The port would be able to accommodate ships up to 200,000 deadweight tons, compared with the existing limit of 60,000 tons. The project would also increase iron ore handling capacity from the present 2 million tons per year to 6 million tons per year.

Japan.—Imports of iron ore decreased to 122.5 million tons from 123.4 million tons in 1984. Production of pig iron, in contrast, rose slightly from 79.1 to 79.3 million tons. The principal suppliers continued to be Australia, Brazil, and India. Consumption of ore was estimated at 130 million tons.

Liberia.—Exports of iron ore products totaled 16.1 million tons, of which 81% was destined for the EC and 13% was destined for the United States. Exports included 11.9 million tons of sinter fines, 3.2 million tons of pellets, and 1.0 million tons of lump ore. All of the pellets and slightly more than one-third of the sinter fines were shipped by Bong Mining Co.

Shipments by LJV totaled 8.4 million tons, about 7% less than in 1984. The company planned to resume production near Tokadeh and was seeking loans for the purchase of mining equipment. The main ore body at the Nimba Mine could be exhausted as early as 1989. However, the western concession areas, which include the Tokadeh, Gangra, and Yuelliton ore bodies, have a total reserve of 400 million tons of crude ore, averaging 50.8% iron. Bethlehem Steel sold its 25% interest in LJV to the Government of Liberia in January 1984 and agreed to purchase 2 million tons of ore annually for a period of 3 years.

The National Iron Ore Co. (NIOC) produced only about 211,000 tons of ore products in 1985. The company has had increasing difficulty finding buyers for its ore in recent years. The financial condition of NIOC has continued to deteriorate despite a loan from the World Bank. On April 1, 1985, NIOC closed its mine near the border with Sierra Leone and began winding down operations. Only limited amounts of siliceous fines have been produced since April.

Malaysia.—The DR plant of Sabah Gas Industries Sdn. Bhd. (SGI) on Labuan Island was completed in early 1984, but did not go into production until the end of the year because of technical problems in the briquetting plant. Since then, SGI has shipped a total of 30,000 tons of hot-briquetted iron to 30 Indian minimills for evaluation. The SGI operation is somewhat unique because it is the first plant to use a modified version of the Midrex process that permits the hot DRI to be discharged directly into the briquetting machines. At Trengganu, the new DR plant of Perwaja Trengganu Sdn. Bhd. reached full-scale production in March. The company initially was using Brazilian and

Swedish pellets along with high-grade Brazilian lump ore as feed. Designed production capacity of each plant is about 650,000 tons of DRI per year.

Mauritania.—Exports of iron ore totaled 9.2 million tons, about 2% less than those of 1984. As in the past 2 years, more than 90% of shipments was destined for EC countries.

The first stage of the Guelbs project was inaugurated in July 1984 and scheduled to reach a production rate of 6 million tons per year by the end of 1987. Mechanical difficulties with a conveyor belt and other ore handling equipment at the mine temporarily delayed the first shipments. Magnetic concentrates were being produced from crude ore mined at El Rhein, about 15 miles north of the Kedia d'Idjil hematite mines. Owing to scarcity of water, the ore was being beneficiated in the dry state, using semiautogenous mills and low-intensity magnetic separators.

New Zealand.—New Zealand Steel Mining Ltd. produced 1.9 million dry tons of titaniferous magnetite concentrates at its beach sand operations on the North Island. Shipments of the concentrates, loosely referred to as "iron sand," included exports of about 1.8 million tons to Japan and 201,000 tons to the Woolf Fisher steelworks of the parent company in South Auckland. New Zealand is currently the sole supplier of iron sand to the Japanese steel industry, where it is added to the blast furnace feed to extend the life of the refractories. Three specially equipped Japanese carriers—the *Taharoa Maru* (126,604 deadweight tons), the *Slurry Express* (122,042 deadweight tons), and the *Taharoa Venture* (124,589 deadweight tons)—haul the iron sand to Japan.

Peru.—Exports of iron ore by Empresa Minera del Hierro del Perú in 1985 totaled 5.2 million dry tons, of which 44% consisted of sinter fines, 37% consisted of pellets, and the remainder was pellet feed. About 2.0 million tons of products was shipped to the Republic of Korea, and 1.4 million tons was shipped to Japan. All of the material passed through the Port of San Nicolás. An additional 345,000 tons of mostly pellets went to the Chimbote steel mill operated by Empresa Siderúrgica del Perú.

South Africa, Republic of.—Production and exports of iron declined slightly from 1984 levels. Production totaled 24.0 million tons, compared with 24.3 million tons in 1984. Exports totaled 10.0 million tons, mostly to Japan and the EC. Domestic sales were 10.4 million tons, as production of pig iron increased 21% and output of DRI jumped to 405,000 tons. All four of the new Lurgi DR rotary kilns at the Vanderbijlpark steelworks of South African Iron and Steel Industrial Corp. Ltd. (Iscor) were in operation at the beginning of 1985. The units have a total design capacity of 709,000 tons of DRI.

Iscor was supplied with 8.4 million tons of ore products from the Sishen Mine and 2.3 million tons from the Thabazimbi Mine. An additional 8.71 million tons was exported from the Sishen Mine through Saldanha Bay. Increased freight charges on the railway from Sishen to Saldanha Bay, reduced ore prices, and nonrenewal of several sales contracts in Western Europe had made exports of ore products increasingly unprofitable. However, the decline of the rand against the dollar and the adoption of certain rationalization measures by Iscor improved the company's position. On September 7, the company exported its 100 millionth ton of ore from Saldanha Bay. At the Sishen Mine, the South Plant, which accounts for one-third of the mine's production capacity of 27 million tons per year, was reopened in the second quarter at a reduced rate. At midyear, the North Plant was operating at full capacity. The life of the Thabazimbi Mine has been extended by the discovery of a minable ore body west of the Donkerpoort open pit. At Iscor's Pretoria Works, workers began constructing the foundations for a 300,000-ton-per-year ironmaking plant. The new plant will utilize the KR—Kohle reduktion (coal reduction)—process developed by Korf Engineering GmbH in Austria and the Federal Republic of Germany.

Spain.—Production of iron ore products in 1985 included a record high 3.7 million tons by Cía. Andaluza de Minas S.A. (CAM); 1.3 million tons by the Agruminsa subsidiary of Altos Hornos de Vizcaya S.A. (AHV); and 1.2 million tons by Cía. Minera de Sierra Menera S.A. CAM's production, consisting of sinter fines, came from the Marquesado Mine at Alquife. Agruminsa's production included siderite concentrates from ore mined underground at Bodovalle as well as oxide ores from four other locations in Spain. In September, Agruminsa closed its Gallarta Mine near Bodovalle for at least 6 months to reduce stocks of sinter feed from 1.1 million tons to 400,000 tons. The Gallarta ores traditionally have been shipped to AHV's sinter plant at Sestao. However, renovation of the No. 2A blast furnace at the Sestao steelworks temporarily reduced demand for the mine's product.

Spanish exports of iron ore totaled 2.0 million tons, of which CAM shipped 1.8 million tons from the Port of Almeria; most of the remainder was shipped from Sagunto by the Sierra Menera company. Imports totaled 4.9 million tons, of which 60% came from Brazil.

Sweden.—Production and exports of iron ore products increased by 28% and 5%, respectively, from 1984 levels. Exports totaled 18.4 million tons including 5.5 million tons of pellets. About 3.8 million tons was shipped for domestic consumption. Stocks of iron ore were reduced by 0.9 million tons, to 3.6 million tons at yearend.

Luossavaara-Kiirunavaara AB (LKAB) produced 17.6 million tons including 8.6 million tons of pellets. Of the company's output, 52% was produced at Kiruna, 34% was produced at Malmberget, and the rest was produced at the Svappavaara pelletizing plant, which resumed production in November 1984. Shipments totaled 18.6 million tons, mostly for export. LKAB increased the capacity of its pelletizing plant at Kiruna to 4 million tons per year, and a steel-belt pelletizing plant began production at Malmberget in late 1985.

Svenskt Stål AB produced 1.9 million tons of concentrates at Grangesberg, including 1 million tons of granulated sinter feed, and produced 500,000 tons of ore products at the Dannemora Mine. These production levels were almost identical to those of 1984. Combined shipments totaled 3.1 million tons including 1.9 million tons for export.

U.S.S.R.—Soviet exports were estimated at 45.0 million tons. According to the Association of Iron Ore Exporting Countries, exports in 1984 totaled 45.2 million tons, of which 10.5 million tons were pellets and 34.7 million tons were lump ore and other products. The material in the latter category included 10.9 million tons to Poland, 9.4 million tons to Czechoslovakia, 4.3 million tons to Romania, and 3.9 million tons to Hungary.

On June 16, the Soviet Premier and the President of Finland formally inaugurated the third stage of the Kostamush project near Lake Kujto in the Karelia A.S.S.R. The mining complex, begun in late 1977, is designed to produce 9 million tons of nonfluxed pellets per year from 24 million tons of ferruginous quartzite ores. The project began production in 1982 when the first of three pelletizing plants, each with a capacity of 2.9 million tons per year of pellets, was completed. All three plants were in operation at mid-1985. The bulk of the pellets reportedly were being railed to the new, 5,600-cubic-meter blast furnace of the Cherepovets Iron and Steel Works, while most of the remainder was being exported to the Raahe Steel Works of Rautaruukki Oy in Finland.

The main processing facilities of Kostamush were designed by the Mekhanobr Institute of Leningrad, with supervision from the Giproruda Planning Institute of the Soviet Ministry of Ferrous Metallurgy. Much of the construction and civil engineering work was carried out by a consortium of 15 Finnish companies led by Finn-Stroi Ltd. The ore body, which was discovered in 1945, contains some 2 billion tons of magnetite ore averaging 31% iron. Beneficiation is complicated by the presence of 0.1% to 3% pyrrhotite and other sulfides in the ore. The finished pellets contain 65.6% iron and less than 0.05% sulfur.[4]

In the fall, the second of four Midrex DR modules was commissioned at the Stary Oskol Iron and Steel Works near Kursk. The third module was already under construction and was expected to be operational by mid-1987. When completed, the DR complex, which is operated by Oskolskiy Electro-Metallurgicheskiy Kombinat (OEMK) will have a capacity of 1.7 million tons of DRI. OEMK produced 420,000 tons of DRI in 1985, primarily with the No. 1 module, and now has an existing capacity of 830,000 tons. OEMK also has its own pelletizing plant, which receives concentrates through a 16-mile-long slurry pipeline from the Gubkin Mine and beneficiation plant in the Kursk Magnetic Anomaly. The Gubkin Mine produced 40 million tons of Lake Superior-type ore, averaging 33% iron, in 1984 and has reserves in excess of 35 billion tons.

Venezuela.—Shipments of iron ore products by the state-owned CVG Ferrominera Orinoco C.A. totaled 14.5 million tons and included about 8.9 million tons for export. Domestic consumption was estimated at 4.8 million tons.

Ferrominera began production in September at its Cerro San Isidro Mine near Cerro Bolivar. The new mine is linked by an 11-mile railway to the main line between

Cerro Bolivar and the docks at Puerto Ordaz. Ore from the open pit operation, which had a capacity of 5 million tons per year, was scheduled to replace about 45% of the production from the Cerro Bolivar Mine in 1986. To accomplish this, San Isidro's output would be raised to 9 million tons per year. Shipments for the first year totaled about 1.4 million tons. A primary objective of the $20 million development was to improve the average grade of ore marketed by the company, creating savings in beneficiating costs. San Isidro ore contains about 0.06% phosphorus, compared with 0.11% at Cerro Bolivar, and the iron content of San Isidro ore is reportedly higher than that at Cerro Bolivar. El Pao, Ferrominera's third mine, shipped about 3 million tons in 1985, but its reserves could be exhausted as early as 1991.

Production of DRI in 1985 was 2.6 million tons, of which about 52% was produced by the Midrex process, 38% was produced by the HYL process, and the rest was produced by Fior de Venezuela S.A. Under contract with Ferrominera, Midrex Corp. was studying the feasibility of modifying the high-iron briquet (HIB) reduction plant at Puerto Ordaz to use the Midrex process. The HIB plant, closed since 1982, would primarily use screened lump ore from San Isidro as feed material. The plant belongs to Minerales Ordaz C.A., a subsidiary of Ferrominera.

Yugoslavia.—Rudarsko Metalurski Kombinat Zenica commissioned its $12 million Omarska Mine on November 1. The mine, near Prijedor in Bosnia-Hercegovina, had been under development for 10 years and will permit Yugoslavia to reduce drastically its dependency on imported ore. In recent years, the country has imported from 1.0 to 1.5 million tons of ore and concentrate per year, mainly from Brazil, India, Peru, and the U.S.S.R. Omarska has an initial production goal of only 400,000 tons of concentrates per year containing 53% iron, but is designed to produce 1.7 million tons per year, which will more than compensate for the exhaustion of several smaller operations.

TECHNOLOGY

Intense competition in iron ore and steel markets and the need to reduce costs continued to stimulate technological improvements in iron ore production and use.

In December, Michigan Technological University (MTU) received a $5.75 million appropriation from the State of Michigan for construction of a demonstration plant that would test a novel ironmaking operation.[5] The ironmaking operation would integrate two patented technologies. The MTU-PELLETECH or cold-bond agglomeration process first would be used to form pellets from a mixture of iron ore fines, carbon fines, and burnt lime. The carbon-bearing pellets would then be reduced in a hot blast cupola to produce molten iron, using a process developed by Pellet Technology Corp. (PTC). PTC, a partnership between MTU and a Pennsylvania entrepreneur, would be responsible for operating both the 80,000-ton-per-year demonstration MTU-PELLETECH pelletizing plant and the 1-1/2-ton-per-hour PTC hot metal pilot plant. Construction of the new facility, which would cost $16 to $20 million in State and private funds, was scheduled to begin in July 1986 at Eagle Mills on the Marquette Range.

The cold-bond agglomeration process has been under development at MTU since the 1960's. The carbon-bearing pellets made by this process can be used either in a blast furnace to produce conventional pig iron, or in a cupola furnace to produce a variety of reduced iron products. The PTC hot metal process should cut pellet reduction time and furnace fuel costs as well as eliminate the enormous costs of building and maintaining a blast furnace. Relatively small amounts of hot metal could be produced profitably in a scaled-down cupola, an impossibility with a conventional blast furnace. The pellets can be used successfully in the cupola because the carbon fines and burnt lime incorporated into the pellet accelerate the rate of reduction. The carbon fines act as a reducing agent, while the burnt lime serves as a bonding agent. Hot metal costs are reported to be as low as $100 to $110 per ton in the PTC process compared with the current $160 to $170 per ton for the blast furnace. The MTU pellets can also be fed into rotary kilns to produce DRI. A large variety of iron oxides of varying quality can be utilized for pellet feed, including iron ore concentrates, steel dust from basic oxygen furnaces, mill scale, and blast furnace sludge. Carbon sources can include coke breeze, anthracite, and coal char. Pellet production costs were expected to be less than those for conventional processes because the pellets are indurated at a lower temperature in less time than in existing pelletizing facilities (i.e., a PTC autoclave would be operated at approximately 390° F compared with 2,400° F for a conventional kiln). Because of the lower temperature of the autoclaving process, the MTU pellets are in the form of magnetite, instead of hematite. This phase phenomenon creates a pellet that has more iron per unit volume and that requires less energy to reduce.

Oxide Recycle Corp. has been designated PTC's exclusive licensee for the North American iron and steel industry. In late 1985, Oxide Recycle began building a PTC hot metal facility in Gary, IN, that would produce iron from steel-plant wastes. This second facility, scheduled for completion by the end of 1987, will have a design capacity of 1.5 million tons per year of molten iron. Production costs would be partially offset by earnings from the waste collection part of the operation. Disposal charges for mill scale, dust, and slag have been running as high as $150 per ton of waste.

The State of Minnesota, U.S. Steel, and Korf Engineering have applied for nearly $100 million in Federal grants and loans to demonstrate new ironmaking technology that could make domestic steel more competitive with imports. The funds would be used to finance a plant in northern Minnesota that would produce 360,000 tons of iron per year with less pollution and possibly at lower cost than iron produced by the conventional coke oven and blast furnace process. The plant would be the first in North America to produce iron commercially through the method developed by Korf Engineering. The KR process eliminates the blast furnace in pig iron production by using coal instead of coke, thus avoiding the costs and environmental problems of coke production. The reactions in the process are similar to those in the conventional blast furnace, but they take place in two separate chambers. One contains a fluidized bed where coal is gasified and prereduced iron is melted. The second chamber is a vertical shaft furnace where ore is reduced by gas from the fluidized bed. Korf Engineering, U.S. Steel, and the State of Minnesota submitted the $94.8 million proposal in February to the U.S. Department of Energy.

Weirton Steel Corp. has also applied to Energy for a $65 million grant to cover about one-half the cost of building and operating, for 1 year, a similar KR plant. Funds for the other half of the project would be provided by the State of West Virginia and West Virginia coal producers.

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[1]Physical scientist, Division of Ferrous Metals. The author was assisted in preparation of this chapter by F. L. Klinger, physical scientist, Division of Ferrous Metals (retired), and William I. Spinrad, Jr., physical scientist, Division of Ferrous Metals (now with the National Park Service, Atlanta, GA).

[2]Unless otherwise specified, the unit of weight used in this chapter is the long ton of 2,240 pounds.

[3]Engineering and Mining Journal. Carajas Iron Ore. V. 186, No. 11, Nov. 1985, pp. 34-42.

[4]Mining Magazine. The Kostomuksha Project. V. 153, No. 3, Sept. 1985, pp. 193-197.

[5]Skillings' Mining Review. Pellet Technology Corp. To Demonstrate New Ironmaking Process at Eagle Mills, MI. V. 75, No. 15, Apr. 12, 1986, pp. 4-6.

Table 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced, and average output per worker hour in the United States in 1985, by district and State

District and State	Average number of employees	Worker hours (thousands)	Production (thousand long tons)			Iron content (natural) percent	Average per worker hour (long tons)		
			Crude ore	Usable ore	Iron contained (in usable ore)		Crude ore	Usable ore	Iron contained
Lake Superior:									
Michigan	2,083	3,427	38,656	12,479	8,052	64.5	11.28	3.64	2.35
Minnesota	5,780	10,020	108,394	34,910	22,411	64.2	10.82	3.48	2.24
Total or average[1]	7,863	13,447	147,050	47,388	30,463	64.3	10.94	3.52	2.27
Other States[2]	315	595	2,162	1,363	834	61.2	3.63	2.29	1.40
Grand total or average[2]	8,178	14,042	149,212	48,751	31,296	64.2	10.63	3.47	2.23

[1]Data may not add to totals shown because of independent rounding.
[2]Includes California, Colorado, Missouri, Montana, Nevada, and Texas.

Table 3.—Crude iron ore[1] mined in the United States in 1985, by district, State, and mining method

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Number of mines	Open pit	Under-ground	Total quantity
Lake Superior:				
Michigan	2	38,656	--	38,656
Minnesota	11	108,394	--	108,394
Total	13	147,050	--	147,050
Other States:				
Missouri	1	--	1,675	1,675
Other[2]	6	486	--	486
Total	7	486	1,675	[3]2,162
Grand total	20	147,536	1,675	[3]149,212

[1]Excludes byproduct ore.
[2]Includes California, Colorado, Montana, Nevada, and Texas.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Usable iron ore produced in the United States in 1985, by district, State, and type of product

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	Direct-shipping ore	Concen-trates	Agglomer-ates	Total quantity[1]
Lake Superior:				
Michigan	--	--	12,479	12,479
Minnesota	--	1,462	33,448	34,910
Total[1]	--	1,462	45,927	47,388
Other States:				
Missouri	--	56	1,044	1,099
Other[2]	58	206	--	263
Total[1]	58	261	1,044	1,363
Grand total[1]	58	1,723	46,970	48,751

[1]Data may not add to totals shown because of independent rounding.
[2]Includes California, Colorado, Montana, Nevada, and Texas.

Table 5.—Shipments of usable iron ore[1] from mines in the United States in 1985

(Exclusive of ore containing 5% or more manganese)

District and State	Gross weight of ore shipped (thousand long tons)				Average iron content (natural) percent	Total value (thousand dollars)
	Direct-shipping ore	Concentrates	Agglomerates	Total quantity		
Lake Superior:						
Michigan	--	--	12,629	12,629	64.2	W
Minnesota	--	1,458	33,519	34,977	63.7	1,430,353
Total reportable	--	1,458	46,148	47,606	63.9	1,430,353
Other States:						
Missouri	--	56	1,054	1,110	65.9	W
Other[2]	60	634	([3])	694	55.1	12,997
Total reportable	60	690	1,054	1,804	61.8	12,997
Total withheld	--	--	--	--	--	633,381
Grand total[4]	60	2,148	47,203	49,411	63.8	2,076,730

W Withheld to avoid disclosing company proprietary data; included in "Total withheld."
[1]Includes byproduct ore.
[2]Includes California, Colorado, Montana, Nevada, New Mexico, New York, and Texas.
[3]Included in concentrates.
[4]Data may not add to totals shown because of independent rounding.

Table 6.—Usable iron ore produced in the U.S. Lake Superior district, by range

(Thousand long tons and exclusive after 1905 of ore containing 5% or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Spring Valley	Black River Falls	Total[1]
1854-1978	478,058	325,267	320,334	103,528	3,182,512	70,336	8,149	7,221	4,495,401
1979	15,100	2,032	--	--	59,320	--	--	698	77,151
1980	14,450	1,970	--	--	45,162	--	--	699	62,282
1981	15,508	75	--	--	51,025	--	--	854	67,462
1982	6,874	--	--	--	23,898	--	--	241	31,013
1983	9,339	--	--	--	26,255	--	--	--	35,594
1984	12,982	--	--	--	36,697	--	--	--	49,679
1985	12,479	--	--	--	34,910	--	--	--	47,388
Total	564,790	329,344	320,334	103,528	3,459,779	70,336	8,149	9,713	4,865,970

[1]Data may not add to totals shown because of independent rounding.

Table 7.—Average analyses of total tonnage[1] of all grades of iron ore shipped from the U.S. Lake Superior district

Year	Quantity (thousand long tons)	Content (percent)[2]					
		Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1981	64,925	63.13	0.020	5.70	0.17	0.30	2.59
1982	32,173	63.50	.018	5.40	.13	.31	2.60
1983	42,418	63.32	.018	5.35	.12	.29	2.64
1984	48,613	63.48	.018	5.28	.14	.32	2.66
1985	46,916	63.64	.016	5.17	.11	.29	2.63

[1]Railroad weight—gross tons.
[2]Iron and moisture on natural basis; phosphorus, silica, manganese, and alumina on dried basis.

Source: American Iron Ore Association.

Table 8.—U.S. consumption of iron ore and agglomerates in 1985, by State

(Thousand long tons and exclusive of ore containing 5% or more manganese)

State	Iron ore and concentrates[1]		Agglomerates[2]		Miscellaneous[3]	Total reportable
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Texas, Utah	W	W	7,606	W	W	7,606
Illinois, Indiana, Michigan	W	W	31,972	W	W	31,972
Maryland and Pennsylvania	995	W	11,885	W	W	12,880
Ohio and West Virginia	1,236	W	15,072	W	W	16,308
Undistributed	292	119	--	268	1,129	1,808
Total[4]	2,524	119	66,535	[5]268	1,129	70,575

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Excludes pellets or other agglomerated products.
[2]Includes approximately 42,878 units of pellets produced at U.S. mines and 7,117 units of foreign pellets and other agglomerates.
[3]Includes iron ore consumed in production of cement and iron ore shipped for use in manufacturing paint, ferrites, heavy media, cattle feed, refractory and weighting materials, and for use in lead smelting.
[4]Data may not add to totals shown because of independent rounding.
[5]Includes an estimated 220 units of ore and agglomerates used for production of direct-reduced iron for steelmaking.

Table 9.—Iron ore consumed in production of sinter at iron and steel plants in the United States in 1985, by State

(Thousand long tons)

State	Iron ore consumed[1]	Sinter produced
Indiana, Kentucky, Michigan, and Utah	3,779	7,988
Maryland and Pennsylvania	3,382	6,333
Ohio and West Virginia	1,359	2,236
Total	8,520	16,557

[1]Includes domestic and foreign ores.

Table 10.—U.S. production of iron ore agglomerates,[1] by type

(Thousand long tons)

Type	1984	1985
Sinter	[2]16,926	[3]16,557
Pellets	50,083	46,970
Total	67,009	63,527

[1]Production at mines and consuming plants.
[2]Includes 7,983 units of self-fluxing sinter.
[3]Includes 7,256 units of self-fluxing sinter.

Table 11.—U.S. exports of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3,780	182,490	4,988	238,856	5,033	240,435
India	(1)	12	(1)	2	--	--
Iraq	(1)	76	--	--	--	--
Mexico	(1)	4	(1)	24	(1)	10
Netherlands	--	--	3	262	--	--
Saudi Arabia	(1)	34	--	--	--	--
United Kingdom	(1)	5	(1)	32	--	--
Venezuela	(1)	10	(1)	15	(1)	22
Other	1	113	1	66	(1)	87
Total[2]	3,781	182,744	4,993	239,257	5,033	240,557

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 12.—U.S. imports for consumption of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value
Brazil	1,276	30,192	2,533	55,132	2,540	49,322
Canada	8,832	339,472	11,190	413,473	8,557	325,248
Chile	--	--	--	--	164	2,320
Liberia	1,732	31,487	1,745	25,270	2,206	30,987
Peru	(1)	5	7	76	121	2,722
Sweden	68	1,540	84	1,659	65	1,503
Venezuela	[2]1,333	[2]42,934	[3]1,524	[3]31,377	[4]2,068	[4]39,369
Other	5	102	104	2,078	50	769
Total	13,246	[5]445,731	17,187	529,065	15,771	452,240

[1]Less than 1/2 unit.
[2]Excludes approximately 82,000 long tons of sponge iron valued at $6,516,000, originally reported as iron ore.
[3]Excludes approximately 64,000 long tons of sponge iron valued at $5,016,000, originally reported as iron ore.
[4]Excludes approximately 214,000 long tons of sponge iron valued at $15,635,828, originally reported as iron ore.
[5]Data do not add to total shown because of independent rounding.

Table 13.—U.S. imports for consumption of iron ore, by customs district

(Thousand long tons and thousand dollars)

Customs district	1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore	3,062	63,216	4,668	133,448	3,673	71,336
Buffalo	195	8,862	(1)	(1)	(1)	5
Chicago	1,625	52,357	2,574	59,705	2,594	58,712
Cleveland	4,491	179,771	3,859	136,654	1,646	59,853
Detroit	182	4,480	393	12,927	542	19,107
Houston	37	1,169	133	2,758	165	2,541
Mobile	525	25,778	1,548	68,283	2,600	111,772
New Orleans	573	12,369	643	12,315	878	16,266
Philadelphia	2,463	93,963	3,250	98,777	3,408	107,029
Other	91	3,768	119	4,198	266	5,620
Total[2]	13,246	445,731	17,187	529,065	15,771	452,240

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 14.—Iron ore, iron ore concentrates, and iron ore agglomerates: World production, by country[1]

(Thousand long tons)

Country[2]	Gross weight[3]					Metal content[4]				
	1981	1982	1983	1984[p]	1985[e]	1981	1982	1983	1984[p]	1985[e]
Albania[e 5]	591	[r]690	[r]840	[6]1,063	1,100	197	[r]230	[r]280	[r]350	370
Algeria	[r]3,426	[r]3,831	3,626	3,606	3,600	[r]1,738	[r]1,915	1,813	1,839	1,840
Argentina	392	578	599	618	620	245	383	384	[r e]400	400
Australia	83,324	86,309	69,916	87,564	98,500	52,518	54,688	44,587	55,920	62,500
Austria	3,002	3,277	3,484	3,543	3,250	933	1,028	1,090	1,120	1,020
Bolivia	6	8	11	--	--	4	5	7	--	--
Brazil	97,928	[r]91,687	87,315	110,287	118,100	[r]63,654	60,070	57,064	71,650	80,300
Bulgaria	1,726	1,527	1,775	2,030	2,070	529	467	545	612	615
Canada[7]	51,164	35,030	32,966	40,416	39,250	32,126	22,279	20,964	25,664	24,730
Chile	[r]8,380	[r]6,368	5,880	7,004	[6]6,407	[r]5,108	[r]3,813	3,545	4,183	[6]3,882
China[e]	65,000	68,000	70,000	74,000	79,000	32,500	34,000	35,000	37,000	39,000
Colombia	[r]426	463	449	434	490	192	209	202	195	220
Czechoslovakia	1,904	1,832	1,873	1,839	1,870	494	475	482	473	480
Denmark[e]	8	8	--	--	--	3	3	--	--	--
Egypt	1,912	2,106	2,188	[e]2,461	2,460	956	1,053	1,094	[e]1,230	1,230
Finland[8]	1,211	1,218	1,257	1,212	1,180	777	774	809	776	740
France	21,257	19,085	15,678	14,605	[6]14,744	6,693	6,088	4,981	4,606	4,580
German Democratic Republic[9]	39	39	39	39	39	20	20	20	20	20
Germany, Federal Republic of	1,547	[r]1,298	961	962	[6]1,018	[r]468	380	275	288	[6]304
Greece[5]	1,252	508	1,322	1,899	1,870	538	218	563	797	790
Hungary	415	460	434	377	310	99	110	104	91	74
India	40,698	40,256	[e]38,187	40,378	[6]43,842	25,479	25,201	23,905	25,276	[6]27,446
Indonesia	86	142	131	82	120	49	82	76	47	70
Iran[e 10]	590	740	840	840	840	360	390	440	440	440
Italy[11]	121	3	--	--	--	49	[r]1	--	--	--
Japan	435	356	293	319	[6]335	270	221	182	199	[6]209
Kenya[12]	[e]4	4	--	--	--	[e]2	[e]2	--	--	--
Korea, North[e]	7,900	7,900	7,900	7,900	7,900	3,200	3,200	3,200	3,200	3,200
Korea, Republic of	585	610	645	615	530	328	342	361	344	290
Liberia	19,393	17,878	14,701	14,862	15,100	12,000	11,082	9,114	[e]9,212	9,330
Luxembourg	422	--	--	--	--	148	--	--	--	--
Malaysia	524	[r]336	112	191	230	320	205	69	117	139
Mauritania[13]	8,567	8,125	7,268	9,377	9,800	5,160	4,675	[e]4,183	5,663	4,900
Mexico[14]	[r]8,573	8,026	7,913	8,186	7,700	[r]5,658	5,297	5,222	5,402	5,067
Morocco	72	220	170	160	188	44	137	104	99	116
New Zealand[15]	3,202	2,747	2,168	2,376	2,400	1,825	1,566	1,236	1,354	1,402
Norway	4,073	3,489	3,489	3,666	[6]3,413	2,648	2,268	2,268	2,382	[6]2,218
Peru	5,973	5,683	4,289	4,012	[6]5,023	3,944	3,751	2,824	2,676	3,350
Philippines	6	6	3	([16])	--	3	3	2	([16])	--

See footnotes at end of table.

Table 14.—Iron ore, iron ore concentrates, and iron ore agglomerates: World production, by country[1] —Continued

(Thousand long tons)

Country[2]	Gross weight[3]					Metal content[4]				
	1981	1982	1983	1984[p]	1985[e]	1981	1982	1983	1984[p]	1985[e]
Poland	103	48	10	11	[6]11	29	14	3	3	[6]3
Portugal[17]	36	27	35	35	[6]26	13	9	[e]11	[r] [e]13	12
Romania	2,268	2,112	1,956	[e]1,968	2,070	591	551	607	512	[6]522
Sierra Leone	--	[r]65	396	[e]349	295	--	40	260	[e]219	185
South Africa, Republic of[18]	27,872	24,166	16,343	24,258	[6]24,008	17,837	15,467	10,459	15,500	[6]15,341
Spain[19]	8,430	[r]8,238	7,331	7,835	[6]6,350	4,151	4,065	3,457	3,502	[6]3,139
Sweden	22,858	15,888	13,003	17,837	20,131	14,835	10,324	8,452	11,003	13,085
Thailand	61	27	39	60	80	33	15	22	32	43
Tunisia	390	[r]271	311	303	[6]304	[r]209	[r]146	166	163	163
Turkey	2,889	[r]3,007	3,573	3,985	3,940	[r]1,562	[r]1,628	1,935	2,164	2,138
U.S.S.R	238,589	240,551	241,328	243,201	244,100	129,001	[r]129,969	131,454	132,680	133,160
United Kingdom	719	463	378	397	340	158	101	80	81	72
United States[19]	73,174	35,433	37,562	51,269	48,751	46,539	22,642	24,167	33,110	31,296
Venezuela	15,286	11,023	9,562	12,848	15,240	9,477	6,834	5,924	7,965	9,450
Yugoslavia	4,718	5,025	4,939	5,237	[6]5,391	1,486	1,653	1,505	[e]1,673	1,770
Zimbabwe	1,079	824	911	912	915	[r]650	[r]492	586	625	625
Total	[r]844,606	[r]768,011	726,399	817,428	845,251	[r]487,850	[r]440,581	416,083	472,870	492,276

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Sept. 5, 1986.
[2]In addition to the countries listed, Cuba and Vietnam may produce iron ore, but definitive information on output levels, if any, is not available.
[3]Insofar as availability of sources permits, gross weight data in this table represent the nonduplicative sum of marketable direct-shipping iron ores, iron ore concentrates, and iron ore agglomerates produced by each of the listed countries. Concentrates and agglomerates produced from imported iron ores have been excluded, under the assumption that the ore from which such materials are produced has been credited as marketable ore in the country where it was mined.
[4]Data represent actual reported weight of contained metal or are calculated from reported metal content. Estimated figures are based on latest available iron ore content reported, except for the following countries for which grades are Bureau of Mines estimates: Albania, China, Denmark, Hungary, and North Korea.
[5]Nickeliferous iron ore.
[6]Reported figure.
[7]Series represent gross weight and metal content of usable iron ore (including byproduct ore) actually produced, natural weight.
[8]Includes magnetite concentrate, pelletized iron oxide (from roasted pyrite), and roasted pyrite (purple ore).
[9]Includes "roasted ore," presumably from pyrite, not separable from available sources.
[10]Year beginning Mar. 21 of that stated.
[11]Excludes iron oxide pellets produced from roasted pyrite.
[12]For cement manufacture.
[13]Gross weight is exported iron ore (Mauritania exports all of its iron ore).
[14]Gross weight calculated from reported iron content based on grade of 66% Fe.
[15]Concentrates from titaniferous magnetite beach sands.
[16]Revised to zero.
[17]Includes manganiferous iron ore.
[18]Includes magnetite ore as follows, in thousand long tons: 1981—4,175; 1982—4,253; 1983—3,414; 1984—3,780 (revised); and 1985—3,550.
[19]Includes byproduct ore.

Iron Oxide Pigments

By Donald P. Mickelsen[1]

U.S. mine production of crude iron oxide pigments increased in 1985 while shipments declined and total value of shipments remained practically unchanged. Total domestic shipments of natural and synthetic finished iron oxides decreased and unit values increased slightly over those of 1984. Synthetic iron oxide comprised 59% of all shipments. Reichard-Coulston Inc. filed for protection under Chapter 11 of the Federal Bankruptcy Code on October 22, 1985, and closed its plant at Bethlehem, PA. Chesapeake Specialty Products, a division of Bethlehem Steel Corp., began processing an iron oxide product in Baltimore, MD.

Paint and coatings was the largest end use for iron oxide pigments, followed, in order of ranking, by construction materials; colorants for glass and ceramics, plastics, paper and textiles, and rubber; foundry uses; industrial chemicals; ferrites; and other end uses.

Price increases proposed by several major producers had little effect on the market because of competitively priced imports that influenced continued discounting for larger orders.

The United States imported 34% more iron oxide pigments than it exported, partly owing to an 8% drop in U.S. exports of pigment-grade iron oxides from 1984 levels. Increased imports were attributed to a strong U.S. dollar compared with foreign currencies. U.S. imports of synthetic iron oxides showed another strong increase in 1985 while imports of natural iron oxides continued to decline. World mine production of natural iron oxide pigments for reporting countries increased compared with that of 1984.

Domestic Data Coverage.—Mine production and sales data for crude iron oxide pigments and sales data for finished iron oxide pigments and iron oxides from steel plant wastes were compiled from voluntary responses received from an annual survey of U.S. producers conducted by the Bureau of Mines. Responses for crude iron oxide mine production and sales data were received from five companies representing 100% of all producers that are known to mine and/or ship crude iron oxide pigments in the United States, as shown in table 1. Of the 17 companies canvassed for finished iron oxide pigments sales data in 1985, 100% responded, representing 100% of the total production shown in table 2. Of the five companies canvassed for sales data for iron oxides recovered from steel plant wastes, including steel plant dust and re-

Table 1.—Salient U.S. iron oxide pigments statistics

	1981	1982	1983	1984	1985
Mine production short tons	28,731	28,082	26,499	29,307	32,234
Crude pigments sold or used do	49,732	46,548	41,875	53,017	46,585
Value thousands	$1,743	$2,059	$2,427	$2,819	$2,826
Finished pigments sold short tons	128,290	104,951	122,861	129,492	126,822
Value thousands	$95,799	$84,736	$110,662	$122,620	$122,716
Exports short tons	4,967	9,065	12,661	32,428	29,720
Value thousands	$11,704	$17,795	$20,692	$31,832	$27,574
Imports for consumption short tons	39,661	25,855	30,747	38,239	39,799
Value thousands	$18,915	$13,330	$16,684	$21,523	$22,565

generator oxide, 100% responded, representing 34% of the estimated production shown in the text discussion under "Domestic Production." Remaining data were estimated through analysis of industry trends and practices.

DOMESTIC PRODUCTION

Mine production of crude iron oxide pigments increased 10% over 1984 levels while shipments decreased 12% and total value of shipments remained practically unchanged. One company in Georgia mined and shipped ocher and umber; magnetite was mined and shipped by a company in Missouri; and of two companies in Virginia, one mined and shipped sienna and umber and the other shipped umber. Cleveland-Cliffs Iron Co. continued to ship hematite from a stockpile at its Mather Mine in northern Michigan, which permanently closed in 1979.

Total domestic shipments of finished iron oxide pigments, excluding regenerator oxide, steel plant dust, and magnetic iron oxide, remained virtually unchanged in quantity and value when compared with that of 1984. Synthetic iron oxides comprised 59% of total shipments, the same as that of 1984. Unit values for all categories of finished iron oxides, except for the "Other" category, increased. Natural iron oxides remained practically the same in both quantity and value when compared with that of 1984. Natural raw umber and red iron oxide underwent large and moderate increases, respectively, while raw sienna, ocher, burnt sienna, and burnt umber decreased, the total of which slightly outweighed the increases. Of the 13 natural iron oxide producers canvassed, 6 reported increases in domestic shipments while the remaining producers reported decreases. Total synthetic iron oxide shipments and value remained relatively stable, with increases in synthetic brown and red oxides offsetting decreases in synthetic yellow and other iron oxides. Only one of the six synthetic iron oxide producers canvassed reported increases in shipments.

Iron oxide for use in magnetic applications, not shown in table 2, was produced by two domestic companies. Production and shipment data are unavailable because of their proprietary nature.

An estimated 38,000 short tons[2] of steel plant byproduct iron oxides, in the form of regenerator oxide and steel plant dust, were shipped in 1985. Of the five plants canvassed, representing 34% of estimated shipments with a value of $1.2 million, two showed decreases in shipments, two showed increases, and one continued to remain inactive. The remaining steel plant wastes, while unaccounted for, are estimated to be used in the manufacture of ferrites according to officials in the industry.

In October, Reichard-Coulston filed for protection under Chapter 11 of the Federal Bankruptcy Code and permanently closed its Bethlehem, PA, plant. The 131-year-old business employed almost 100 workers as late as 1984. The plant has since been sold to the Pennsylvania Perlite Corp. and will be refitted to prepare and package perlite. Reasons for the closure were attributed to competitively priced imports and a strong U.S. dollar. Chesapeake Specialty Products, a division of Bethlehem Steel, began processing an iron oxide product at their new plant in Baltimore, MD.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kind

Kind	1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Black: Magnetite	5,389	$877	5,440	$908
Brown:				
Iron oxide[1]	W	W	W	W
Umbers:				
Burnt	3,432	2,903	3,135	2,778
Raw	1,559	1,151	1,863	1,340
Red:				
Iron oxide[2]	24,648	4,353	25,913	4,321
Sienna, burnt	631	561	554	502
Yellow:				
Ocher[3]	17,272	4,968	14,613	4,494
Sienna, raw	280	249	233	228
Total	53,211	[4]15,063	51,751	14,571

See footnotes at end of table.

Table 2.—Finished iron oxide pigments sold by processors in the United States, by kind —Continued

Kind	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Synthetic:				
Brown: Iron oxide[5]	16,307	$22,128	18,484	$25,566
Red: Iron oxide	33,435	45,403	33,729	47,045
Yellow: Iron oxide	21,482	27,431	18,112	24,225
Other: Specialty oxides[6]	5,057	12,594	4,746	11,309
Total	76,281	107,556	75,071	108,145
Mixtures of natural and synthetic iron oxides	W	W	W	W
Grand total	129,492	[4]122,620	126,822	122,716

W Withheld to avoid disclosing company proprietary data.
[1]These data are included with yellow ocher to avoid disclosing company proprietary data.
[2]Includes pyrite cinder.
[3]Includes yellow and brown iron oxides.
[4]Data do not add to total shown because of independent rounding.
[5]Includes synthetic black iron oxide.
[6]Includes mixtures of natural and synthetic iron oxides.

Table 3.—Producers of iron oxide pigments in the United States in 1985

Producer	Mailing address	Plant location
Finished pigments:		
American Minerals Inc	Foot of Jefferson St. Camden, NJ 08101	Camden, NJ.
BASF Chemicals, Dyestuffs & Pigments Group.	100 Cherry Hill Rd. Parsippany, NJ 07054	Wyandotte, MI.
Blue Ridge Talc Co. Inc	Box 39 Henry, VA 24102	Henry, VA.
Chemalloy Co. Inc	Box 350 Bryn Mawr, PA 19010	Bryn Mawr, PA.
Columbian Chemicals Co	1600 Parkwood Circle Suite 400 Atlanta, GA 30339	St. Louis, MO, and Monmouth Junction, NJ.
DCS Color & Supply Co. Inc	2011 South Allis St. Milwaukee, WI 53207	Milwaukee, WI.
Foote Mineral Co	Route 100 Exton, PA 19341	Exton, PA.
Hoover Color Corp	Box 218 Hiwassee, VA 24347	Hiwassee, VA.
Mobay Chemical Corp	Penn Lincoln Parkway West Pittsburgh, PA 15205	New Martinsville, WV.
New Riverside Ochre Co	Box 387 Cartersville, GA 30120	Cartersville, GA.
Pfizer Pigment Inc	235 East 42d St. New York, NY 10017	Emeryville, CA; East St. Louis, IL; Easton, PA.
Prince Manufacturing Co	700 Lehigh St. Bowmanstown, PA 18030	Quincy, IL, and Bowmanstown, PA.
Reichard-Coulston Inc	1421 Mauch Chunk Rd. Bethlehem, PA 18018	Bethlehem, PA.
St. Joe Lead Co., Pea Ridge Iron Ore Co	7733 Forsyth Blvd. Clayton, MO 63105	Sullivan, MO.
George B. Smith Color Co	Route 72, Box 396 Kirkland, IL 60146	Maple Park, IL.
Solomon Grind-Chem Services Inc	Box 1766 Springfield, IL 62705	Springfield, IL.
Sterling Drug Inc., Hilton-Davis Chemicals Div.	2235 Langdon Farm Rd. Cincinnati, OH 45237	Cincinnati, OH.
Crude pigment:		
Cleveland-Cliffs Iron Co., Mather Mine and Pioneer Plant (closed July 31, 1979; shipping from stockpile).	1460 Union Commerce Bldg. Cleveland, OH 44115	Negaunee, MI.
Hoover Color Corp	Box 218 Hiwassee, VA 24347	Hiwassee, VA.
New Riverside Ochre Co	Box 387 Cartersville, GA 30120	Cartersville, GA.
St. Joe Lead Co., Pea Ridge Iron Ore Co	7733 Forsyth Blvd. Clayton, MO 63105	Sullivan, MO.
Virginia Earth Pigments Co	Box 1403 Pulaski, VA 24301	Hillsville, VA.

CONSUMPTION AND USES

Consumption data for iron oxide pigments, shown as percentages by end use of reported shipments in table 4, are estimates because some producers keep less detailed data concerning end-use breakdowns than others.

Paint and coatings, which continued to be the largest end use for iron oxide pigments, comprised 33% of all shipments and totaled 42,431 tons in 1985. Consumption decreased slightly compared with that of 1984. Preliminary data developed by the U.S. Department of Commerce[3] indicate that slightly more than 982 million gallons of coatings valued at $9.9 billion was shipped, up 7% in volume over that of 1984. Architectural coatings comprised 49% of total shipments and totaled 486 million gallons; product coatings-original equipment manufacture (OEM) was 320 million gallons, or 33% of shipments; and 18%, or 176 million gallons, was special-purpose coatings.

Usage of iron oxide pigments in construction materials remained at about the same quantity and percentage of total shipments. Consumption increased slightly from 1984 levels, to 36,179 tons, and comprised 28% of all iron oxide pigments consumed.

Twelve percent, or 15,054 tons, of all iron oxides was consumed as colorants for plastics, glass and ceramics, rubber, and paper and textiles, by order of ranking, representing a small decrease in consumption from that of 1984. One published report indicated that 4,800 tons of iron oxide was consumed in plastics in 1985, virtually the same as that of 1984.[4] Iron oxides, which are the second largest inorganic pigments consumed, are popular because of their low cost, coloring effectiveness in thermoplastics and thermosets, and because of Food and Drug Administration acceptance for food contact and medical applications.

The remaining 27% of reported iron oxide pigment consumption, by order of ranking, was in the manufacture of animal feed and fertilizers, foundry sands, industrial chemicals, ferrites, cosmetics, jewelers' rouge, and other end uses.

Regenerator oxide and steel plant dust, not accounted for in table 4, were used mainly in the manufacture of ferrites, with lesser amounts used in paint and coatings, as colorants for construction materials, and in fertilizers and foundry sands. An estimated 38,000 tons was shipped for consumption in 1985. Magnetic iron oxides, also not included in the table, were mainly used in the manufacture of magnetic media such as magnetic tapes and floppy disks, magnetic toners, and other electronic applications. Over 15,000 tons was estimated to be consumed.

Table 4.—Estimated iron oxide pigment consumption,[1] by end use, as a percentage of reported shipments

End use	All iron oxides		Natural iron oxides		Synthetic iron oxides	
	1984	1985	1984	1985	1984	1985
Coatings (industrial finishes, trade sales paints, varnishes, lacquers)	35	33	25	22	r42	41
Construction materials (cement, mortar, preformed concrete, roofing granules)	28	28	28	30	r28	28
Colorants for plastics, rubber, paper, textiles, glass, ceramics	r11	12	r11	12	r11	12
Industrial chemicals (such as catalysts)	5	5	3	1	6	7
Animal feed and fertilizers	r5	6	r12	13	r2	1
Foundry sands	5	6	r12	14	--	--
Other (including ferrites, cosmetics, and jewelers' rouge)	r11	10	r9	8	r11	11
Total	100	100	100	100	100	100

rRevised.
[1]Data do not include magnetic iron oxide usage.

PRICES

One major domestic producer announced price increases of approximately 5% for its line of synthetic iron oxides, effective January 1, 1985. This increase was a continuation of similar increases announced by other major producers for December 1984 because of increased production costs. Following these announced increases, list prices for natural and synthetic grades of iron oxide pigments sold by major domestic producers remained unchanged for the rest of 1985. Competition from low-priced imports and a strong U.S. dollar led to price discounting for larger accounts and in effect nullified announced 1985 price increases for these orders. In the fourth quarter, prices charged for raw sienna by other producers and distributors advanced from 36 to 44 cents to 41 to 53 cents per pound; burnt siennas advanced from 45 cents per pound to a range of 48 to 54 cents per pound; and Vandyke brown increased 3 cents to 45 cents per pound according to the American Paint and Coatings Journal.

Table 5.—Prices quoted on finished iron oxide pigments, per pound, bulk shipments,[1] December 31, 1985

Pigment	Low	High
Black:		
Natural	--	$0.2700
Synthetic	$0.6900	.7150
Micaceous	--	.6875
Brown:		
Ground iron ore	.1300	.1450
Metallic	.1650	.2950
Pure, synthetic	--	.7050
Sienna, domestic, burnt	.4800	.5400
Sienna, domestic, raw	.4100	.5300
Sienna, Italian, burnt	.4500	.7300
Umber, Turkish, burnt	.4350	.5200
Vandyke brown	--	.4500
Red:		
Domestic primers, natural, micronized	--	.2375
Pure, synthetic	--	.6600
Spanish	--	.2950
Yellow:		
Synthetic	--	.6800
Ocher, domestic	--	.2200

[1]Prices shown represent the best information available but are not to be considered definite according to the source.

Source: American Paint and Coatings Journal.

FOREIGN TRADE

The United States imported 34% more iron oxide pigments than it exported in 1985, with much of the continued trade imbalance being caused by a strong U.S. dollar compared with foreign currencies. Total value of U.S. exports of iron oxide pigments was $27.6 million, or $5.0 million greater than that of U.S. imports, however.

U.S. imports of iron oxide pigments for consumption increased 4% in quantity and 5% in value compared with those of 1984, and were received from 23 countries. Monthly import levels advanced through the first two quarters, peaked in June, and then retreated through the rest of the year. Imports of synthetic iron oxides increased 10% in quantity and 6% in value and comprised 83% of all imports received, 5% more than that for 1984. All grades of synthetic iron oxides increased in quantity, the most notable occurring in black and yellow grades, which increased 19% and 16%, respectively. The unit value for synthetic black decreased 5 to 26 cents per pound; synthetic red decreased 15 to 25 cents per pound; and synthetic yellow iron oxides decreased 10 to 19 cents per pound. Other grades of synthetic iron oxides increased 18 to 51 cents per pound, however. Synthetic iron oxides were received chiefly from the Federal Republic of Germany, Canada, Japan, Mexico, and the United Kingdom, comprising 48%, 25%, 12%, 8%, and 3% of total imports, respectively.

Periodically, iron oxide pigments also enter the United States under the combined classification, "Iron compounds, other." In 1985, iron oxides, including regenerator oxides, were received from Canada and several Western European countries.

U.S. exports of pigment-grade iron oxides and hydroxides decreased 8% in quantity and 13% in value compared with those of 1984. These exports were received by 44 countries, principally in Europe, Asia, and other North American countries. Chief destinations for iron oxide pigments, by order of ranking, were the Federal Republic of Germany, Japan, Canada, Belgium-Luxembourg, and the United Kingdom. Exports to the Federal Republic of Germany decreased 16% from those of 1984 and had an average value of 26 cents per pound, the same as that of 1984. Exports of other grades of iron oxides and hydroxides increased 39% in quantity and 4% in value compared with those of 1984. Main destinations were Japan, Oman, Indonesia, and Singapore.

U.S. imports of natural iron oxides decreased 19% in quantity and 13% in value compared with 1984 levels. The most sizable decreases, which were responsible for overall decreases in natural imports, occurred in crude and finished umbers and Vandyke brown, these categories declining 23%, 18%, and 39%, respectively, from 1984 levels. Unit values for all grades of natural crude iron oxides, finished sienna, and finished other natural iron oxide pigments increased, while all other grades decreased. Cyprus, Spain, the Federal Republic of Germany, Italy, and the United Kingdom, by order of ranking, supplied 95% of all imports of natural iron oxides. Finished umber was primarily received from Cyprus and the United Kingdom; sienna, from Cyprus and Italy; and Vandyke brown was received principally from the Federal Republic of Germany. The United States also received 20 tons of micaceous iron oxide from Austria. Minor amounts of natural crude and synthetic iron oxides were received and stored in bonded warehouses for future consumption.

Table 6.—U.S. exports of iron oxides and hydroxides, by country

Country	1984				1985			
	Pigment grade		Other grade		Pigment grade		Other grade	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Algeria	115	$88	--	--	--	--	--	--
Argentina	8	26	(1)	$2	2	$9	--	--
Australia	97	148	263	598	45	89	186	$532
Belgium-Luxembourg	250	357	113	207	2,126	1,099	319	465
Brazil	176	657	137	530	91	259	158	542
Bulgaria	(1)	1	27	59	44	98	--	--
Canada	2,521	3,659	186	372	2,171	2,983	274	441
Colombia	61	41	19	30	59	48	11	17
Denmark	17	54	2	2	3	11	3	12
Dominican Republic	(1)	2	28	25	1	6	23	6
Ecuador	60	105	8	9	15	31	1	9
Egypt	--	--	33	20	--	--	20	26
El Salvador	19	38	2	3	30	72	4	9
Finland	23	34	--	--	24	35	10	14
France	535	810	135	286	666	1,078	118	230
Germany, Federal Republic of	23,210	12,473	64	152	19,587	10,389	76	176
Hong Kong	325	575	18	62	358	352	82	304
Indonesia	--	--	--	--	--	--	616	269
Ireland	51	163	--	--	67	216	--	--
Israel	6	8	3	6	--	--	--	--
Italy	301	1,744	62	128	268	1,499	7	11
Jamaica	4	6	1	4	2	4	--	--
Japan	2,732	3,985	1,658	4,833	2,186	2,307	1,752	4,708
Korea, Republic of	259	199	11	36	155	154	117	328
Libya	--	--	--	--	--	--	24	56
Malaysia	21	44	40	88	--	--	--	--
Mexico	236	369	188	394	293	437	390	1,027
Morocco	--	--	--	--	--	--	33	50
Netherlands	60	200	56	201	115	180	62	159
New Zealand	8	14	11	26	16	38	19	46
Oman	--	--	204	164	--	--	653	301
Panama	30	38	--	--	6	6	--	--
Peru	22	19	1	1	1	2	--	--
Philippines	21	18	3	8	15	11	2	3
Singapore	37	58	170	565	22	62	430	409

See footnotes at end of table.

Table 6.—U.S. exports of iron oxides and hydroxides, by country —Continued

Country	1984				1985			
	Pigment grade		Other grade		Pigment grade		Other grade	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
South Africa, Republic of	11	$24	1	$5	7	$15	--	--
Spain	12	30	33	72	11	42	--	--
Sweden	6	43	4	10	1	2	10	$23
Switzerland	24	84	1	4	20	48	--	--
Taiwan	42	168	21	46	65	177	94	214
Thailand	24	29	2	4	19	15	4	4
Tunisia	--	--	58	78	--	--	--	--
Turkey	16	160	--	--	--	--	--	--
United Arab Emirates	--	--	10	14	--	--	38	63
United Kingdom	896	4,920	313	732	1,073	5,424	274	543
Uruguay	10	11	6	4	5	6	--	--
Venezuela	158	361	340	1,029	133	292	42	144
Yemen, Aden	--	--	--	--	--	--	55	104
Yemen, Sana	--	--	--	--	--	--	20	43
Yugoslavia	--	--	48	84	--	--	--	--
Other	25	69	10	[r]15	18	78	23	76
Total[2]	32,428	31,832	4,292	10,909	29,720	27,574	5,953	11,364

[r]Revised.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of selected iron oxide pigments, by type

Pigment	1984		1985		Major sources, 1985
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	
Natural:					
Crude:					
Ocher	7	$31	1	$6	Japan 1.
Sienna	38	22	225	30	Italy 225.
Umber	5,963	860	4,564	674	Cyprus 4,526; France 26; Canada 11.
Other	134	142	150	248	Canada 43; Cyprus 40; Panama 23; Japan 19; France 10.
Total[1]	6,143	1,054	4,940	957	
Finished:					
Ocher	([2])	([2])	25	16	Spain 22; France 3.
Sienna	122	50	45	19	Cyprus 26; Italy 19.
Umber	438	152	357	121	Cyprus 204; United Kingdom 105; West Germany 40; Canada 8.
Vandyke brown	659	244	404	140	West Germany 362; Netherlands 21; Belgium-Luxemburg 21.
Other	862	302	876	313	Spain 734; Netherlands 75; Australia 20; Austria 20; West Germany 20.
Total[1]	2,081	748	1,707	608	

See footnotes at end of table.

Table 7.—U.S. imports for consumption of selected iron oxide pigments, by type —Continued

Pigment	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)	Major sources, 1985
Synthetic:					
Black	614	$386	733	$386	West Germany 376; United Kingdom 162, Netherlands 99; Belgium-Luxemburg 40; Canada 26.
Red	5,690	4,634	5,724	2,835	West Germany 2,100; Japan 1,407; Mexico 808; Canada 616; United Kingdom 400; Brazil 250.
Yellow	12,978	7,525	15,011	5,773	West Germany 11,664; Mexico 1,708; Canada 665; United Kingdom 279; Brazil 182; Belgium-Luxemburg 180.
Other[3]	10,733	7,174	11,684	12,005	Canada 6,985; Japan 2,435; West Germany 1,724; Netherlands 317; United Kingdom 117.
Total[1]	30,015	19,720	33,151	20,999	
Grand total[1]	38,239	21,523	39,799	22,565	

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, by country

Country	Natural				Synthetic			
	1984		1985		1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	--	--	20	$10	--	--	--	--
Austria	122	$64	20	9	--	--	--	--
Belgium-Luxembourg	9	6	21	7	218	$65	303	$102
Brazil	--	--	--	--	300	163	432	235
Canada	12	64	62	28	8,851	2,550	8,292	2,230
Cyprus	5,772	889	4,796	742	--	--	--	--
Denmark	--	--	--	--	--	--	11	10
Dominican Republic	--	--	--	--	--	--	60	16
France	2	27	41	60	2	10	3	16
Germany, Federal Republic of	688	269	422	177	13,678	6,936	15,864	7,997
Ireland	63	9	--	--	--	--	21	14
Italy	80	40	245	37	16	12	--	--
Japan	18	76	28	157	4,146	8,176	3,963	7,826
Mexico	68	47	--	--	1,603	789	2,527	1,350
Netherlands	52	52	96	79	194	79	489	226
Norway	--	--	--	--	24	19	--	--
Portugal	117	17	--	--	--	--	--	--
Spain	660	121	756	159	116	22	143	45
Sweden	--	--	6	10	20	378	17	349
Switzerland	1	1	--	--	12	26	15	11
United Arab Emirates	--	--	--	--	--	--	20	10
United Kingdom	559	119	111	47	817	482	958	545
Other	1	1	25	43	[r]18	[r]14	33	17
Total[1]	8,224	1,802	6,647	1,566	30,015	19,720	33,151	20,999

[r]Revised.
[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World mine production of natural iron oxide pigments for reporting countries increased 10% compared with that of 1984. In addition to these countries, other countries undoubtedly produce natural iron oxide pigments including, but not limited to, the centrally planned economy countries. Natural red iron oxide was produced primarily by India and Spain; yellow ocher was produced principally by France, Spain, the Republic of South Africa, and the United States; and sienna was mainly produced by Cyprus and Italy. Cyprus was the major umber producer, Austria was the principal micaceous iron oxide producer, and the Federal Republic of Germany was the main Vandyke brown producer.

Synthetic iron oxides comprise the largest percentage of colored inorganic pigment production in the world. Their popularity is attributed to performance/price relationship. Iron oxides exhibit high tinctorial strength and hiding power, chemical resistance, lightfastness, and weatherfastness at low pigmentation costs. Synthetic iron oxides have also made continuous gains in total market share over natural iron oxides because of product consistency, higher tinting strengths, and more saturated color shades compared with natural grades. Principal world producers of synthetic iron oxides include the Federal Republic of Germany, the United States, Japan, Mexico, and Brazil.

Japan.—Titan Kogyo Co. Ltd. of Japan developed a heat-resistant yellowish iron oxide capable of withstanding heat up to 300° C. This is 100° C higher than present commercially available iron oxides. In addition to greater heat resistance, the product has excellent weather and chemical resistance and ultraviolet ray absorption. The product consists of 0.08- to 0.8-micrometer diameter crystals and is designed for use as a colorant for plastics. Titan Kogyo began construction of a full-scale commercial plant at its Ube plant location. Completion was expected by the end of 1985.[5]

According to the Japan Inorganic Chemical Industry Association, sales of iron oxide were forecast to remain stable in 1985, totaling 172,800 tons. This follows a 22% jump in sales from 1983 to 1984. Magnetic material end uses were expected to continue to dominate iron oxide sales comprising 76% of the total or 131,000 tons. The largest consumer of magnetic materials is the electronics industry, which underwent a slump in the second quarter of 1985. Little growth was expected in 1985 in sales of office automation, audio, and visual equipment, and demand for hard and soft ferrites and magnetic material were forecast to remain stable. Other major areas for domestically produced iron oxide and their projected end-use sales were paints, roads, printing inks, construction materials, synthetic resin, ceramics, paper and other uses, by order of rank. In 1985, 18 companies at 19 locations manufactured ferric oxide.[6]

Published statistics indicate that iron oxide production for the first 7 months of 1985 totaled 96,953 tons, 6% greater than that for the comparable period in 1984. Monthly production capacity for the same period increased from 15,808 tons to 18,156 tons, causing capacity utilization to decrease 85.7% to 68.2%. Wholesale prices, f.o.r., remained unchanged for ferrite use iron oxides and special use iron oxides during 1985.[7] Prices were $0.83 per kilogram in 10-metric-ton delivery units and $1.74 per kilogram in 1-metric-ton shipments, respectively.[8]

Spain.—The major iron oxide producers in Spain are Productos Minerales para la Industria S.A. (Promindsa) and Óxidos Rojos de Málaga S.A. Promindsa's product line includes natural red iron oxide, natural yellow ocher, black magnetic iron oxide, and high-purity iron oxide (Ferrox). Hematite is mined at its underground operation in Tierga in northern Spain. Proven resources have been estimated at 2.2 million tons with exploratory work continuing. The processing plant at the minesite has an annual production capacity of 22,000 tons. Recently, as much as 13,000 tons per year of micronized red iron oxide has been produced at the plant. About 90% of Promindsa's products are exported through the ports of Bilboa, Barcelona, and Valencia, by order of ranking.

Óxidos Rojos de Málaga, a wholly owned subsidiary of Golden Valley Colours Ltd., Bristol, the United Kingdom, produces both superfine and micronized grades of natural red iron oxide from its mines in Málaga. About 6,000 tons were produced in 1984.

Other iron oxide producers are Sociedad Española de Óxidos de Pinturas, Ramón Alcalde Zorilla, and Óxidos del Sur SL. Zorilla has its own mine in Jaén, while the others purchase iron oxides for further processing. Óxidos del Sur purchases iron oxides from Almeria, Granada, and Jaén, and processes the oxides at its plant in Almeria, which has a production capacity of 3,900 tons per year. Up to 1,300 tons of granular grey micaceous iron oxide, 900 tons of platy brown micaceous iron oxide, and 1,700 tons of natural red iron oxide can be produced annually. Both wet and dry concentration methods are used depending on grade and price of material.[9]

Table 9.—Natural iron oxide pigments: World mine production, by country[1]

(Short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina	815	1,027	940	882	880
Australia	925	--	--	--	--
Austria	12,478	10,549	12,935	[e]12,700	11,000
Brazil	4,578	5,811	4,211	4,689	5,000
Burma	386	--	--	--	--
Canada[e]	3,100	3,100	3,100	3,100	2,200
Chile	5,390	2,695	7,442	17,762	16,500
Cyprus	22,046	22,046	17,637	14,440	14,300
Egypt	[e]140	[e]160	--	--	--
France[e]	16,530	17,600	17,600	16,500	16,500
Germany, Federal Republic of[3]	24,828	20,491	21,921	[e]22,000	23,000
India	87,778	93,464	97,701	118,886	119,000
Iran[e 4]	550	550	660	660	660
Italy[e]	1,000	900	1,000	900	900
Pakistan	[r]1,531	[r]453	1,187	1,205	1,800
Paraguay[e]	220	130	200	[r]275	220
South Africa, Republic of	1,430	2,355	1,861	1,092	770
Spain:					
Ocher	17,110	12,907	10,890	[e]11,000	11,000
Red iron oxide[e]	27,600	25,000	22,000	22,000	22,000
United States	28,731	28,082	26,499	29,307	[5]32,234
Zimbabwe[e]	1,320	1,100	1,100	1,100	1,100

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 15, 1986.
[2]In addition to the countries listed, a considerable number of others undoubtedly produce iron oxide pigments, but output is not reported, and no basis is available for formulating estimates of output levels. Such countries include (but are not limited to) China and the U.S.S.R. Because unreported output is probably substantial, this table is not added to provide a world total.
[3]Includes Vandyke brown.
[4]Iranian calendar year (Mar. 21 to Mar. 20), beginning in the year stated.
[5]Reported figure.

TECHNOLOGY

A comprehensive study was recently completed on magnetic materials by the National Materials Advisory Board of the National Research Council in response to a request from the U.S. Department of Defense. Members on the committee on magnetic materials, which conducted the study, represented major producers and universities concerned with this technological area. The committee's purpose was (1) to access current progress in research and development of magnetic materials in the United States, (2) to identify key problems and factors that may limit the use of needed future magnetic materials, and (3) to recommend research and development areas, including those in manufacturing technology, that appear most likely to return the highest scientific and technological dividends within the decade. Among the areas extensively studied were hard and soft magnetic materials; storage media, including particulate coatings and thin films, magneto-optic materials, and magnetic bubbles; magnetostriction and magnetoresistance transducers; and fine particles for uses other than recording such as electrophotography and ferrofluids.

The report concluded that, despite the critical importance of magnetic materials, the United States is rapidly losing its competitive position in major magnetic technologies because of the growing reliance by the U.S. industry on external sources for magnetic devices. Meanwhile, foreign nations, notably Japan, have invested in research and development to improve the performance of their materials, including permanent magnets, soft magnetic materials, and magnetic recording materials. Recommendations were that (1) research should be increased in support of those magnetic technologies with strong growth potential or having strategic value, (2) an effort be made to regenerate a strong university-based research program in magnetism and magnetic materials, (3) the relationships between scientific research in magnetism and magnetics technology be strengthened, and (4) a national resource center for the assimilation of information on magnetic materials should be formed.[10]

A comprehensive review of printing ink was published covering approximately 319 printing ink formulations, including pigment content, ink vehicles, varnishes, and ink suppliers.[11]

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[1]Mineral Data Specialist, Division of Ferrous Metals.

[2]Unless otherwise specified, the unit of weight in this chapter is the short ton.

[3]Bureau of the Census (Dept. of Commerce). Paint, Varnish, and Lacquer. R. M28F (monthly), 1985.

[4]Modern Plastics. Special Report: Chemicals and Additives: Colorants. V. 62, No. 9, Sept. 1985, pp. 61-62.

[5]Japan Chemical Week. Titan Kogyo Plans Mass Production of Yellowish Iron Oxide. V. 26, No. 1327, Sept. 5, 1985, p. 2.

[6]Roskill Information Services Ltd. (London). Roskill's Letter From Japan. Ferric Oxide: Sales to Ferrite and Magnetic Tape Sectors Up 31%: Little Growth Anticipated for 1985. RLJ No. 114, Oct. 1985, pp. 8-10.

[7]Japan Chemical Week (weekly).

[8]Where appropriate, values have been converted from Japanese yen (Y) to U.S. dollars at a 1985 11-month average rate of Y241.78=US$1.00.

[9]Industrial Minerals (London). Spain's Industrial Minerals. No. 217, Oct. 1985, pp. 23-63.

[10]National Materials Advisory Board, Commission on Engineering and Technical Systems. Magnetic Materials. Natl. Res. Counc., Natl. Mater. Advis. Board, Publ. NMAB-426, Natl. Acad. Press, Washington, DC, 1985, 90 pp.

[11]Flick, E. W. Printing Ink Formulations. Noyes Publ., 1985, 184 pp.

Iron and Steel

By Frederick J. Schottman[1]

Despite somewhat lower imports, steel production and shipments declined, remaining at relatively low levels. The industry operated at less than two-thirds of capability. Low shipments combined with price competition resulted in losses for many companies.

A major steel company entered bankruptcy and was struck by its unionized workers when it reduced pay and benefits. Other companies entered joint ventures with foreign steel companies. Although some older plants were closed, others were modernized with continuous casters or other equipment. Five new electrolytic galvanizing lines were being built.

Imports declined somewhat because of trade restraint agreements with exporting countries. New agreements were negotiated with additional countries, and coverage of restraints was expanded and extended for exports from the European Economic Community (EEC).

World production of steel remained well below capacity, and the steel industries in most industrialized countries reduced capacity. Expansion of capacity continued in certain countries with low labor cost, particularly China and the Republic of Korea.

Table 1.—Salient iron and steel statistics

(Thousand short tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Pig iron:					
Production	73,755	43,342	48,770	51,961	49,963
Shipments	74,218	43,449	49,081	52,164	50,010
Annual average composite price, per ton[1]	$204.66	$213.00	$213.00	$213.00	$213.00
Exports[2]	16	54	6	57	32
Imports for consumption[2]	468	322	242	702	338
Steel:[3]					
Production of raw steel:					
Carbon	101,462	64,143	73,783	79,918	76,699
Stainless	1,743	1,235	1,750	1,772	1,683
All other alloy	17,623	9,198	9,082	10,838	9,877
Total	120,828	[4]74,577	84,615	92,528	88,259
Capability utilization[5] ......percent	78.3	48.4	56.2	68.4	66.1
Net shipments of steel mill products	88,450	61,567	67,584	73,740	73,043
Finished steel annual average composite price ...... cents per pound[1]	24.224	25.271	26.190	27.313	27.582
Exports of major iron and steel products[2]	3,557	2,367	1,589	1,413	1,266
Imports for consumption of major iron and steel products[2]	20,818	17,385	17,964	27,488	25,707
World: Production:					
Pig iron	r553,186	r503,999	510,211	p546,317	e555,222
Raw steel (ingots and castings)	r778,948	r709,668	730,604	p782,008	e788,119

e Estimated. p Preliminary. r Revised.
[1] Iron Age.
[2] Bureau of the Census.
[3] American Iron and Steel Institute (AISI).
[4] Data do not add to total shown because of independent rounding.
[5] Raw steel production capability is defined by AISI as the tonnage capability to produce raw steel for a sustained full order book.

Domestic Data Coverage.—Domestic data for the iron and steel industry are developed by the Bureau of Mines from the annual "Blast Furnace and Steel Furnace Report." Of the 34 steel operations to which a survey request was sent, 68% responded, representing 71% of the total pig iron production shown in table 1. Production for nonrespondents was estimated using data from prior year reports and from published and privately communicated information.

Legislation and Government Programs.—The Environmental Protection Agency (EPA) listed coke oven emissions as hazardous air pollutants. The classification of the emissions as hazardous required strict regulation of emissions levels.

In another action, EPA proposed an August 8, 1988, deadline for ending land disposal of electric-furnace dusts that are classified as hazardous wastes. Some dusts contain toxic forms of elements such as lead, cadmium, and chromium, which may be leached into ground water. Various processes to recycle or to make the dusts nonhazardous were under study.

EPA also issued final waste water standards for the foundry industry, including iron foundries. The regulation specified the permitted discharge of certain pollutants for 28 processes used in foundries. In most cases, the best practicable technology will require high-rate recycling of process water with treatment of the fraction discharged.

DOMESTIC PRODUCTION

Production of raw steel and shipments of finished products declined slightly, continuing at historically low levels. Raw steel production remained under 93 million short tons for the fourth consecutive year, compared with an average output of 130 million tons per year for the decade prior to 1982. As in the other years since 1982, production in 1985 reached a peak early in the year and then declined. Raw steel production exceeded 72% of capability in March but dropped below 60% in December. The American Iron and Steel Institute (AISI) estimated that the raw steel capability of the industry declined from 135.3 million tons in 1984 to 133.6 million tons in 1985.

After a temporary increase in open-hearth steel production in 1984, production in such furnaces resumed its long-term decline in 1985. Basic oxygen furnaces (BOF), electric furnaces, and open-hearth furnaces produced 58.8%, 33.9%, and 7.3%, respectively, of raw steel. Requirements for raw steel were reduced by increased imports of semifinished steel, which was finished and shipped by domestic steel companies, and by the increased use of continuous casting, which increases the ratio of finished products to raw steel. The portion of raw steel that was continuously cast rose to 42.3% from 39.6% in 1984. The ratio had doubled since 1980.

Total shipments were little changed from those of 1984. Shipments of products such as structural shapes and piling used in commercial construction were higher than those of 1984. On the other hand, shipments of products for heavy construction, industrial equipment, and machinery such as plates, structural tubing, and bars were lower. Shipments of rails and accessories dropped 25%. Shipments of oil country tubular goods were also lower. The long-term decline for shipments of tin mill products continued. Overall, shipments of sheet and strip were little changed, but there was a shift from uncoated sheet and strip to galvanized.

Domestic shipments of ferrous castings declined 7% compared with those in 1984, according to U.S. Department of Commerce data. Shipments of ductile and malleable iron and castings were little changed, but shipments of gray iron castings declined about 10%. Domestic gray iron casting producers faced competition from low-priced imports of commodity-type castings such as manhole covers. Shipments of steel castings also declined because of weakness in the domestic heavy equipment and machinery industries. Shipments included 7.165 million tons of gray iron, 2.583 million tons of ductile iron, 0.378 million tons of malleable iron, and 0.889 million tons of steel castings.

Despite cost-cutting efforts, most major steel producers continued to be unprofitable. Of the six leading integrated steel companies, which produced almost two-thirds of domestic steel, only two reported profits. Wheeling-Pittsburgh Steel Corp. (W-P) suffered losses equal to over 40% of its sales because of a strike. On the other hand, Weirton Steel Corp. had its second profitable year since becoming an independent, employee-owned company.

Employment in the steel industry continued to decline. As reported to AISI, total annual average employment declined from

236,000 workers in 1984 to 208,000 in 1985. The industry employed 151,000 workers on wages and 57,000 on salaries. Employment had declined by more than one-half since 1979. AISI reported that average employment costs for hourly employees increased 7% to $22.81 per hour. Part of the increase was recovery by workers of part of the concessions made in contract talks in 1983.

Companies reduced salaried employment and pay and sought concessions from unions. In some cases, unusual features such as profit sharing or an all-salaried work force were introduced in contracts.

The multicompany committee that for almost 30 years had negotiated industrywide, pattern-setting contracts with the United Steelworkers of America was disbanded. The committee, which had at one time included almost all the major steel companies, had been reduced to five members as companies withdrew or were expelled for deviation from the pattern contract.

W-P, the seventh largest domestic steel company, entered chapter 11 bankruptcy. Unionized workers began a 98-day strike when the company, with bankruptcy court approval, revoked its labor contract and set reduced pay and benefit levels for its workers. The strike was finally settled with a new contract that reduced employment costs by about 16%. The actual loss by the workers was considerably less than 16%, however, because much of the cost savings resulted from the termination of an underfunded pension plan. The cost of pensions under the plan was thereby shifted to the Federal Pension Benefits Guaranty Corporation. The union agreed to changes to increase productivity that would result in the layoff of some workers. W-P later closed an inactive seamless tube mill and a hot strip mill at Allenport, PA.

Other companies also restructured and closed unneeded or high-cost capacity. Inland Steel Co. began to reduce the capacity at its Indiana Harbor Works, East Chicago, IN, by about 30% by closing the plant's seven open-hearth furnaces. Inland also closed two bar mills at Indiana Harbor, reducing its involvement in the bar market. LTV Steel Co. indefinitely closed all operations at its Aliquippa, PA, plant except for a structural mill and a tinplate line. Earlier in the year, the hot strip mill and seamless tube mill at Aliquippa were permanently closed. Armco Inc. also closed a tubular goods plant at Ambridge, PA. Minimills were closed by Soule Steel Corp., Carson, CA; Marathon Steel Corp., Tempe, AZ; Hurricane Industries Inc., Sealy, TX; Green River Steel Corp., Owensboro, KY; and Kentucky Electric Steel Co., Ashland, KY. Eastmet Corp. ended production of stainless steel sheet and strip at its Eastern Stainless Steel Co. plant in Baltimore, MD, but continued to produce plate. Enduro Stainless Inc., a new company that bought a stainless steel finishing plant in Massillon, OH, from LTV Steel in 1984, went bankrupt and closed in 1985.

The structure of the industry was further changed by corporate reorganization and sales. LTV Steel reorganized its plants into three subsidiaries organized along product lines. It then offered the profitable LTV Specialty Steel Inc. subsidiary for sale to raise cash. At yearend, final arrangements were being made to sell LTV Steel's Gadsden, AL, plant as Gulf States Steel Corp. to an investment group. LTV Steel had agreed in 1984 to divest the plant in order to gain antitrust approval of the merger of LTV Steel's steel operations with Republic Steel Corp.

Birmingham Bolt Co. acquired the Mississippi Steel Div. minimill in Jackson, MS, from the Magma Corp. North Star Steel Co. bought an 80% interest in the bankrupt Ohio River Steel Corp. rolling mill, Calvert City, KY, and bought the bankrupt Hunt Steel Co. plant in Youngstown, OH. The two plants were expected to broaden North Star's product range. The Ohio River Steel mill rolled medium structural shapes, and Hunt Steel produced seamless casings for oil and gas wells.

Continental Steel Corp. filed for bankruptcy but continued in operation. Phoenix Steel Corp., which had been in bankruptcy since 1983, was bought by a group of investors. Armco was selling its aerospace and nonsteel materials divisions to improve the company's financial position, and Cyclops Corp. was selling its steel divisions. Lone Star Steel Co. was spun off to the shareholders of its parent company.

United States Steel Corp. (USS) formed a joint venture with Pohang Iron and Steel Co. Ltd. (Posco) of the Republic of Korea to own and modernize USS's Pittsburg, CA, mill. The new company will invest $300 million over 4 years for new continuous pickling, cold rolling, and annealing lines. The Pittsburg plant processed hot-rolled coil from USS's Geneva, UT, plant but was expected to shift to coil from Posco's plants when import restrictions expire in 1989.

The Timken Co. started production at its new $500 million Faircrest plant at Canton, OH. The plant is designed to produce 500,000 tons of special-quality steel per year. It has a 96-megavolt-ampere, 160-ton electric furnace, scrap preheating, and ladle refining. Bottom-poured ingots and continuous rolling are used for high quality. The plant was highly automated and used only 80 production workers per shift.

Tuscaloosa Steel Corp. completed its new $75 million rolling mill in Tuscaloosa, AL. The Steckel strip mill had a capacity of 600,000 tons per year. Initially, the plant was expected to roll 250,000 tons of slab per year imported from British Steel Corp., which was a part owner of Tuscaloosa Steel.

Two minimills were installing new technology. At its Darlington, SC, plant, Nucor Corp. operated a direct-current arc furnace and signed a contract to convert another furnace to the Consteel continuous steelmaking process. Nucor also ordered an experimental Hazelett thin-slab caster that will, if successful, allow Nucor to enter the flat-rolled market. Meanwhile, Connecticut Steel Corp. was installing equipment for a 200,000-ton-per-year "micromill" at Wallingford, CT. The plant, which was expected to start up in 1986, was to use a Korf-Stahl AG Energy Optimizing Furnace that uses coal or other carbon to melt scrap.

Bethlehem Steel Corp. was installing slab casters at Burns Harbor, IN, and Sparrows Point, MD, with startup scheduled in 1986. USS was installing a 3.3-million-ton-per-year caster at Fairfield, AL, for a 1987 startup.

The Great Lakes Steel Div. of National Steel Corp. planned to build a new two-strand slab caster at Ecorse, MI. The company will also install a ladle metallurgy station at the plant as part of a $200 million modernization project. When completed in 1987, the 2.2-million-ton-per-year caster will allow Great Lakes Steel to continuously cast 100% of its production. Seattle Steel Inc. was modernizing its plant, which it bought from Bethlehem Steel in 1984, with a continuous billet caster and a new rod mill to increase total capacity to 540,000 tons of finished steel per year in 1986.

Despite the bankruptcy of W-P, Nisshin Steel Co. Ltd. and W-P signed an agreement to build a sheet coating line at Follansbee, WV. The $50 million plant was expected to be completed in 1987. Meanwhile, construction continued on five new electrogalvanizing lines. These lines, along with the Follansbee plant, were planned to provide corrosion-resistant steel with good surface finish to the automobile and appliance industries. The new electrogalvanizing lines were being built by National Steel at Ecorse, MI, with an annual capacity of 400,000 tons; by USS and the Rouge Steel Co. subsidiary of Ford Motor Co. at Dearborn, MI, with a 560,000- to 700,000-ton capacity; by LTV Steel and Sumitomo Metal Industries Ltd. at Cleveland, OH, with a 500,000-ton capacity; by Armco at Middletown, OH, with a 200,000- to 400,000-ton capacity; and by a joint venture of Bethlehem Steel, Inland, and Pre-Finish Metals Inc. at Walbridge, OH, with a 400,000-ton capacity.

Materials Used in Ironmaking.—Domestic pellets charged to blast furnaces in 1985 totaled 48.0 million tons, and sinter charged amounted to 18.6 million tons. Pellets and other agglomerates from foreign sources amounted to 7.9 million tons. A total of 10.9 million tons of iron ore was consumed by agglomerating plants at or near blast furnaces, producing 18.5 million tons of agglomerates. Other materials consumed by agglomerating plants were 2.6 million tons of mill scale, 0.9 million tons of flue dust, 0.8 million tons of coke breeze, and 4.1 million tons of fluxes.

Blast furnace oxygen consumption totaled 18.0 billion cubic feet according to AISI. Blast furnaces, through tuyere injection, consumed 20.5 billion cubic feet of natural gas; 3.2 billion cubic feet of coke oven gas; 111 million gallons of oil; and 26.5 million gallons of tar, pitch, and miscellaneous fuels.

Materials Used in Steelmaking.—According to AISI, steelmaking furnaces consumed 4.61 million tons of lime, 0.76 million tons of limestone, 0.40 million tons of fluorspar, 0.78 million tons of other fluxes, and 126 billion cubic feet of oxygen. Metalliferous materials consumed in domestic steel furnaces, per ton of raw steel produced, averaged 1,127 pounds of pig iron, 1,113 pounds of scrap, 25 pounds of ferroalloys, and 6 pounds of ore and agglomerates. The comparable figures for 1984 were 1,109 pounds of pig iron, 1,046 pounds of scrap, 25 pounds of ferroalloys, and 6 pounds of ore and agglomerates.

PRICES

The annual average composite price for finished steel in 1985, as reported by Iron Age, was 27.582 cents per pound, up only slightly from the average for 1984. The Iron Age composite remained unchanged from July 1984 through 1985. The composite price for pig iron remained unchanged since 1982 at $213 per ton.

Despite some easing of pressure from imports, transaction prices generally declined. As major integrated steel producers reduced production costs, they were able to reduce their sale prices in efforts to maintain or increase their market share. Discounts of 20% to 30% from list were reported for various products.

Increased competition between integrated mills and minimills tended to lower prices for special-quality bars. Some minimills were trying to improve their profitability by beginning to produce these higher quality bars with premium prices. Prices of other minimill products such as reinforcing bar were generally firm to slightly higher because of relatively strong construction activity. Reported prices for reinforcing bar were about 13 cents per pound.

Late in the year, major producers announced lower list prices for many products that were intended to bring list prices more in line with transaction prices. As announced, the lower list prices combined with reduced discounting would in effect slightly raise actual prices.

FOREIGN TRADE

Exports of major iron and steel products from the United States declined for the fifth consecutive year. Canada was again the most important importer of U.S. steel mill products, taking over one-third of the total. Exports to Mexico increased for the second year and were about one-sixth of total exports. The high value of the dollar kept U.S. steel relatively expensive in most foreign markets. Except for local trade with Canada and Mexico, much of the steel exported was specialized high-value products. The average value of steel mill products exported was $919 per ton compared with $394 for comparable products imported.

Imports of steel mill products declined, partly because of trade restrictions. On the other hand, imports of other steel products, including fabricated steel, and imports of iron products increased. Japan continued to be the leading exporter of steel mill products, shipping 6.0 million tons, which was down about 10% from the amount shipped in 1984. Canada, the second largest supplier, exported 2.9 million tons, down from 3.2 million tons in 1984. Imports from the Republic of Korea declined from 2.2 million tons in 1984 to 1.9 million tons. Imports from the EEC increased from 6.3 million tons in 1984 to 7.0 million tons in 1985. Among the EEC countries, the Federal Republic of Germany supplied 2.4 million tons; France, 1.6 million tons; Belgium-Luxembourg, 1.1 million tons; and Italy, the United Kingdom, and the Netherlands, about 0.6 million tons each. Imports from Spain, which was to join the EEC in 1986, declined from 1.4 million tons in 1984 to 0.5 million tons. Other important suppliers included Brazil, 1.7 million tons; Sweden, 0.7 million tons; and the Republic of South Africa, Venezuela, and Romania, about 0.4 million tons each.

Continuing the program begun in 1984, steel export restraint agreements were negotiated with nine additional countries. By yearend, of the countries exporting at least 200,000 tons of steel in 1985, only Canada, Sweden, and Taiwan remained without restraint agreements. The agreements were scheduled to limit exports to the United States until October 1, 1989.

The domestic steel industry continued to bring trade complaints against countries or products not covered by restraint agreements. Many of these cases were decided in favor of the domestic industry and resulted either in additional import duties or in the negotiation of new restraint agreements.

Negotiations were conducted with the EEC to expand the coverage and extend the export restraint agreement that had been in force since 1982. Early in the year, after the United States had unilaterally imposed a quota, a new agreement was reached to restrain pipe and tube exports. In the summer, another agreement restricted exports of most other products not included in the 1982 agreement. In November, an agreement was reached to extend the 1982 agreement and the new pipe and tube agreement until October 1989, when the restraint agreements negotiated with other countries were to expire. The new agreement was expanded to include most steel mill products other than semifinished steel. When no agreement was reached on semifinished steel by yearend, the United States unilaterally imposed a quota.

WORLD REVIEW

Australia.—The Broken Hill Pty. Co. Ltd. (BHP) began construction of a bar mill in Brisbane, Queensland. Plans by the Quest Corp. Pty. Ltd. for a rival minimill in Brisbane were abandoned when financing could not be obtained.

Austria.—Stahl-und Walzwerk Marienhutte GmbH, at its minimill in Graz, operated the first commercial wheel-and-belt rotary caster in Europe. Only two other Japanese casters of this type were in operation.

Brazil.—The coke ovens and billet mill at the new integrated Aço Minas Gerais S.A. (ACOMINAS) steel mill began production, but completion of other parts of the plant was delayed by lack of funds. As part of an austerity program, the Government of Brazil restricted the funds available to Siderúrgia Brasileira S.A. (SIDERBRÁS), the state-owned steel group that controls ACOMINAS. The sinter plant, blast furnace, and BOF shop were nearly complete. The equipment for section and rail mills was in storage at the plantsite, but installation was not expected to begin until at least 1987.

The sale of at least parts of the SIDERBRÁS companies to private investors was proposed to reduce the public sector debt.

Cia. Siderúrgica Belgo-Mineira S.A., controlled by Arbed S.A. of Luxembourg, started operation of a 1.1-million-ton-per-year BOF shop at its João Monlevade, Minas Gerais, plant. The shop will replace older furnaces as part of a modernization program that also includes a new continuous caster.

Brazilian producers continued to expand charcoal pig iron capacity. Four new 65,000-ton-per-year blast furnaces were being installed in northern Brazil near the new Carajás iron mine, and another 65,000-ton-per-year furnace was to begin operation in Minas Gerais State in the southeast. Most charcoal pig iron in Brazil has been produced in Minas Gerais, but deforestation there was increasing shipping distances and driving up prices to producers there. As an alternative to pig iron and to scrap, which were in short supply, a group of privately owned minimills planned building a 390,000-ton-per-year gas-fueled, direct-reduction plant near a railway that carries ore from mines in Minas Gerais.

Canada.—Stelco Inc. continued a $300 million modernization program for its Hilton Works in Hamilton, Ontario. A slab caster and a convertible slab-billet caster were ordered for an early 1987 startup. Other improvements included modifications to a BOF, a bar mill, and a heat treating furnace. Another billet caster was planned for late in the decade. Stelco closed several older facilities at other plants for pipe, wire, and fastener production that were no longer competitive. Sydney Steel Corp., Sydney, Nova Scotia, received $110 million from the Federal and Provincial governments to modernize its steel mill. An electric furnace, which will use pig iron from the blast furnace as well as scrap, will replace the existing open hearths, and a ladle refining unit will upgrade quality. Although the changes will reduce the plant's raw steel capacity of 1.1 million tons by about 50%, the remaining capacity would be sufficient for expected markets.

QIT-Fer et Titane Inc. was constructing a new steel shop at its Sorel, Quebec, ilmenite smelter. The $70 million project includes a BOF, a ladle refining unit, and a four-strand billet caster. The plant will produce steel from pig iron that is produced as a byproduct of titanium slag production. Up to 225,000 tons of billets per year will be sold under a 6-year contract to Ivaco Inc. for production of wire rod, and other billets will also be marketed. The plant will also supply liquid steel to a 41,000-ton-per-year steel powder plant being built by Quebec Metal Powders Ltd. (QMP). QMP has an existing plant to produce up to 56,000 tons of iron powder per year from QIT-Fer pig iron. QIT-Fer and QMP are both owned by Standard Oil Co. (Ohio).

Although Canada, unlike other major steel exporters to the United States, did not have a formal steel export restraint agreement with the United States, consultations took place between the two countries. At the request of the Canadian steel pipe producers, the Government imposed country-of-origin marking requirements on imported pipe. The producers feared that pipe from third countries would be reexported to the United States and counted as Canadian, further increasing pressure for trade restraints. Late in the year, the Government made a preliminary finding that certain oil well casings from the United States and from other countries were being dumped in Canada.

China.—China continued to expand its iron and steel capacity. The first stage of the new steel mill at Baoshan began production with a capacity of 3.3 million tons of raw steel per year. Plans for a third stage were officially approved. Construction starting in 1991 was to raise capacity to 11 million tons per year.

Other plants were being expanded. Second-stage construction of the Panzhihua plant would add a new blast furnace and raise steel capacity by 40% to 2.7 million tons per year. Expansion at Maanshan would triple capacity to 3 million tons per year. A new blast furnace, new BOF's, and a new plate mill were being added. Older open-hearth furnaces were to be phased out as the BOF's became operational. Raw steel capacity at Handan was to be raised from 1.1 to 1.5 million tons per year.

China was attempting to minimize the cost of its expansion program by buying used equipment. Two rebuilt electric furnaces and a rod mill were bought from U.S. companies.

Egypt.—Alexandria National Steel Co.'s new El Dikheila plant on the outskirts of Alexandria was nearing completion for a 1986 startup. The plant will have an 800,000-ton-per-year Midrex direct-reduction unit, a 900,000-ton-per-year melt shop, and bar and rod mills.

European Economic Community.—The EEC countries agreed to extend their system of steel market controls for up to 3 years after their original expiration at the end of 1985. The 3-year period was to be used to phase out the controls gradually to avoid the disruption of a sudden return to a free market. The controls included production quotas, minimum prices, and import restraints. The EEC reaffirmed that investment and operating subsidies by governments would not be permitted after the end of 1985, although aid for research, pollution control, and plant closings would be allowed in some circumstances.

The EEC continued to restrict imports of steel, using quotas and bilateral agreements with exporting countries. In general, the new agreements negotiated in 1985 would allow about 3% more steel to be exported in 1986. Special agreements were negotiated with Spain and Portugal, which were to join the EEC in 1986. Exports from Spain and Portugal to other EEC countries were to be restricted during a transition period during which those countries were to be allowed to subsidize the restructuring of their steel industries.

Finland.—Outokumpu Oy planned to install a $100 million hot strip mill at its stainless steel plant in Tornio. Production of stainless steel began in 1976, but slabs were shipped to other companies for hot rolling. The mill was expected to operate in late 1987.

France.—The two major state-owned steel companies, Union Sidérurgique du Nord et de l'Est de la France S.A. (Usinor) and Société Aciéries et Laminoirs de Lorraine (Sacilor), continued to restructure. The companies were evolving into holding companies as they set up their operating parts as subsidiaries. The Government of France provided over $2 billion in assistance to strengthen the companies financially before the EEC deadline for such aid. Ownership of two jointly owned subsidiaries of Usinor and Sacilor was shifted entirely to Sacilor as part of the arrangement dividing state aid between the two companies. The two subsidiaries, Ascométal and Unimétal, had been set up in 1984 by merging parts of the bar, rod, and wire operation of Usinor and Sacilor.

Germany, Federal Republic of.—A proposed merger between Krupp-Stahl AG and Klöckner Werk AG was called off, reportedly because the companies and the Federal Government could not agree on the amount of financial aid the merged company would receive to cover the cost of plant closings and layoffs. Regional governments reportedly opposed the merger because of job losses. After the breakdown of merger talks, Krupp-Stahl and Klöckner planned their own rationalization programs. Krupp-Stahl planned to reduce its employment by 2,000 from 28,000 by the end of 1987.

The Saarland regional government was trying to work out a plan to keep Arbed Saarstahl GmbH out of bankruptcy. The plan would transfer controlling ownership of Arbed Saarstahl from Arbed SA of Luxembourg to a trust with a Saar bank. Arbed Saarstahl would be managed by AG der Dillenger Huttwerke, another Saar steelmaker.

India.—The Steel Authority of India Ltd. continued its expansion and modernization programs. Major expansions at Bhilai and Bokaro were to raise capacity at each plant to 4.4 million tons of raw steel per year. Other mills were being modernized.

Work on the new steel mill at Vishakhapatnam, the Government's other major steel project, was proceeding but was slowed by lack of funds. Alternative scaled-down plans were proposed for possible new integrated plants at Vijayanagar and Daitari.

A 170,000-ton-per-year SL/RN direct-reduction plant was ordered by Bihar Sponge Iron for installation at Chandil, Bihar. The plant was intended to supply iron to existing minimills in the region.

Ireland.—Union workers at the Irish Steel Ltd. minimill accepted a wage freeze and a reduction in employment in order to keep Ireland's only steel mill open. Although the EEC had approved financial aid, the Irish Government refused to provide assistance unless labor costs were reduced.

Italy.—Production of iron and steel was restarted at the Cornigliano works, near Genoa, of Ste. Finanziaria Siderurgica p.A. (Finsider) to produce billets for Finsider plants and for private steelmakers. Cornigliano had been shut down when its production quota for sheet had been used to reopen the Bagnoli plant in 1984. Higher costs for electricity and scrap made billets from Cornigliano attractive as a substitute for steel made in electric-furnace plants. Privately owned Acciaierie e Ferriere Lombarde Falck S.p.A. offered to close its hot strip mill near Milan and to transfer its production quota to Bagnoli in exchange for a Finsider plate plant and financial assistance from the Italian Government. Similarly, minimills received assistance in closing excess uneconomical electric furnace capacity.

Japan.—The Japanese steel industry planned slightly lower capital spending in fiscal 1985, the third consecutive drop. Most spending was intended to improve quality or productivity. Major steel companies were diversifying into nonsteel areas because of increasing difficulty competing in international markets. Nippon Steel Corp., the largest steel company in Japan, proceeded with its planned capacity reduction. Nine inactive blast furnaces were to be scrapped. Sumitomo Metal Industries Ltd. planned a 3-year program that was to reduce employment by 14%. Tokyo Steel Manufacturing Co. Ltd., the largest nonintegrated steel company in Japan, closed its Senju plant in Tokyo because of inadequate sales in export markets.

Korea, Republic of.—Construction of ironmaking and steelmaking facilities began on the new Kwangyang integrated steel mill of Posco. The first stage, with a capacity of 3 million tons of raw steel per year, was scheduled to be completed in June 1987, and a second stage, by the end of 1988. The plant is designed for eventual expansion to 13 million tons of capacity per year. Posco was also adding a second cold-rolling mill, with a capacity of 1 million tons per year, and a third continuous caster at its Pohang plant.

Libya.—Construction continued on the 1.2-million-ton-per-year Misratah plant, with startup expected in 1986. The plant will use natural-gas-based direct reduction to provide iron for electric-furnace steelmaking.

Malaysia.—A 660,000-ton-per-year direct-reduction plant began operation at the new Perwaya Terengganu Sdn. Bhd. steelworks, a joint venture firm of Heavy Industries Corp. of Malaysia Bhd. The plant is the first commercial user of direct-reduction technology developed by Nippon Steel. The steelworks had three 80-ton electric furnaces and ordered a 280,000-ton-per-year section mill.

Mexico.—Raw steel production declined 3% because of continued weakness of the domestic economy and a 54% drop in exports. Most of the decline in exports was because of the restraint agreement limiting exports to the United States.

Construction of the second stage of the Siderúrgica Lázaro Cárdenas-Las Truchas S.A. (SICARTSA) works at Las Truchas, Michoacán, was slowed because of Federal Government budget reductions. The works, which were to begin some operations in late 1985, included a 2.2-million-ton-per-year HYL III direct-reduction plant, four 220-ton electric furnaces, three two-strand slab casters, and a plate mill.

Tubos de Acero de México S.A. (TAMSA) was building a 660,000-ton-per-year electric-furnace melt shop to supply its seamless tube mill. It also planned to double its direct-reduced iron capacity to 770,000 tons per year in order to reduce its need for scrap. Another company, Productora Mexicana de Tuberia, began production of large-diameter linepipe at its new mill at Lázaro Cárdenas. The 330,000-ton-per-year plant was planned to use plate from the new SICARTSA plate mill. The company is owned by Siderúrgica Mexicana S.A. (SIDERMEX), which is the Government's steel industry holding company, by the Mexican development bank, and by a consortium of Japanese companies.

New Zealand.—New Zealand Steel Ltd. expected to complete the expansion of its raw steel capacity from 160,000 to 800,000 tons per year. The company was also adding new rolling mills for plate and sheet, which were scheduled to start up in 1986.

Norway.—The Christiania Spigerverk steel mill of Elkem A/S was merged with state-owned A/S Norsk Jernverk (NJ). In return, Elkem received a payment plus a 20% interest in NJ.

A rotary kiln direct-reduction plant was being installed at the K/S Ilmenittsmelteverket A/S plant to produce iron from ilmenite ore.

Portugal.—State-owned Siderurgia Nacional EP received approval to modernize its Seixal works near Lisbon. A new six-strand continuous caster was to be installed, and the BOF and a rolling mill were to be upgraded. The caster is part of the equipment ordered, and then put in storage, for a large-scale expansion plan that was canceled in 1982 because of the steel market downturn. Portugal was trying to modernize its industry before Government subsidies are forbidden after Portugal joins the EEC.

South Africa, Republic of.—South African Iron and Steel Industrial Corp. Ltd. (Iscor) ordered a KR process ironmaking plant for its Pretoria works. The 330,000-ton-per-year plant would be the first commercial application of the new technology to produce molten pig iron using noncoking coal. Because the Republic of South Africa lacks sufficient high-grade coking coals, Iscor was shutting down blast furnaces and replacing their output with direct-reduced and KR iron. In other modernization, Iscor commissioned two 140-ton electric furnaces at Pretoria. The furnaces were bought secondhand from British Steel.

Spain.—Restructuring of the Spanish steel industry continued as Spain prepared to join the EEC. Altos Hornos de Vizcaya S.A. started up a new meltshop with three 110-ton BOF's and two of three continuous casters being built at the Sestao works near Bilbao. Spain's largest steel company, Empresa Nacional Siderúrgica S.A. (ENSIDESA), was modernizing its Avilés plant with a new 2.8-million-ton-per-year, two-vessel BOF shop. The new shop will replace two older shops. Two continuous casters were also being installed, and the hot strip mill was being modernized. Siderúrgica del Mediterráneo, a newly created subsidiary of ENSIDESA, took over the cold-rolling mill and a new electrogalvanizing line being built at the Sagunto works of Altos Hornos del Mediterráneo S.A. (AHM). The blast furnaces and BOF's at AHM were closed down. Olarra S.A., a specialty steelmaker, started operating a new 30-ton electric furnace, replacing three smaller units, and a new rolling mill. It also began installation of a horizontal continuous caster.

Spanish steel producers were modernizing to reduce costs in preparation for Spain's entry into the EEC. During the 3-year transition period beginning in 1986, Spain's exports to other EEC countries were to be limited by quotas, while other EEC countries could ship freely into the Spanish market.

Sweden.—Continuing the restructuring begun in 1984, Avesta AB closed a cold-rolling strip mill at Avesta and the melt shop at Fagersta. Avesta AB is the descendant company from the merger of most of the Swedish stainless steel industry in 1984.

Turkey.—A third blast furnace and a third BOF increased the capacity of the state-owned Iskenderun plant from 1.3 to 2.4 million tons per year. A continuous bloom caster and two new rolling mills were also being added. The Government also approved plans to expand its other plant at Karabük.

U.S.S.R.—A new 5-year plan, beginning in 1986, emphasized modernization and quality improvements rather than higher production in the iron and steel industry. Up to 33 million tons of capacity in open-hearth furnaces, which still produced over one-half of Soviet steel in 1985, was to be replaced by BOF's or electric furnaces. Continuous casting was to be more than doubled to improve yield. Production of more sophisticated products such as specialty steels, oil country tubular goods, and high-quality cold-rolled and coated sheet was to be increased in order to satisfy increased demand and to reduce reliance on imports.

A $975 million contract was signed with an Italian company to build an 800,000-ton-per-year oil country tubular goods mill at Volzhskiy. The plant was to have a 1.1-million-ton-per-year electric-furnace shop, which will supply rounds to an existing pipe mill as well as to the new mill.

The second of four Midrex direct-reduction furnaces came on-line at the Oskol Electro-Metallurgical Combine (OEMK) in Kursk. Two additional units under construction will bring capacity to 1.8 million tons per year. Eventually, capacity is planned to be tripled with the addition of eight more units. The OEMK works included a pelletizing plant, electric furnaces, and rolling mills for producing specialty steels.

In 1985, two new minimills started production at Rybnitsa, Moldavia, and at the Komsomol'sk-na-Amure plant in the Far East. The new minimills are part of a shift away from the very large integrated steelworks that the U.S.S.R. has traditionally built.

TECHNOLOGY

Development continued on casting thin slab or strip. The U.S. Department of Energy provided funding for two projects. In the first, USS and Bethlehem Steel were jointly trying to cast slab less than 1 inch thick using a Hazelett double-belt casting machine. In the second, Westinghouse Electric Corp. and Armco were developing a process to cast thin strip onto a large wheel. Allegheny Ludlum Steel Corp. was independently working on a similar process.[2] Nucor was trying to commercialize the Hazelett process for products where surface quality is not critical.

New steelmaking technology was beginning commercialization. Plasma furnaces, compared to conventional electric furnaces, offered savings on electrode costs, low noise, low shock load on the electrical system, and better yield.[3] The development of alternating current plasma torches offered the possibility of lower cost plasma furnaces.[4] Higher productivity could be obtained from a conventional electric furnace using the Consteel process. In the process, scrap is fed to the furnace almost continuously, except just before tapping, and the furnace is run at full power continuously.[5] As an alternative to electric furnaces, the energy-optimizing furnace could offer lower cost melting of scrap. In the process, energy is obtained from carbonaceous fuel injected through submerged tuyeres and energy efficiency is increased by preheating the scrap.[6]

Alternative processes for smelting iron were being tested. Allis-Chalmers Corp. tested a combined pelletizing and direct-reduction system. Hot pellets from a traveling grate furnace were fed directly to a coal-fired rotary kiln for reduction.[7] A joint research project supported by Pickands Mather & Co., Westinghouse, and Minnesota Power & Light Co. investigated a plasma process for producing molten iron from iron ore concentrates. Low-grade carbonaceous materials can be used as reductants.[8] A cold-bonding process to produce self-reducing pellets was demonstrated. Because the carbonaceous reductant is mixed with the iron oxide, the reduction reaction is rapid. The pellets can be reduced in a conventional blast furnace or hot-blast cupola to produce molten iron, or in a rotary kiln to produce sponge iron. The process was reportedly suitable for recycling steel plant wastes.[9]

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[1]Physical scientist, Division of Ferrous Metals.

[2]33 Metal Producing. Three "Thin" Ways To Trim Steel's Hot End. V. 23, No. 4, Mar. 1985, pp. 46-49.

[3]Knoppek, T. Initial Results From the Voest-Alpine Plasma Furnace. Iron and Steel Eng., v. 62, No. 5, May 1985, pp. 23-26.

[4]Neuschutz, D., H. Rossner, H. J. Bebber, and J. Hartwig. Development of 3-Phase A-C Plasma Furnaces at Krupp. Iron and Steel Eng., v. 62, No. 5, May 1985, pp. 27-33.

[5]Vallomy, J. A. Continuous Electric Furnace Steelmaking—The CONSTEEL Process. Iron and Steel Eng., v. 62, No. 11, Nov. 1985, pp. 44-47.

[6]Bonestall, J. E., and R. Weber. EOF (Energy Optimizing Furnace) Steelmaking. Iron and Steel Eng., v. 62, No. 10, Oct. 1985, pp. 16-22.

[7]33 Metal Producing. A "New" Direction in Direct Reduction. V. 23, No. 4, Apr. 1985, p. 70.

[8]Peters, H. Making the Most of Mesabi Ore. Met. Bull. Monthly, Mar. 1985, pp. 11-17.

[9]Weiss, F. J., A. Goksel, and F. T. Kaiser. Production of Hot Metal From Carbon-Bearing Iron Oxide Pellets by the Pelle Tech (PTC) Process. Iron and Steel Eng., v. 63, No. 2, Feb. 1986, pp. 34-40.

Table 2.—Pig iron produced and shipped in the United States in 1985, by State

State	Production (thousand short tons)	Shipped from furnaces: Quantity (thousand short tons)	Shipped from furnaces: Value (thousands)	Average value per ton at furnace
Alabama, Kentucky, Maryland	6,745	6,774	$1,442,050	$212.88
Illinois	2,921	2,921	480,795	164.60
Indiana	15,651	15,649	3,215,206	205.46
Michigan	4,770	4,772	845,942	177.27
Ohio	9,259	9,260	1,900,897	205.28
Pennsylvania	6,473	6,490	1,366,820	210.60
Texas, Utah, West Virginia	4,144	4,145	873,513	210.74
Total[1] or average	49,963	50,010	10,125,222	202.46

[1]Data may not add to totals shown because of independent rounding.

Table 3.—Foreign iron ore and manganiferous iron ore (excluding agglomerates) consumed in manufacturing pig iron in the United States, by source

(Thousand short tons)

Source	1984[1]	1985[2]
Brazil	679	40
Canada	256	1,456
Venezuela	994	1,202
Other countries	114	92
Total	2,043	2,790

[1]Excludes 10,054,084 tons used in making agglomerates.
[2]Excludes 9,798,277 tons used in making agglomerates.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grade[1]

Grade	1984			1985		
	Quantity (thousand short tons)	Value: Total (thousands)	Value: Average per ton	Quantity (thousand short tons)	Value: Total (thousands)	Value: Average per ton
Basic	51,526	$10,065,652	$195.35	49,333	$9,990,377	$202.51
Foundry	W	W	W	W	W	W
All other (not ferroalloys)	637	128,533	201.78	677	134,845	199.18
Total or average	[2]52,164	10,194,185	195.43	50,010	10,125,222	202.46

W Withheld to avoid disclosing company proprietary data; included with "All other."
[1]Includes molten iron transferred directly to steel furnaces.
[2]Data do not add to total shown because of independent rounding.

Table 5.—Iron ore and other metalliferous materials, coke, and fluxes consumed in blast furnaces, and pig iron produced in the United States, by State

(Thousand short tons unless otherwise specified)

State	Metalliferous materials consumed in blast furnaces: Iron and manganiferous ores: Domestic	Iron and manganiferous ores: Foreign	Agglomerates	Net ores and agglomerates[1]	Net scrap[2]	Miscellaneous[3]	Net total[4]	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made (short tons): Net ores and agglomerates[1]	Net scrap[2]	Miscellaneous[3]	Net total[4]	Coke and fluxes consumed per ton of pig iron (short tons): Net coke	Fluxes
1984:																
Illinois	1	--	4,296	4,287	412	133	4,832	1,774	504	3,042	1.409	0.135	0.044	1.588	0.583	0.166
Indiana and Michigan	5	33	33,000	32,825	304	709	33,838	10,580	585	20,963	1.566	.015	.034	1.614	.505	.028
Ohio	30	46	13,775	13,740	435	424	14,599	5,651	922	9,593	1.432	.045	.044	1.522	.589	.096
Pennsylvania	109	1,227	10,551	11,793	446	92	12,331	4,167	554	7,603	1.551	.059	.012	1.622	.548	.073
Alabama, Kentucky, Maryland	--	650	9,420	10,078	113	293	10,484	3,526	335	6,440	1.565	.017	.046	1.628	.548	.052
Texas, Utah, West Virginia	59	87	6,454	6,513	234	127	6,874	2,317	314	4,323	1.506	.054	.029	1.590	.536	.073
Total[4] or average	204	2,043	77,496	79,236	1,944	1,778	82,958	28,014	[5]3,214	51,961	1.525	.037	.034	1.596	.539	.062
1985:																
Illinois	--	--	4,139	4,124	447	157	4,728	1,659	385	2,921	1.412	.153	.054	1.619	.568	.132
Indiana and Michigan	6	15	31,669	31,469	1,040	589	33,097	10,252	582	20,421	1.541	.051	.029	1.621	.502	.029
Ohio	2	1,372	13,410	14,687	308	592	15,587	5,229	969	9,259	1.586	.033	.064	1.683	.565	.105
Pennsylvania	48	1,031	8,949	9,961	293	333	10,586	3,563	581	6,473	1.539	.045	.051	1.635	.550	.090
Alabama, Kentucky, Maryland	--	312	9,983	10,239	97	252	10,588	3,666	351	6,745	1.518	.014	.037	1.570	.544	.052
Texas, Utah, West Virginia	91	60	6,368	6,464	195	100	6,759	2,195	264	4,143	1.560	.047	.024	1.631	.530	.064
Total[4] or average	147	2,790	74,519	76,944	2,381	2,023	81,346	26,564	[6]3,132	49,963	1.540	.048	.040	1.628	.532	.063

[1]Net ores and agglomerates equal ore plus agglomerates plus flue dust used minus flue dust recovered.
[2]Excludes home scrap produced at blast furnaces.
[3]Does not include recycled material.
[4]Data may not add to totals shown because of independent rounding.
[5]Fluxes consisted of the following: 1,595,000 tons of limestone, less than 500 tons of burnt lime, 1,444,000 tons of dolomite, and 173,000 tons of other fluxes, excluding 2,244,000 tons of limestone, 71,000 tons of burnt lime, 1,904,000 tons of dolomite, and 96,000 tons of other fluxes used in agglomerating production at or near steel plants and an unknown quantity used in making agglomerates at mines.
[6]Fluxes consisted of the following: 1,651,000 tons of limestone, 6,000 tons of burnt lime, 1,310,000 tons of dolomite, and 165,000 tons of other fluxes, excluding 2,417,000 tons of limestone, 15,000 tons of burnt lime, 1,663,000 tons of dolomite, and 28,000 tons of other fluxes used in agglomerating production at or near steel plants and an unknown quantity used in making agglomerates at mines.

Table 6.—Number of blast furnaces in the United States, by State

State	1984			1985		
	In blast[1]	Out of blast	Total	In blast[1]	Out of blast	Total
Alabama	2	2	4	2	3	5
Illinois	4	1	5	4	2	6
Indiana	10	8	18	11	7	18
Kentucky	2	--	2	2	--	2
Maryland	2	2	4	3	1	4
Michigan	6	3	9	6	3	9
Ohio	11	10	21	11	8	19
Pennsylvania	8	14	22	9	11	20
Texas	1	--	1	1	--	1
Utah	2	1	3	2	1	3
West Virginia	3	1	4	3	--	3
Total	51	42	93	54	36	90

[1]In blast for 180 days or more during the year.

Table 7.—U.S. steel production, by type of furnace

(Thousand short tons)

Year	Open-hearth	Basic oxygen converter	Electric	Total
1981	13,452	73,231	34,145	120,828
1982	6,110	45,309	23,158	74,577
1983	5,951	52,050	26,615	[1]84,615
1984	8,336	52,822	31,370	92,528
1985	6,428	51,885	29,946	88,259

[1]Data do not add to total shown because of independent rounding.

Source: American Iron and Steel Institute.

Table 8.—Metalliferous materials consumed in steel furnaces[1] in the United States

(Thousand short tons)

Year	Iron ore[2]		Agglomerates[2]		Pig iron	Ferro-alloys[3]	Iron and steel scrap
	Domestic	Foreign	Domestic	Foreign			
1981	27	207	43	34	71,284	1,663	63,195
1982	29	64	31	58	42,395	947	40,379
1983	9	96	75	33	48,300	1,063	45,280
1984	43	98	78	43	51,291	[r]1,166	48,415
1985	54	91	79	29	49,257	1,088	49,889

[r]Revised.
[1]Basic oxygen converter, open-hearth, and electric furnaces.
[2]Consumed in integrated steel plants only.
[3]Includes ferromanganese, spiegeleisen, silicomanganese, manganese metal, ferrosilicon, ferrochromium, and ferromolybdenum. Includes ferroalloys added to steel outside the furnace.

Table 9.—U.S. consumption of pig iron, by type of furnace or other use

Type of furnace or other use	1983		1984		1985	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Basic oxygen converter	44,330	88.5	45,551	85.6	44,515	86.6
Open-hearth	3,918	7.8	5,720	10.7	4,737	9.2
Electric	341	.7	368	.7	503	1.0
Cupola	425	.8	469	.9	501	1.0
Air and other furnaces[1]	91	.2	92	.2	56	.1
Direct castings[2]	965	1.9	1,002	1.9	1,100	2.1
Total[3]	50,070	100.0	53,202	100.0	51,411	100.0

[1]Includes vacuum-melting furnaces and miscellaneous melting processes.
[2]Castings made directly from blast furnace hot metal. Includes ingot molds and stools.
[3]Data may not add to totals shown because of independent rounding.

Table 10.—U.S. consumption of pig iron,[1] by State

(Thousand short tons)

State	1984	1985
Arkansas	1	--
Connecticut	5	6
Georgia	1	2
Illinois	2,884	2,702
Indiana	16,206	16,016
Iowa	30	42
Kansas	3	8
Massachusetts	16	24
Michigan	5,179	5,088
Minnesota	28	17
Missouri	6	4
New Jersey	2	1
New York	22	16
Ohio	10,309	9,700
Oklahoma	11	W
Pennsylvania	7,701	6,775
Texas	646	525
Virginia	14	13
Wisconsin	46	51
Undistributed[2]	10,092	10,422
Total	53,202	[3]51,411

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Includes Alabama, California, Colorado (1984), Delaware, Florida, Kentucky, Maine, Maryland, New Hampshire, North Carolina, Oregon, Rhode Island (1984), South Carolina, Tennessee, Utah, Washington, West Virginia, and item indicated by symbol W.
[3]Data do not add to total shown because of independent rounding.

Table 11.—U.S. exports of major iron and steel products

Product	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	102,756	$27,638	73,536	$19,165	89,708	$28,000
Wire rods	6,346	7,246	8,744	10,187	4,922	8,047
Structural shapes, 3 inches and over	47,024	30,478	29,049	18,366	41,633	40,461
Structural shapes, under 3 inches	21,801	36,047	11,231	9,655	7,139	7,897
Sheet piling	2,097	11,527	3,355	2,655	628	466
Plates	101,982	61,875	88,185	54,162	82,988	57,784
Rails and track accessories	18,516	15,833	15,225	11,370	10,937	10,844
Wheels and axles	1,558	9,040	3,854	13,377	2,493	14,875
Concrete reinforcing bars	34,528	9,340	9,889	4,678	7,409	3,553
Bars, carbon, hot-rolled	36,592	17,759	32,162	16,377	27,577	11,842
Bars, alloy, hot-rolled	53,992	41,626	49,969	39,773	34,871	37,298
Bars, cold-finished	21,567	24,954	28,125	24,796	20,854	28,182
Hollow drill steel	1,378	3,279	2,123	2,920	1,062	1,891
Pipe and tubing	257,967	404,319	207,428	325,800	199,258	285,182
Wire	20,349	37,689	19,440	37,747	18,758	31,215
Nails, brads, spikes, staples	6,916	24,326	7,161	24,199	5,445	21,670
Blackplate	60,929	13,704	38,781	9,779	32,754	7,704
Tinplate and terneplate	188,628	83,826	138,764	70,149	141,729	64,463
Sheets, hot-rolled	42,544	32,934	51,580	39,220	56,696	35,429
Sheets, cold-rolled	50,431	47,126	51,202	46,236	46,465	47,968
Strip, hot-rolled	16,428	16,308	11,563	14,254	12,482	13,742
Strip, cold-rolled	26,152	42,255	26,182	46,696	23,827	41,073
Plates, sheets, strip, galvanized, coated or clad	78,142	55,665	69,736	62,450	60,319	55,493
Total	1,198,623	1,054,794	977,284	904,011	929,954	[1]855,078
Other steel products:						
Plates and sheets, fabricated	21,990	39,922	11,371	22,955	13,677	27,214
Structural shapes, fabricated	65,803	133,037	86,854	141,849	46,770	93,396
Architectural and ornamental work	3,643	15,178	2,207	9,186	1,765	8,174
Sashes and frames	9,197	38,069	8,986	31,894	6,815	20,339
Pipe and tube fittings	22,831	141,646	11,426	98,915	16,362	126,336
Pipe and tubing, coated or lined	13,025	17,533	7,778	12,535	5,472	8,010
Bolts and nuts	72,913	106,242	86,897	127,017	58,944	106,094
Forgings	33,048	55,132	41,739	63,515	46,269	68,444
Cast-steel rolls	977	2,347	1,438	2,415	1,471	2,389
Railway track material	3,215	4,788	2,550	3,661	2,843	5,276
Total	246,642	553,894	261,246	513,942	[1]200,387	465,672
Iron products:						
Cast-iron pipes, tubes, fittings	85,513	128,523	51,682	99,252	41,523	64,236
Iron castings	58,344	45,866	122,375	110,084	94,419	90,994
Total	143,857	174,389	174,057	209,336	135,942	155,230
Grand total	1,589,122	1,783,077	1,412,587	1,627,289	1,266,283	1,475,980

[1]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 12.—U.S. imports for consumption of pig iron, by country

Country	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Belgium-Luxembourg	915	$129	--	--	--	--
Brazil	135,955	14,413	421,176	$43,703	130,762	$13,772
Canada	94,802	16,004	171,708	29,638	166,291	29,920
China	--	--	--	--	1,968	330
France	772	101	1,704	253	7,241	1,219
South Africa, Republic of	9,650	1,259	31,489	4,593	30,504	4,936
Venezuela	--	--	54,274	3,815	--	--
Other	20	10	22,004	1,983	1,492	442
Total	242,114	[1]31,917	702,355	83,985	338,258	50,619

[1]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 13.—U.S. imports for consumption of major iron and steel products

Product	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	822,483	$176,621	1,515,734	$332,664	1,878,953	$385,462
Wire rods	1,188,918	392,317	1,594,437	540,315	1,479,749	501,994
Structural shapes, 3 inches and over	1,489,226	425,557	2,075,027	587,961	2,019,245	580,305
Structural shapes, under 3 inches	88,288	29,298	174,787	60,846	140,317	53,507
Sheet piling	69,050	26,744	80,709	30,862	102,790	37,837
Plates	1,393,378	358,945	1,880,297	539,927	2,303,682	628,335
Rails and track accessories	168,933	56,528	350,300	113,724	358,442	127,906
Wheels and axles	6,500	7,030	23,591	18,184	23,604	19,638
Concrete reinforcing bars	208,304	39,126	434,147	87,581	409,612	88,353
Bars, carbon, hot-rolled	322,518	109,504	540,302	184,926	445,001	152,544
Bars, alloy, hot-rolled	139,806	87,275	216,421	118,633	207,427	112,279
Bars, cold-finished	204,575	160,887	338,754	213,840	326,395	213,153
Hollow drill steel	--	--	1,811	2,310	1,260	1,383
Welded pipe and tubing	1,728,716	595,175	2,753,108	1,051,932	2,529,895	1,028,470
Other pipe and tubing	1,124,266	650,002	2,676,358	1,394,148	1,942,051	1,173,810
Wire	478,776	316,761	702,493	472,053	629,086	428,856
Wire nails	374,039	188,544	458,326	235,270	403,522	199,126
Wire fencing, galvanized	10,762	6,991	r12,011	r7,459	25,311	16,915
Blackplate	170,420	66,939	278,003	116,068	241,375	99,928
Tinplate and terneplate	293,819	168,413	373,277	203,147	419,242	222,114
Sheets, hot-rolled	2,030,684	545,735	2,690,721	782,510	2,433,705	708,727
Sheets, cold-rolled	2,425,167	886,228	3,672,456	1,499,599	2,803,532	1,208,379
Sheets, coated (including galvanized)	2,059,275	863,471	2,899,825	1,319,928	2,621,340	1,226,192
Strip, carbon, hot-rolled	32,530	11,491	79,592	25,373	62,154	19,353
Strip, carbon, cold-rolled	66,090	55,159	145,333	95,717	216,458	127,200
Strip, alloy, hot- or cold-rolled (including stainless)	27,798	47,447	51,604	86,441	67,849	105,585
Plates, sheets, strip, electrolytically coated (other than with tin, lead, or zinc)	110,067	61,448	149,624	79,656	186,485	98,291
Total	17,034,388	6,333,636	r26,169,048	r10,201,074	24,278,482	9,565,642
Other steel products:						
Plates, sheets, strip, fabricated	5,536	4,430	13,085	11,805	36,157	16,578
Structural shapes, fabricated	206,296	155,308	235,950	136,717	285,169	271,542
Pipe fittings	71,161	92,146	105,095	136,475	118,328	176,135
Rigid conduit	282	2,187	373	15,826	17,650	11,955
Bale ties made from strip	643	546	r940	r642	812	634
Nails, brads, spikes, staples, tacks, not of wire	40,670	46,977	48,662	61,217	45,801	60,298
Bolts, nuts, rivets, washers, etc.	450,707	473,157	684,761	753,707	638,314	724,509
Forgings	28,800	20,730	57,267	38,997	68,915	47,270
Total	804,095	795,481	r1,146,133	r1,155,386	1,211,146	1,308,921
Iron products:						
Cast-iron pipes, tubes, fittings	30,629	32,155	40,471	42,211	78,395	59,455
Iron castings	94,742	76,693	132,078	96,675	139,313	85,088
Total	125,371	108,848	172,549	138,886	217,708	144,543
Grand total	17,963,854	7,237,965	27,487,730	11,495,346	25,707,336	11,019,106

rRevised.

Source: Bureau of the Census.

Table 14.—Pig iron: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Algeria	989	[r]1,209	1,213	[r] [e]1,210	1,210
Argentina[3]	1,896	2,090	2,052	1,983	[4]2,557
Australia	7,529	6,565	5,561	5,874	[4]6,173
Austria	3,832	3,434	3,660	4,128	[4]4,117
Belgium	10,724	8,638	8,849	9,886	[4]9,611
Brazil[3]	11,901	11,935	14,269	18,960	[4]20,911
Bulgaria	1,667	1,717	1,789	1,739	[4]1,876
Burma	4	14	17	9	13
Canada	10,740	8,818	9,443	10,629	[4]10,646
Chile	642	500	595	654	[4]634
China	37,666	39,171	41,204	44,070	48,100
Colombia	257	271	266	299	[4]271
Czechoslovakia	10,354	10,500	10,434	10,539	10,500
Egypt	[e]240	125	216	248	250
Finland	2,180	2,157	2,092	2,242	2,000
France	19,035	16,569	15,274	16,578	[4]17,004
German Democratic Republic[5]	2,691	2,369	2,433	2,598	2,800
Germany, Federal Republic of	35,137	30,447	29,319	33,293	[4]34,719
Greece	[r]48	[r]121	152	152	150
Hungary	2,417	2,404	2,256	2,310	[4]2,309
India	10,443	10,582	10,016	10,342	[4]10,841
Iran[e]	600	700	800	800	800
Italy	13,514	12,717	11,399	12,818	[4]12,851
Japan	88,238	85,603	80,398	88,629	[4]88,812
Korea, North[e]	5,500	5,800	6,100	6,300	6,400
Korea, Republic of	8,739	9,309	8,845	9,660	9,700
Luxembourg[5]	3,185	2,852	2,553	3,051	[4]3,037
Mexico[3]	6,011	5,625	5,549	5,895	[4]5,483
Morocco[e]	13	13	17	17	17
Netherlands	5,071	3,987	3,800	5,430	[4]5,313
New Zealand[e 3]	165	165	170	190	190
Norway	[r]647	[r]503	623	631	670
Pakistan[e]	[r]200	[r]470	[r]520	[r]624	[4]885
Peru[3]	266	225	154	68	235
Poland	10,307	9,395	10,710	11,002	11,000
Portugal	452	237	391	411	[4]456
Romania	9,763	9,521	9,028	[e]8,900	8,900
South Africa, Republic of	8,119	7,454	5,746	6,013	[4]7,247
Spain	7,080	6,604	5,950	5,884	[4]6,037
Sweden[3]	2,131	2,076	2,328	2,561	2,650
Switzerland	[r]36	[r]11	11	60	55
Taiwan	1,776	2,971	3,764	3,704	3,750
Thailand	11	7	([6])	--	--
Trinidad and Tobago (sponge iron)	198	261	313	263	230
Tunisia	[r]174	[r]107	162	165	165
Turkey	[r]2,260	[r]2,396	2,997	3,161	3,245
U.S.S.R	118,141	116,955	120,923	122,238	121,000
United Kingdom	10,439	9,179	10,447	10,458	11,600
United States	73,755	43,342	48,770	51,961	[4]49,963
Venezuela[3]	2,458	2,598	2,476	3,511	3,300
Yugoslavia	3,105	2,980	3,136	3,147	[4]3,439
Zimbabwe	[e]440	[e]300	1,021	1,022	1,100
Total	[r]553,186	[r]503,999	510,211	546,317	555,222

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table excludes ferroalloy production except where otherwise noted. Table includes data available through June 24, 1986.

[2]In addition to the countries listed, Vietnam and Zaire have facilities to produce pig iron and may have produced limited quantities during 1981-85, but output is not reported and available general information is not adequate to permit formulation of reliable estimates of output levels.

[3]Includes sponge iron output.

[4]Reported figure.

[5]Includes blast furnace ferroalloys.

[6]Less than 1/2 unit.

Table 15.—Raw steel:[1] World production, by country[2]

(Thousand short tons)

Country[3]	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	[4]575	630	660	770	830
Angola[e]	11	11	11	11	11
Argentina	2,784	3,211	3,244	2,918	[4]3,242
Australia	8,416	7,023	6,200	6,943	7,290
Austria	5,132	4,694	4,862	5,368	5,200
Bangladesh[5]	153	120	52	80	[4]111
Belgium	13,645	10,931	11,196	12,459	[4]11,788
Brazil	14,584	[r]14,330	16,160	20,267	[4]22,549
Bulgaria	2,738	2,848	3,121	3,172	[4]3,225
Canada	16,326	12,965	14,140	16,220	16,500
Chile	710	542	681	763	[4]751
China	39,242	40,962	44,040	47,800	51,500
Colombia	443	466	531	550	[4]584
Cuba	364	332	401	373	410
Czechoslovakia	16,832	16,526	16,561	16,348	[4]16,574
Denmark	675	617	543	604	580
Ecuador	31	31	25	20	[4]20
Egypt	[r]243	[r]125	216	248	250
El Salvador[e]	11	8	17	[r]12	11
Finland	2,676	2,661	2,663	2,901	2,750
France	23,433	20,300	19,426	20,944	[4]20,759
German Democratic Republic	8,231	7,902	7,958	8,348	[4]8,708
Germany, Federal Republic of	45,867	39,551	39,384	43,419	[4]44,644
Greece	1,002	[r]1,028	946	987	[4]1,086
Hong Kong[e]	130	130	130	130	130
Hungary	4,016	4,081	3,986	4,134	[4]4,020
India[6]	11,442	11,811	11,359	11,402	11,970
Indonesia	551	551	882	[e]1,100	1,500
Iran[e]	1,300	1,300	1,500	1,300	1,300
Iraq[e]	50	50	([7])	([7])	--
Ireland	35	61	150	[r] [e]170	220
Israel	[r]132	[r]132	165	[e]220	170
Italy	27,312	26,434	23,891	26,484	[4]26,173
Japan	112,078	109,733	107,121	116,389	[4]116,052
Jordan	149	154	[e]150	[e]150	150
Kenya[e]	11	11	11	11	11
Korea, North[e]	6,100	6,400	6,700	7,200	7,200
Korea, Republic of	11,854	12,955	13,134	14,366	14,900
Luxembourg	4,178	3,869	3,631	4,395	[4]4,349
Malaysia[e]	230	230	390	390	390
Mexico	8,447	7,778	7,692	8,277	[4]8,015
Morocco[e]	7	7	7	7	7
Netherlands	6,032	4,791	4,935	6,326	[4]6,063
New Zealand	255	278	257	302	250
Nigeria[e]	17	110	150	[r]200	[4]280
Norway	935	847	987	1,009	1,000
Pakistan[e]	390	390	600	[r]670	770
Peru	401	302	330	377	[4]453
Philippines	386	386	220	[e]280	220
Poland	17,327	16,309	17,897	18,224	[4]17,747
Portugal	607	556	734	757	[4]731
Qatar	499	524	526	[e]538	540
Romania	14,358	14,391	13,881	15,914	[4]15,212
Saudi Arabia	[e]80	[e]77	303	928	940
Singapore[e]	386	386	386	390	390
South Africa, Republic of	9,925	9,117	7,926	8,628	8,300
Spain	14,233	14,506	14,034	14,864	[4]15,691
Sweden	[r]4,168	[r]4,339	4,537	5,186	5,200
Switzerland	1,065	1,047	920	1,078	1,100
Syria[e]	120	[4]109	90	[r]76	76
Taiwan	3,465	4,495	5,530	[e]5,500	5,500
Thailand	331	344	269	[e]280	280
Trinidad and Tobago	58	[r]197	231	219	[4]184
Tunisia[e]	[r]176	[r]110	[r]165	[r]165	165
Turkey	[r]2,673	[r]3,134	4,227	4,729	[4]5,469
U.S.S.R	163,632	162,221	168,118	170,018	171,000
United Kingdom	17,170	15,106	16,519	16,668	[4]17,331
United States	120,828	74,577	84,615	92,528	[4]88,259
Uruguay	17	31	51	53	50

See footnotes at end of table.

Table 15.—Raw steel:[1] World production, by country[2] —Continued

(Thousand short tons)

Country[3]	1981	1982	1983	1984[p]	1985[e]
Venezuela[6]	2,003	2,531	2,820	3,241	3,500
Vietnam[e]	120	130	110	110	110
Yugoslavia	4,383	4,244	4,558	4,669	[4]4,938
Zimbabwe	762	582	741	431	440
Total	[r]778,948	[r]709,668	730,604	782,008	788,119

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Steel formed in first solid state after melting, suitable for further processing or sale; for some countries, includes material reported as "liquid steel," presumably measured in the molten state prior to cooling in any specific form.
[2]Table includes data available through June 24, 1986.
[3]In addition to the countries listed, Ghana, Libya, and Mozambique are known to have steelmaking plants, but available data are insufficient to make reliable production estimates. Burma reportedly has a remelt capacity of 40,000 tons; however, plant output, if any, is not known.
[4]Reported figure.
[5]Data are for year ending June 30 of that stated.
[6]Includes steel castings.
[7]Revised to zero.

Iron and Steel Scrap

By Franklin D. Cooper[1]

Brokers, dealers, and other outside sources supplied domestic consumers with 37.4 million tons[2] of all types of ferrous scrap at a delivered value of approximately $2.94 billion, while exporting 9.95 million tons valued at $918 million. In 1984, domestic consumers received 34.3 million tons at a delivered value of approximately $2.82 billion, while exports totaled 9.5 million tons valued at $918 million.

Domestic Data Coverage.—Domestic production data for ferrous scrap are developed by the Bureau of Mines from voluntary monthly or annual surveys of U.S. operations. Of the operations to which a survey request was sent, 76% responded, representing an estimated 80% of the total consumption shown in table 2 for three types of scrap consumers. Consumption for the nonrespondents was estimated using prior reports adjusted by industry trends. An estimation error is also contained in the difference between the reported total consumption of purchased and home scrap and the sum of scrap receipts plus home scrap production, less scrap shipments, and adjustments for stock changes. For scrap consumption data shown in table 2, this difference amounted to 1% for the manufacturers of pig iron and raw steel and castings, 0.3% for the manufacturers of steel castings, and 3% for iron foundries and miscellaneous users.

Table 1.—Salient U.S. iron and steel scrap and pig iron statistics

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
Stocks, Dec. 31:					
Scrap at consumer plants	8,118	6,418	5,807	5,261	5,104
Pig iron at consumer and supplier plants	859	622	345	304	266
Total	8,977	7,040	6,152	5,565	5,370
Consumption:					
Scrap	85,097	56,386	61,782	65,702	70,493
Pig iron	75,040	44,409	50,070	53,202	51,411
Exports:					
Scrap (excludes rerolling material and ships, boats, and other vessels for scrapping)	6,415	6,804	7,520	9,498	9,950
Value	$638,644	$610,302	$636,723	$917,981	$918,186
Imports for consumption:					
Scrap (includes tinplate and terneplate)	556	468	641	572	601
Value	$62,126	$37,572	$48,219	$46,946	$45,620

Legislation and Government Programs.—On July 12, 1985, the President signed compromise legislation (S. 883) to reauthorize the Export Administration Act of 1979 and for other purposes. This Public Law 99-64 included limited contract sanctity, clarified the foreign availability test, and required the President to consult with an affected industry before imposing export policy controls.

Findings of the U.S. International Trade Commission (ITC), published in May 1985, indicated that imports of slab steel in the 1979-83 period had no significant impact on the U.S. ferrous scrap industry.

Rhode Island's tax administrator determined that a scrap metal processor producing tangible personal property for sale was exempt from the State's sales and use taxes on new equipment purchased and that its investment in processing equipment was classed as an investment tax credit.

Massachusetts was the 50th State to classify a scrap metal processor as a manufacturing business.

AVAILABLE SUPPLY, CONSUMPTION, AND STOCKS

In expectation of a severe winter, steel producers built up their stocks and then drastically reduced purchases in early spring. Scrap processors in the Midwest reluctantly agreed to overnight delivery to some purchasers who maintained small stocks. Scrap processors in the South sold scrap at bargain prices to maintain some cash flow. An oversupply of ferrous scrap in the Pittsburgh area was further increased by the fabrication of domestic-made and imported steel products. LTV Steel Co.'s Pittsburgh Works with two electric arc furnaces (EAF) was the principal consumer at a maximum 50,000- to 60,000-ton-per-month demand. In August, scrap demand for the Pittsburgh area foundries was at such a low level that it was difficult to set prices on foundry scrap grades. Scrap demand was further decreased in the area because LTV no longer made steel in its Aliquippa Works and Wheeling-Pittsburgh Steel Corp.'s plants were strikebound for 2 months.

Raw steel production was 88.3 million tons compared with 92.5 million tons in 1984. Raw steel capacity utilization was 66.1% in 1985 compared with 68.4% in 1984.

Steel mills accounted for 71.9% of all scrap received from brokers, dealers, and other outside sources; steel foundries received 4.1%, and iron castings producers and miscellaneous users received 24.0%.

The apparent consumption of scrap, in million tons, comprised 38.8 net receipts (total receipts minus shipments), 30.5 home scrap, 0.6 imports, and 0.2 withdrawals from stocks for a total of 70.1.

The 1984-85 status of U.S. manufacturing sectors that were major consumers of iron and steel products was as follows:

Appliances.—In 1985, 41.8 million units were shipped, 17% more than in 1984.

Automobiles.—In 1985, 8.2 million units were made in the United States, 5.1% more than in 1984. In the first 5 months of 1985, 169,600 recreational vehicles were shipped to dealers, 9.4% less than in 1984, and in the first 6 months of 1985, 39,900 recreational homes were shipped to dealers, 16% less than in 1984.

Castings, iron.—Shipments totaled 10.1 million tons in 1985 compared with 10.9 million tons in 1984.

Castings, steel.—Shipments totaled 889,000 tons in 1985 compared with 940,000 tons in 1984.

Construction equipment.—The value of shipments in 1985 totaled $4.2 billion compared with $4.0 billion in 1984.

Farm, wheeled tractors.—Units sold in 1985 totaled 120,000 compared with 110,000 in 1984.

Housing starts.—Starts in 1985 totaled 1.74 million tons compared with 1.75 million in 1984.

Materials handling.—The value of shipments in 1985 was $4.4 billion compared with $4.0 billion in 1984.

Mining equipment.—Sales were $155 million in 1985 and $125 million in 1984.

Service centers, steel.—Shipments to service centers were 21.0 million tons in 1985 and 20.9 million tons in 1984.

Shipbuilding.—Contracts in 1985 totaled $753 million for nine ships for the Armed Forces and five noncombat ships. The total for 1984 contracts was $530 million.

Steel.—Shipments of all grades of finished steel were 72.7 million tons in 1985 and 73.7 million tons in 1984.

Tubular goods.—Shipments were 1.5 million tons in 1985 and 1.2 million tons in 1984. These tonnages exclude oil country products.

News of acquisitions included the following: Steelmet Inc., Pittsburgh, PA, was purchased by ELG Haniel Metals Corp., a wholly owned subsidiary of Haniel GmbH, Duisburg, Federal Republic of Germany; Purdy Metals Corp. sold its Los Angeles, CA, scrapyard to Hugo Neu, a major scrap exporter situated on nearby Terminal Island; Miller Compressing Co. bought most of the assets of Afram Bros. Co., Milwaukee, WI; the Union Corp., Verona, PA, sold the operating assets of its Jacobsen Metal Co., Chesapeake, VA, division to some private investors; and Addlestone International

Corp., Charleston, SC, purchased Associated Iron & Metal Co., Jacksonville, FL.

New ventures included the following: Orange County Steel Salvage Inc. opened an export yard on Terminal Island, CA, featuring the Ro-Con method of loading that included containers and bulk shipments so that 20,000 tons of scrap could be loaded aboard a vessel in 2 days; Schiabo-Chatham Co., Savannah, GA, and Southern Scrap Material Co. Ltd., Baton Rouge, LA, created a new venture for purchasing, processing, and marketing stainless steel scrap in the gulf region; and Steelmet opened a trading office in St. Louis, MO, to handle stainless and nickel alloy scrap sales.

Scrapyard closings included the permanent termination in October 1985 of the export yard of Schiavone & Sons Inc., Boston, MA, and the processing facilities of World Trade Options, Spring Valley, NY.

Phibro Bros. (United States) in August severed its trade connections with the Republic of South Africa, and in late October, announced that its subsidiary Philipp Bros. would withdraw from steel, bulk ferroalloys, and ferrous scrap trading. Resulting dismissals will affect 600 of its 1,400 employees.

Some miscellaneous happenings relating to ferrous scrap were as follows: The Public Service of Indiana in June auctioned portions of $700 million worth of steel and equipment intended for a nuclear plant that was canceled in 1984; General Motors Corp.'s plan to take its automobile bundle scrap off the open market was postponed for the second time in November; Schnitzer Steel Products Co., Oakland, CA, was selected to be the exclusive scrap supplier for Judson Steel Corp., Emeryville, CA; and Lindemann Recycling Equipment Inc., a subsidiary of Lindemann Machinefabric GmbH of Dusseldorf, Federal Republic of Germany, established its U.S. headquarters in New York City.

Ferrous scrap in stockpiles of domestic consumers totaled 5,104,000 tons at yearend, down 157,000 tons from the 5,261,000 tons at yearend 1984. Stocks held by steel manufacturers continued a recurring annual decline, while stocks held by makers of ferrous castings increased significantly in 1985.

The U.S. ferrous scrap industry's annual processing capability in 1984 was 130 million tons, 18% more than that of 1974, according to a report by the Battelle Columbus Laboratories for the Metal Scrap Research and Education Foundation (MSREF). The replacement value of the industry's capital investment increased to $2.3 billion, 183% more than that of 1974. Land represented a $636 million investment, and buildings, $481 million. The cost of a greenfield scrap processing yard was $1.5 million to $2.0 million. In 1984, there were 1,407 processing plants in operation compared with 1,330 in 1974. The number of plants in the 30,000- to 60,000-ton-per-year range was 275, up from 152 such plants in 1974. Collectively, the East North-Central and Northeast census regions accounted for 50% of the total U.S. plants and 63% of the total tonnage processed.

According to the Battelle report, in 1984, 800 balers processed 8.9 million tons; 770 guillotine shears processed 11.2 million tons; and 200 shredders processed 11.2 million tons. Ferrous scrap processors operated 36,000 pieces of equipment, of which balers, guillotine shears, and alligator shears were the predominant types; shredders and briquetters had the largest relative growth in the 1974-84 period. Shears, balers, and shredders of recent vintage required less power input and had a longer life than similar equipment placed in operation 10 to 20 years earlier. The installed cost of a guillotine shear ranged from $450,000 to $800,000, and a large-capacity baler cost up to $2 million.

A growing trend for processing the total products from an automobile shredder using water instead of air to separate the nonmetallic constituents. The wet system required less power and reduced air pollution.

Scrap processing equipment, in new or redesigned configurations, offered by the United States and foreign manufacturers included balers capable of higher productivity while making higher density bundles from the Harris Press and Shear Co., Cordele, GA; Al-jon's 990 four-wheel drive hydrostatic loader; and Caterpillar Tractor Co.'s integrated toolcarrier wheel loader with power takeoff for use with a variety of small equipment in scrapyards. Shears available included La Bounty Model MSD-22, capable of processing subway cars in an as-received condition; ECON's Model 210-P portable guillotine shear; and Harris energy-efficient Model BSH-22-883 shear. The joint use of a 245 Hydraulic Excavator teamed with a La Bounty shear could process one railroad car per hour into No. 1 heavy melting scrap, and Allied-Gator Co.'s mobile shear was capable of a shearing force up to 1,600 tons.

Foreign-made shears included six basic models from Dudley Shearing Machine Manufacturing Co. Ltd., Stoke-on-Trent, United Kingdom; shears from J. McIntyre (Machinery) Ltd., Nottingham, United Kingdom; and a shear marketed by the NEW DJ Press Co., a division of Wendt Manufacturing Corp., North Tonawanda, NY, made by Thyssen Henschel of the Federal Republic of Germany, the use of which did not need feed scrap presorting. Southern Scrap, a large tonnage processor in New Orleans, LA, bought a Lindemann LU-810 shear made in the Federal Republic of Germany. The shear was put into operation in late 1985.

The Fujiar Newell shredder, introduced into Japan in 1980, now has the dominant share of new shredder sales in Japan. The shredder is made by Fujican Manufacturing Co. under license from Newell Industries Inc.

Proler International Corp., Houston, TX, operated nine shredders either in a joint venture with Prolerized Schiabo Neu Co. or by Proler alone.

Cholmondeley Industrial Associates Inc., Cincinnati, OH, was selected by Lindemann Recycling to represent its processing equipment in Kentucky, Tennessee, and parts of Indiana, Ohio, and West Virginia. Harris became the sole agent in the United Kingdom for Lollini S.p.A. of Italy, and Lollini will be Harris' agent in Italy for Harris' equipment, excluding balers.

Analyzers for a wide range of scrap metals included the 3600 Mobil Metal Analyzer of Applied Research Laboratories; the Clandon Portable Metascope from Clandon Scientific Ltd., Aldershot, HANTS, United Kingdom, G0125QR; the X-Met 840, a hand-held, portable, microprocessor-based, multielement X-ray fluorescent analyzer by Columbia Scientific Industries Corp.; a readout system, called Spectrographix 16, from the Labtest Equipment Co.; Texas Nuclear's 9266 Alloy Analyzer; and Walker Scientifics Inc.'s Alloy Thermo-Sorter Model ATS-6044.

Activities of ferrous-scrap-related foundations and associations are noted. The Executive Director of the Institute of Scrap Iron and Steel (ISIS) testified on March 12 before the ITC that imports of semifinished steel and slabs threatened the domestic scrap industry. ISIS published a booklet relating to insurance coverage for scrap processors. ISIS' members in the Buffalo, NY, area and ISIS' national office stopped the Buffalo City Council's attempt to classify scrap metal processing operations as junkyards. ISIS approved the provisions of the Export Administration Act of 1985, and ISIS issued a general information, updated and revised, folder entitled "Mines Above Ground." MSREF, the research arm of ISIS, updated the original 1975 study of the U.S. ferrous scrap industry's processing capability. The study's results showed current processing capability to be 130 million tons per year. A detailed listing and count of the major types of equipment, plant count, and net capacity of equipment installed or on order were published in the fall 1985 issue of the ISIS "Phoenix Quarterly." The National Association of Recycling Industries Inc. (NARI), in May, postponed the establishment of an association to negotiate favorable freight rates. NARI opposed proposed legislation in Rhode Island to make recycling mandatory.

Safety conditions received increasing attention in the processing and use of ferrous scrap. J. J. Keller and Associates Inc., Neenah, WI, introduced its new Hazardous Material Incident Kit designed to provide instructions and material to respond to a hazardous release of contaminants from ferrous scrap. The Environmental Protection Agency (EPA) determined in February that scrapyard shredder residue contaminated by sodium azide from airbag canisters was not hazardous. To call attention to hazardous materials, ISIS started an advertising campaign directed to State government officials. A full-page advertisement suggested that manufacturers were responsible for keeping hazardous materials out of their products that eventually would be scrapped and recycled. Materials receiving current attention are polychlorinated biphenyl (PCB), dioxin, and radioactive ferrous scrap.

On May 24, the TAMCO Co., Los Angeles, CA, closed its EAF melt shop after radioactive contamination was discovered. Of the 350-employee work force 3 employees received extensive tests that showed negative results. Fortunately, the radioactive contamination was trapped in 100 tons of baghouse dust.

TRANSPORTATION

The CSX Corp., formed in 1980 by the merger of Chessie System Railroad Inc. and Seaboard Coast Line Industries Inc., in December 1985 announced a writedown of surplus assets that included 1,000 miles of track, 600 unused locomotives, and 41,000 idle freight cars.

The total annual capability of the U.S. freight-car-building industry in 1985 was 82,000 cars, of which a 29,000-car capacity was completely inactive. Freight car deliveries were 95,650 in 1979, decreasing to 85,465 in 1980, 44,825 in 1981, 17,236 in 1982, and to a low of 5,772 in 1983. Production recovered to more than 12,000 cars in both 1984 and 1985, equal to 15% of production capacity. Of the 1,765 coal-carrying cars ordered in 1985, 1,633 had aluminum sides whose life was expected to be 30 years compared with 20 years for steel sides. Cars for hauling coal in unit trains for electric utilities generally had bottom-emptying hoppers; other cars were emptied by rotary-dump equipment. Such cars usually had a 4,330-cubic-foot internal volume; their payload rating was 106 to 108 tons maximum, their length ranged from 51 to 54 feet, and their empty weight was 15 to 21 tons, of which 31% to 36% consisted of aluminum components. The term "gondola" has been inadvertently used for such coal cars; however, ferrous scrap could not be hauled in such cars because of their configuration and the fact that electric utilities, which owned the cars, specified their use.

Three U.S. makers of aluminum-steel rail cars were Rail Car Co. (Tarco), Ortner Freight Car Co., and Bethlehem Steel Corp.

PRICES

Based on the average composite delivered prices per long ton quoted monthly and separately by the American Metal Market and Iron Age, No. 1 heavy melting steel scrap cost $74.91 in 1985, ranging from $85.75 in March to $66.58 in June.

The 110,000 gross tons of No. 1 factory bundles auctioned in May by General Motors Corp., Ford Motor Co., and Chrysler Corp. brought $13 to $15 per ton less than in the two preceding months.

In the Pittsburgh area, processors bought only enough scrap to maintain good working relations with their suppliers. Although ferrous scrap sales were classed as bargains, major traders expected higher sales prices because of lower interest rates and the Government's voluntary restraint program on steel imports. When buyers could be found, shredded scrap brought $80 per gross ton, a level at which Pittsburgh scrap could not compete with exports by east coast processors.

In early June, Midwest scrap consumers paid prices near those in 1982 and early 1983. West coast prices were down $1 to $5 per gross ton because of decreasing exports.

Purchases by domestic consumers of scrap from brokers, dealers, and other outside sources were as follows:

Consumer	Quantity (thousand short tons)	Approximate delivered value: Total (millions)	Approximate delivered value: Average (per ton)
Steel manufacturers	26,866	$2,124	$79
Steel castings manufacturers	1,517	133	88
Iron castings manufacturers	8,979	682	76
Total or average	37,362	2,939	[1]79

[1]Average for the first 6 months was $82, and for the second 6 months, $74.

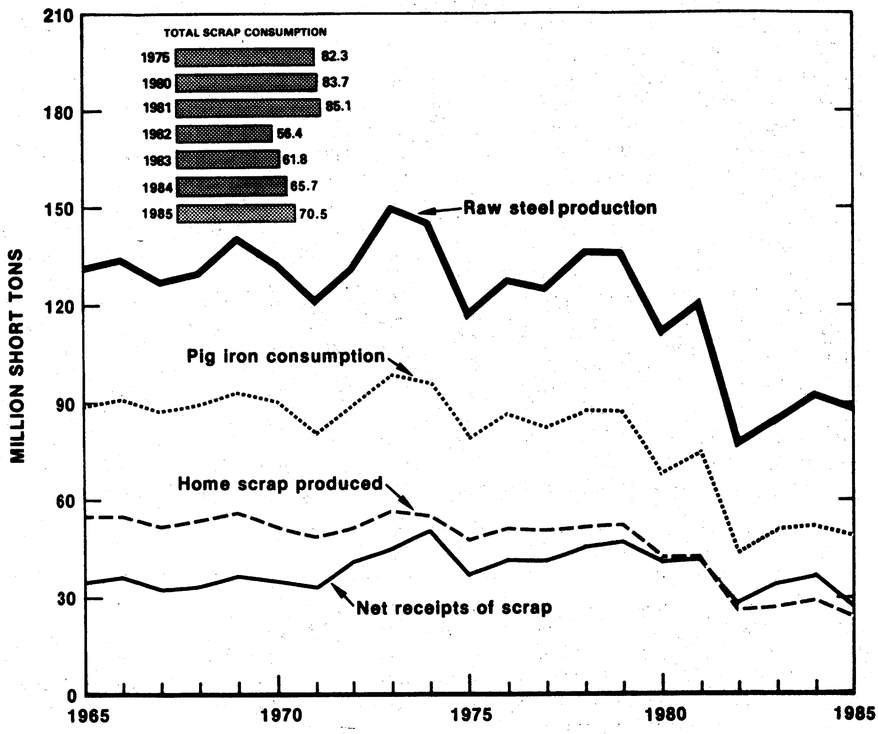

Figure 1.—Raw steel production (AISI), total iron and steel scrap consumption, pig iron consumption, home scrap production, and net scrap receipts.

FOREIGN TRADE

Total ferrous scrap exports increased 4.7% over those of 1984 and accounted for the largest tonnage since 1980 when 11.2 million tons was exported. The tonnages and values of the 1985 exports, as released by the Bureau of the Census, were as follows:

Type	Quantity (short tons)	Customs value: Total (thousands)	Customs value: Average (per ton)
Ferrous	9,639,455	$794,305	$82.40
Stainless steel	179,583	104,898	584.12
Alloy steel (excluding stainless)	129,358	18,981	146.73
Total or average	9,948,396	918,184	92.29

Canada, Japan, the Republic of Korea, Mexico, Spain, Turkey, and Venezuela collectively received 7.47 million tons, valued at $645 million and averaging $86.35 per ton.

The four countries that received the largest tonnages of U.S. stainless steel scrap exports were Japan, 46,997 tons; Spain, 27,222 tons; the Netherlands, 24,891 tons; and the Federal Republic of Germany, 23,799 tons. Collectively, these countries received 68.6% of the total stainless steel scrap exported. Canada, Sweden, Mexico, Thailand, Taiwan, and India, in decreasing order of tonnage, collectively received 99,528 tons or 76.9% of the total alloy scrap exported.

The tonnages and customs value of the total scrap exported through the five leading customs districts were as follows:

Area and leading district	Quantity (thousand short tons)	Customs value	
		Total (thousands)	Average (per ton)
East coast: New York, NY	1,711	$159,613	$93.29
Great Lakes: Detroit, MI	733	57,614	78.60
Gulf coast: New Orleans, LA	486	66,121	136.05
Inland: Laredo, TX	408	40,804	100.01
West coast: Los Angeles, CA	1,320	126,055	95.50
Total or average	4,658	450,207	96.65

No. 1 heavy melting and shredded were the leading grades of scrap exported. Collectively, these two grades accounted for 53.5% of the total scrap exported. Borings, shovelings, and turnings totaled 875,000 tons; No. 2 heavy melting totaled 767,000 tons; and iron scrap, excluding borings and shovelings, totaled 666,000 tons. These five grades accounted for 7.63 million tons or 76.7% of all ferrous scrap exports.

The tonnages and values of stainless steel scrap and alloy steel scrap (except stainless) exported from the five leading customs districts, according to the Bureau of the Census, were as follows:

Area	Quantity (short tons)	Customs value	
		Total (thousands)	Average (per ton)
Detroit, MI:			
Stainless steel	4,816	$3,366	$698.92
Alloy steel	20,411	2,420	118.56
Laredo, TX:			
Stainless steel	23	43	1,869.57
Alloy steel	12,117	2,315	191.05
Los Angeles, CA:			
Stainless steel	29,597	16,847	569.21
Alloy steel	17,632	2,215	125.62
New Orleans, LA:			
Stainless steel	24,749	12,777	516.26
Alloy steel	3,518	344	97.78
New York, NY:			
Stainless steel	23,912	13,531	565.87
Alloy steel	6,396	2,574	402.44
Total or average:			
Stainless steel	83,097	46,564	560.36
Alloy steel	60,074	9,868	164.26

Imports for consumption of iron and steel scrap containing no dutiable alloys totaled 601,000 tons, valued at $45,620,000 and averaging $75.91 per ton. Imports from Canada equaled 93.5% of the total, and imports from Mexico equaled 4.1%.

WORLD REVIEW

Foreign shipbreaking activities continued to be significant contributors to the ferrous scrap supply, particularly in the Far East.

In 1984, worldwide breakers demolished 1,785 vessels totaling 19.9 million tons. Taiwan, the world leader, broke 7.5 million tons, followed by the Republic of Korea with 4.6 million tons, China with 2.3 million tons, and Japan and Pakistan with 1.3 million tons each.

In 1985, scrapping continued at a high level in Taiwan, the Republic of Korea, and China because of the strong demand for rerolled steel products.

Worldwide in 1985, 987 vessels were scrapped; tankers and combined carriers totaled 251 and represented 56% of the purchased tonnage, and 736 bulk carriers accounted for 44% of the purchased tonnage.

Prices paid by shipbreakers were influenced by the type and size of the vessel. Chinese breakers paid approximately $105 per ton; in Taiwan, very large cargo carriers (VLCC) and 30,000-ton bulk carriers sold for $90 to $96 per ton, and vessels under 4,000 tons were bought for $80 per ton, while Turkish breakers paid $76 per ton for small tonnage vessels.

Because of high labor costs and safety codes in Western Europe, demolition yards similar to those in the Republic of Korea and Taiwan were not economically feasible. Two French supertankers, the *Botillus* and the *Bellamya*, were sold for scrap in October. One vessel went to Taiwan, and the other, to the Republic of Korea.

The Government of Greece approved plans to build a new breaking yard in northern Greece at an estimated cost of $17.5 million. The Japanese Transport Ministry encouraged shipbreaking by way of subsidies and the return of duty paid on vessels imported for scrapping. The Ministry also had plans to use official development funds to construct shipbreaking yards in Burma, Indonesia, Malaysia, and the Philippines. Three Japanese VLCC were sold to a breaking yard in Hakodate Prefecture. A shipbreaking yard in Thailand was scheduled to start operation in December. The yard could scrap three VLCC annually. A new breaking yard started official operation in September at Aliaca in the Izmir region of Turkey. In the startup period, five medium-sized tankers were scrapped. Vessels laid up in nearby Eleusis Bay and the Black Sea were acquired for $76 per ton. A 1.1-million-ton-per-year steel plant was to be built near the Aliaca yard.

The Turkish shipping Zihni Group leased two Government-owned sites at Aliaca where a 1,000-ton-per-day-capacity breaking yard will be built in 2 years.

The shipbreaking yard of H. Stewart (Metals) Ltd., at Birkenhread, United Kingdom, continued in operation despite the loss of its main customer, the minimill of the Manchester Steel Group, at Bidston.

The Government of India shortened the time to obtain a shipbreaking permit to 57 days and readied a $27 per ton tax on ships imported for breaking. The state-owned Metal Scrap Trade Corp. (MSTC) actively sought 6,000- to 6,500-ton ships for breaking. MSTC was the sole buyer of vessels purchased for 90 breaking yards. However, in 1984-85, MSTC supplied only 40 yards; the remaining yards remained idle.

On February 1, 30 vessels averaging 5,500 tons were laid up at Gadani, Pakistan, for scrapping. Because recovered plate was limited to 0.5-inch thickness, only low-tonnage vessels were imported. In mid-May, a consortium of Greek shipowners agreed to supply 20 to 25 vessels annually to Pakistani breakers, whose import duty payment on vessels was increased 5% in May.

In 1984, the revival in world demand for ferrous scrap benefited European processors who found new markets in the Far East. Scrap collection in some European countries improved, thereby making 6.6 million tons total available for export to developing countries.

Worldwide, there were more than 500 shredders whose operators' major problem was finding sufficient supplies of feed materials at the right price.

Belgium.—Although export restrictions imposed by the Government had no effect on the total tonnage exported by Belgian processors, Belgian steelmakers demanded urgent action by the European Economic Community (EEC) to restrict EEC scrap exports.

Brazil.—Brazil was the world's largest producer of charcoal pig iron, a growing competitor of ferrous scrap. According to the Bank of Brazil's foreign trade department (CACEX), exports of charcoal pig iron in 1984 were 2.76 million tons, reportedly owing in part to the increased ferrous scrap shortage in the world market. The Far East received 60% of the country's production; EEC countries obtained 20%; and the United States, 15%.

Independent pig iron producers in Brazil's Minas Gerais State did not accept a 70% price increase for charcoal to approximately $47 per ton.

Canada.—On June 30, two 605-foot lakers, one built in 1957 and the other in 1963, were sold to Cord Steel, Montreal, which resold them to a Curacao, West Antilles, shipbreaking facility. The ships left Montreal July 1 and were towed in single file by the tugboat *Capt. Tonnais S.*

China.—Three delegations visited some U.S. ferrous-scrap-processing facilities in the United States to investigate recycling technology and equipment. The delegates made two contracts for purchasing a total of 260,000 tons from the U.S. gulf region for approximately $105 per ton for exports to the ports of Tienchin and Xingang. A major problem in Chinese ports was the unloading of scrap from vessels at a speed commonplace in the Far East; one solution was to receive scrap by vessels that would remain in China for scrapping. Because pig iron receipts could be unloaded at a rate faster than for ferrous scrap, purchases of pig iron stood at 1.0 million tons each from Brazil and Japan in 1985. Pig iron was shipped from three Japanese integrated steelmakers to China Metallurgical Import and Export Corp. Three Chinese groups concerned with scrap purchases were the State Bureau of Supplies, the Ministry of Commerce, and the Ministry of Metallurgy. Local governments were responsible for domestic scrap collection. Industrial scrap was returned for recycling by mandate. Private peddlers collected obsolete scrap predominantly from households, and received payment set by the Government's collection stations where the scrap had to be sold. Thyssen Henschel of the Federal Republic of Germany sold several 1,250-ton-force scrap shears to Chinese steelworks.

Czechoslovakia.—The state-owned scrap processor Kovosrot Brno obtained equipment and technology for a continuous detinning process developed and operated by the United Kingdom processor Vulcan Materials. The new plant was expected to convert 30,000 tons annually of low-quality tinplate scrap into high-quality detinned steel scrap and high-grade secondary tin ingots.

Denmark.—The newly-formed SR Scandinavian Recycling AB established a marketing arrangement with the E. Laursen Maskinfabrik A/S. Two shredders and two grinders in Denmark had a 4,250 total horsepower and a single-shift annual capacity of 75,000 tons.

European Communities (EC).—In late February, the European Committee of the National Ferrous Scrap Association rejected an EC proposal for a ferrous-scrap-sale monitoring system because it would result in an advantage to U.S. scrap merchants. A below normal U.S. steel output further depressed European scrap prices. Nuova Campsider of Italy attempted to restrict Italian ferrous scrap exports. In a March 26 meeting, EC ministers for industrial affairs ruled out the possibility of ferrous scrap export controls. In 1984, ferrous scrap consumption in the EC was less than 6% greater than that in 1983. The EC scrap supply situation eased because of lower prices prompted by the decrease in the dollar exchange rate. EC officials reported that EC steelmakers no longer faced supply shortages, although in some situations the demand for low-residual scrap exceeded the supply. The main reason for a $30 per ton decrease in the British stainless steel scrap price was attributed to the strengthening of the pound sterling against the dollar.

France.—In 1984, exports of ferrous scrap totaled 4.5 million tons, of which 2.1 million tons went to Italy. More than one-half of the French scrap iron consumption came from home scrap, and 5%, from imports. Imports in the first 8 months of 1984 totaled 364,000 tons. Cie. Française de Ferailles planned to install one shredder in its Bordeaux yard and another in its Toulouse yard primarily to supply the Spanish ferrous scrap market. Metalinor, formed by the merger of Otto Lazar and Vidal & Champreddonder, became one of Europe's biggest scrap dealers. The presence of new EAF's, notably in steel mills at Neuves-Maisons, Hagendange, and Valenciennes, reportedly could increase the annual domestic demand for scrap iron by 1.1 million tons.

Germany, Federal Republic of.—In late March, the Iron and Steel Industry Association filed a case against the EC Commission concerning its failure to prevent Italian subsidies on ferrous scrap imports. Other steel federations had not made similar objections in late March. The short-term availability of ferrous scrap eased, and there were no indications of a major turndown in supplies although higher quality grades were barely sufficient to meet demand. Steelmakers used 19 kilograms less scrap per metric ton of steel produced, bringing the average to 347 kilograms in the first half of 1985 because of the high price of scrap in this time period. Beitrage zur Danziger Statistik, the West German scrap federation, reported 1.65 million tons of ferrous scrap exports in the first 5 months of 1985 and imports of 1.2 million tons.

The EC Commission approved the acquisition of Walter Trapp GmbH by Thyssen Sonnenberg, which gave the company a 27% share of the West German scrap market and more than an 8% share of the EC trade. Thyssen AG merged its subsidiaries Thyssen Sonnenberg (Duisburg) and Thyssen Carbometal Co. (New York) into a single company. Elg Haniel GmbH (Duisberg) appointed Kinsho Mataich as Japanese sales agent for Elg's stainless steel scrap, special steel scrap, and rare metal scrap. Kinshofer Maschinefabrik designed a hydraulic ram to handle thin-gauge scrap.

India.—Imports of ferrous scrap were principally baled shredded because in past years some receivers obtained usable and rerolling material and fraudulently declared it for assessed import duty as heavy melting steel scrap. Four tenders submitted to the MSTC, the last in early November 1985, totaled 556,000 metric tons in the range of $116 to $128 per metric ton. Traders included Nissho-Iwai Corp. from (Japan), the Associated Minerals Consolidated Ltd. (United Kingdom), the Independent Bulk Commodity Trading Ltd. (United Kingdom), Krupp AG (Federal Republic of Germany), and Hugo Neu (United States). Receiving ports were Bhovnagar, Bombay, Calcutta, Kandla, Madras, and Vizagapatnam. Most scrap was bought by MSTC, a Government agency, through tenders from a limited number of participants. Eventually, the successful bidder had to establish an unconditional performance bond. Then, it often required 14 days until the seller had a workable letter of credit (LC) in hand, and during this time period, the seller decided on the source of scrap, the chartering of a vessel, and exchange transactions. India always includes a 180-day term in the LC and often converted U.S. dollars in the calculation of the sale price.

Shipments to India were not the easiest. Recurring factors were port and vessel restrictions, frequent congestion in ports, wildcat strikes, a shortage of trucks to receive the cargo directly from vessels, and the monsoon period in June through August. Substantial demurrage charges developed from the foregoing factors. The latest development in scrap shipments to India was an indefinite quality control procedure introduced by the MSTC, which dictated to the inspection company handling 100,000-ton minimum orders placed under tender T-11.

Ireland.—Irish Steel Ltd.'s board considered a partial or total closure of its works during a cashflow crisis in early 1985 because of high scrap prices contracted in 1984 that could not be passed along by way of higher steel prices. The firm had to pay $4.5 million more for scrap in the first half of 1985.

Italy.—The decreased output of EAF steel was attributed to high scrap prices within the EC because of reduced levels of supply. Price was the deciding factor for Soviet and U.S. ferrous scrap contracts. Supplies from Middle East and African sources were insufficient to meet the EAF demands. The decline in the dollar in October resulted in a 15% decline in Italian scrap prices. Italy had 20 shredders with an annual single-shift capacity of 600,000 tons.

Japan.—Major ferrous scrap traders were C. Itoh & Co. Ltd., Hyuka Sangyo, Japanese Kanematsu Gosho Ltd., Marubeni Corp., Mitsubishi Corp., Mitsui & Co., Nissho-Iwai, Okaya Koki, Sumitomo Corp., Takunam Seitetau, Tokyo-Takko, and Toyo-Menka.

Domestically available ferrous scrap moved in significant tonnages to steelmakers. Eight companies in the Kyushu region bought 105,000 metric tons in June and July. The companies were Nippon Steel Corp., Sumitomo Metal Industries Ltd., Tokai Steel Works Ltd., Kiyomato Tekko K.K., Showa Kogyo K.K., Nishinhon Seiko K.K., Nikon Chutanko K.K., and Hitachi Metals Ltd. In the February to November period, Nippon Steel bought 43,900 metric tons of domestic scrap, and Nippon Kokan Steel Corp. obtained 4,000 to 5,000 metric tons monthly from the Tokyo Yohahama area. The Kanto region in eastern Japan sent 60,000 metric tons in April to the Humaji and Osaka areas.

Japan had 50 shredders each rated at more than 1,000 horsepower and 54 shredders in the 100- to 800-horsepower range.

In December, the Japan Steel Scrap Reserves Association, a joint group of steelmakers and merchants, boosted local ferrous scrap prices in the Kanto region. The average of 12 midmonth quotations of the Tex Report are shown for 5 types of ferrous scrap purchased in 1985 by major EAF mills in the Kanto region, in dollars[3] per metric ton and using Japanese scrap-trade terminology, were as follows:

Type	Price
Cut and pressed	$112.52
Extra special	112.45
Special G-2	105.70
Turnings A	90.89
Press A	80.41

The delivered price for H-2 scrap to seven areas of Japan, as reported in the Tex Report, January 9, 1986, and in dollars per metric ton, were as follows:

Area	Price
Kansai	$113.05
Chungoku-Shikoku	108.43
Kuyushu	108.21
Kanto	105.22
Chubu	99.90
Tohuku	99.72
Hakkaido	98.00

Dealer quotations for SUS 18/8 Sabot-grade stainless steel scrap in dollars per metric ton cost, insurance, and freight (c.i.f.) Japan, were obtained from all relevant issues of the Tex Report in 1985. The average of 183 quotations for Hong Kong cargo was $628.90; for 178 quotations for U.S. cargo from the west coast, the average was $630.92.

The Tex Reports for 1985 published 54 instances of f.o.b. values and freight rates of ferrous scrap exported from the U.S. east coast and 54 instances of f.o.b. values and freight rates for the U.S. west coast. Data in dollars per ton were as follows: East coast exports averaged $77.56 f.o.b. in a range from $72.46 to $84.39, and freight averaged $16.48 in a range from $12.73 to $19.64. Exports from the U.S. west coast averaged $79.71 f.o.b. in a range from $75.38 to $87.05, and freight averaged $14.07 in a range from $13.39 to $14.73.

Pig iron imported by Japan in 1985 totaled 747,579 metric tons (equal to 23.0% of the tonnage of all ferrous scrap imports), averaging $132.83 per metric ton. The Republic of South Africa supplied 299,991 tons at $122.74 per ton, and Brazil supplied 140,967 tons at $139.64 per metric ton.

Imports of all types of ferrous scrap in 1985 totaled 3,253,534 metric tons averaging $125.09 per ton, according to the Japan Iron and Steel Federation in the Tex Report of March 14, 1986.

According to the Bureau of the Census, U.S. Department of Commerce, exports of 11 grades of U.S. ferrous scrap to Japan totaled 2,110,086 tons averaging $94.37 per ton. The U.S.S.R. was the second largest supplier of ferrous scrap to Japan with 400,241 metric tons averaging $98.96 per metric ton.

According to the Tex Report of February 19, 1986, quantity and average value of Japanese exports of pig iron and ferrous scrap, in metric tons and dollars per metric ton, were as follows:

Material	Quantity	Average value
Pig iron	1,066,307	$125.45
Scrap:		
Cast iron	5,937	103.51
Steel	NA	189.86
Alloy steel	458	181.62

NA Not available.

Japanese exports of pig iron to China totaled 1,003,889 metric tons valued at $124.49 per ton.

Production of pig iron was about 79.0 million metric tons, and of raw steel, about 103.6 million, both down from the levels in the preceding fiscal year. EAF raw steel production equaled 30.2 million metric tons. Stocks of ferrous materials (pig iron and scrap iron) totaled 5.5 million metric tons, up from 4.8 million tons at the end of fiscal year 1984.

Missions for the Japanese stainless steel industry to study ferrous-scrap-processing operations spent April 27 to May 13 in the United States and Brazil. A mission from the Kansai Scrap Association was in the United States on May 14. These missions were planned to continue indefinitely at 3-month intervals.

Korea, Republic of.—According to the Korean Iron & Steel Association, EAF steel production totaled 4.25 million metric tons in 1985 and 3.84 million in 1984; converter raw steel production totaled 9.28 million metric tons in 1985 and 9.20 million in 1984. EAF mills were operated by Dongkuk Steel Mill Co. Ltd., Hanbo Steel Co. Ltd., Inchon Iron & Steel Co. Ltd., and Kang Won Industries. Imports of steel scrap were 2.76 million metric tons for melting and 0.80 million for rerolling; respective tonnages in 1984 were 2.32 million and 0.79 million. Monthly average stocks of ferrous scrap were 238,000 metric tons in 1985 and 135,000 in 1984. Domestically purchased scrap in 1985 for melting totaled 2.16 million metric tons and 1.94 million in 1984.

Netherlands.—The new European S terminal operated by the Dutch stevedoring company Dalmeijer's Metalen BV was expected to attain, in 3 years, an annual throughput of 1.5 million metric tons. The terminal has four cranes and can load two 60,000-ton cargoes simultaneously. In 1985, only grades OA, No. 1, No. 2, and shredded were handled. A ninth shredder started operation in the Netherlands bringing total horsepower to 11,100 and annual single-shift capacity to 450,000 metric tons, roughly equal to the amount of feed available.

South Africa, Republic of.—National Metals, a ferrous and nonferrous scrap processor, installed equipment on a site near Pretoria owned by state-owned steelmaker South African Iron and Steel Industrial Corp. Ltd. (Iscor). The steelmaker had no equity in the operation and was not obliged to take scrap from National Metals. Domestic steelworks annual consumption was expected to reach 2.5 million tons in 1986, 2.5% more than total overall domestic scrap. Some of the shortfall will be met by sponge iron costing $75 per metric ton compared with $45 per ton for high-grade ferrous scrap. In mid-1986, Iscor exported heavily from its substantial ferrous scrap stockpile. Since 1977, Iscor and Korf Stahl AG developed modification of a direct-reduced-iron (DRI) process using South African noncoking coal. Other steelmakers producing coal-based DRI were Dunswart, operating a 140,000-ton-per-year Codir plant supplied by Krupp, and Scaw Metals Ltd., producing 90,000 tons annually in a Direct Reduction Corp. DRI plant. Union Steel Corp.'s Vaal works operated the only gas-based DRI plant using synthetic gas from the nearby Sasol plant. Davsteel (Pty.) Ltd. made DRI in a converted small rotary kiln.

Spain.—In the first 9 months of 1985, imports of ferrous scrap totaled 4.0 million metric tons. The United Kingdom supplied 2.1 million tons; France, 0.9 million; the United States, 0.7 million; and the U.S.S.R., 0.3 million. Beginning January 1, 1986, Spanish steelmakers must pay a 12% value-added tax (VAT) on imported ferrous scrap instead of the current 2% duty. The number of steel foundries decreased from 66 in 1977 to 53 in 1983, thereby reducing the annual output from 160,000 tons to 150,000 tons, and the number of employees by 12%. The Spanish scrap industry declared impractical a proposal to concentrate the buying of ferrous scrap by a Government agency. The Spanish steelmaker Empresa Nacional Siderúrgica S.A. sold 175,000 tons of ferrous scrap in both 1983 and 1984. The firm adhered to a 1-year-old policy and bought no scrap from either domestic or foreign sources in 1985, according to Metales y Máquinas.

Taiwan.—Imports of ferrous scrap were stagnant in February 1985; only state-run plants with sufficient funds or other mills, compelled to make purchases, were in the market. Several influential EAF mills were consolidated to make radical changes in the supply-demand situation, and only minor imports of scrap were made. In early November, a reduction of import duty stimulated scrap imports.

Turkey.—In November, Cukorova's Aliaca works became Turkey's largest electric steelmaker with an annual capacity of 1.0 million metric tons, although the 1984 output of raw steel was only 0.4 million metric tons. The Habas Group was installing two 75-ton EAF's at Izmir. Asil Celik, almost entirely state-owned and Turkey's principal specialty steelmaker, experienced serious financial problems. In 1985, Asil bought about 100,000 metric tons of scrap from the United States, the United Kingdom, and the Federal Republic of Germany. Plans were under way to buy 40,000 tons of domestic scrap in 1986, up 18,000 tons from those in 1985.

United Kingdom.—The increased use of EAF's helped maintain a strong domestic demand for ferrous scrap. The steel industry's scrap stocks were 450,000 metric tons at yearend 1984 compared with 858,000 metric tons in 1980. In August, the British Steel Corp. (BSC) announced a 3-year strategic plan that could lead to a fundamental shift in scrap purchasing in the United Kingdom. BSC expected to use more scrap to reduce its reliance on blast furnaces.

The United Kingdom exported about 50% of its total available ferrous scrap. Quantity and average value of ferrous scrap exports during the first 11 months of 1985, in thousand metric tons and dollars per ton, were as follows:

Material	Quantity	Average value
Iron and steel	3,823	$71.65
Cast iron	292	71.58
Stainless steel	30	456.67
Alloy steel	14	614.29

In this 11-month period, total exports to developing countries totaled 3,527,000 metric tons and averaged $73.89 per metric ton. In the first half of 1985, total exports were 2,479,000 metric tons, of which 59.9% went to Spain, 11.2% to Sweden, 4.6% to the German Democratic Republic, 3.7% to the Federal Republic of Germany, and 19.6% to all other countries. The unexpected very large exports of U.S. scrap in August 1985 (an all-time high monthly record) affected the British traditional markets in Europe and the Mediterranean area. The managing director of a British exporter, Mayer Newman and Co. Ltd., claimed that port dues and other high costs drove exports away from British shippers to European competitors. A 32,000-metric-ton cargo of shredded scrap sank in the Red Sea enroute to India. The $4 million cargo was shipped by Sheppard Waste Recovery Ltd. from Liverpool.

The British Scrap Federation (BSF), in February, asked British steelmakers to put political pressure on Italy and Spain to remove their subsidies on scrap imports. Two major protagonists who complained to the Department of Trade and Industry about an anticipated lack of ferrous scrap set up their own processing and marketing subsidiaries.

Billiton (U.K.) Ltd. reorganized its Billiton International Metals BV ferrous business by locating to a quayside site on the Manchester Ship Canal at Irwell Park, Eccles. The Hulbert of Dudley scrap metal division, after 50 years of trading mostly in the Midlands, entered the bulk export market. Hulbert chartered its own vessels to ship 1,000- to 2,000-ton cargoes of graded steel scrap to the Mediterranean area and to move container lots to continental users. Such low-tonnage cargoes were requested by customers who maintained low inventories to improve their cash-flow situation. London Metals moved its activities to larger premises in Cannonburg, North London. A. R. Brown, McFarlane & Co., acquired the scrap exporter Arnott Young Ltd. from Tarmac Roadstone Holdings Ltd. Arnott Young will continue to trade under its own name from its dock at Dalmuir, Clydebank. BSC and other British steelmakers asked their suppliers to accept unchanged prices for September 1985 scrap deliveries. BSC reduced its surcharge from $28 to $13 per metric ton in line with the downward drift of ferrous scrap prices. The surcharge was calculated using Metal Bulletin's Ferrous Scrap Market Index. Scrap prices strengthened in December because of rising exports and local shortages in the United Kingdom. Spanish steelmakers built up stockpiles prior to Spain's entry into the EC when Spanish receipts would be subject to higher taxes effective January 1, 1986. Rising prices for ferrous scrap, pig iron, and foundry coke were blamed for British foundries' increased costs, according to the British Foundry Association (BFA). BFA claimed that suppliers of pig iron and foundry coke enjoyed a virtual monopoly because they were mainly "nationalized industries."

A report by Marketing Strategies for Industry, entitled "MSI Data Base: Foundries and Castings, United Kingdom, July 1985," and a survey by a Department of Trade and Industry's Business Statistics Office disclosed that over one-half of British iron foundries terminated production in the 1974-83 period. The annual output of castings decreased from 3.45 million metric tons to 1.45 million metric tons in the same time period. Productivity per person per year fell marginally to 39 metric tons, probably reflecting a trend to lighter, higher value castings. The ferrous scrap industry comprised 400 BSF members and about 9,500 registered scrap dealers. The 400 members operated 70 fragmentation plants, 300 shears ranging from 300 to 2,000 tons of shear force, and hydraulic balers whose annual capacity was 400,000 metric tons of No. 1 bales. A new inland scrap-loading wharf on the River Trent at Readby, Humberside, was managed by the Associated Waterway Services Ltd. Four "purpose-built" scrap bundlers were installed in the Tipton Works of Firth Cleveland Steel Strip Ltd. Edgar Allen Developments Ltd. designed a shredder that could handle automobiles and domestic appliances without the need for precrushing or shearing. Sheppard Waste Recovery at Rochdale ordered a large shear from Thyssen Henschel of the Federal Republic of Germany costing about $2.7 million.

Modifications to British iron and steel scrap specifications became effective November 1 following months of discussions involving the BSF, BSC, and British Independent Steel Producers Association (BISPA). The modifications included the views of the BFA. In summary, 4 general conditions were applicable to 26 grades of scrap. These modifications replaced those of August 1980.

U.S.S.R.—Much scrap for export tended to be hand sorted, and the quality reportedly was generally good. The Soviet's selling policy did not appear to follow usual commercial practice; accordingly, the Spanish steel industry built up a barter scheme for scrap movements. The U.S.S.R. trade organization Promsyrioimport sent 20,000 metric tons of scrap from a Black Sea port to Japan at $100 per ton c.i.f. Generally, Soviet scrap to Japan originated at Siberian ports.

Venezuela.—Ferrous scrap imports at 600,000 tons per year were predicted to decrease to 200,000 tons in the next few years as the domestic production of DRI increased. DRI output is currently limited because the only merchant plant, operated by Fior de Venezuela S.A., concentrates on the export market. C.V.G. Siderúrgica del Orinoco C.A.'s Hojalata y Lámina S.A. DRI facilities continued to have technical operating problems.

TECHNOLOGY

The Consteel continuous steelmaking process permits the use of purchased ferrous scrap having various qualities, limited preparation, and maximum dimensions. Generally, 2- by 2-foot scrap can be charged continuously; when factory bundles are similarly charged, the preheating efficiency decreases. Intersteel Technology Inc., Charlotte, NC, is the vendor of the process.[4]

More than 200 tons of scrap iron from the Statue of Liberty and Ellis Island was converted into metal powders destined to make commemorative souvenirs; the conversion was done by the Hoeganaes Corp., Riverton, NJ.[5]

The current use of galvanized ferrous scrap in EAF operations produces 0.5 million tons of dust and fume annually, mostly comprising iron oxides. These solids are trucked to conventional landfills. By 1988, this tonnage is predicted to reach 3.0 million tons per year as electrogalvanized steel production lines are increased to double the output of galvanized products. The fabrication of such products will increase the zinc content of home scrap and industrial-grade bundled scrap. The EPA now designates EAF dusts and fumes produced during the melting of galvanized scrap as hazardous because of their contained cadmium, lead, and zinc. Currently, the total of these three metals is limited to 1,000 kilograms per month per melting furnace. Because the smelting of the collected dusts and fumes to reclaim these metals is impractical, larger haulage costs to special landfills are inevitable. Further, pelletized dust, although high in iron oxide content, cannot be added to blast furnace burden because it forms scabs and causes spalling of the refractory lining.

Currently, industrial scrap bundles are the principal source of the zinc contaminant. Zinc contamination from an automobile hulk is relatively small owing to the oxidation of zinc metal to zinc oxide during the vehicle's lifetime.[6]

The Center for Metals Production and the America Iron and Steel Institute (AISI) planned research that focused on the recycling of EAF dust and fumes back into the EAF. The purpose is to increase the concentration of zinc and other metals in the dust and fumes to enhance their economic recovery.[7] Other research on recovery of zinc from steel plant dusts was reported at the "International Symposium on Recycle and Secondary Recovery of Metals." The processes are designed for zinc recovery by leaching techniques.[8]

NARI and the Bureau of Mines extended an agreement, terminating in May 1987, for research on scrap metal recovery, processing, and technology. The agreement provided for the development and exchange of information relating to the processing of scrap metal and waste, and the rapid identification of components.[9]

Phoenix Metals Corp., Plymouth, MI, planned the startup of a 20,000-ton-per-year plant to convert machine shop turnings into powder suitable for making powdered metal parts and welding electrodes. This plant will use a comminution process licensed from the Ford Motor Co.[10]

Preliminary results of joint research conducted by the U.S. Department of Energy and ISIS indicated that untreated shredder scrap residues have the energy equivalent of low-grade bituminous coal. These residues could be suitable for steam generation in equipment using specially designed combustion controls. Combustion of the residues results in no emission problems; however, data on the stability of the heavy metals content in the resulting ash was incomplete.[11]

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[1]Physical scientist, Division of Ferrous Metals.

[2]All quantities are in short tons unless otherwise specified.

[3]Where necessary, values have been converted form Japanese yen (Y) to U.S. dollars at the rate of Y237=US$1.00.

[4]American Metal Market. V. 93, No. 25, Feb. 6, 1985, p. 12.

———. V. 93, No. 104, May 30, 1985, p. 8.

[5]Recycling Today. V. 23, No. 6, June 1985, p. 74.

[6]American Metal Market. V. 94, No. 1, Jan. 2, 1986, p. 8.

[7]Phoenix Quarterly. V. 17, No. 4, Winter 1986, p. 11.

[8]Taylor, P. R., H. Y. Sohn, and N. Jarrett. Paper in Proceedings of the International Symposium on Recycle and Secondary Recovery of Metals. Metall. Soc., pp. 143-157, 195-201.

[9]Work cited in footnote 4.

[10]33 Metal Producing. V. 23, No. 4, Apr. 1985, p. 53.

[11]American Metal Market. V. 93, No. 100, May 23, 1985, p. 9.

Table 2.—U.S. consumer receipts, production, shipments, and stocks of iron and steel scrap and pig iron in 1985, by grade

(Thousand short tons)

Grade	Receipts of scrap: From brokers, dealers, other outside sources	Receipts of scrap: From other own-company plants	Production of home scrap: Recirculating scrap resulting from current operations	Production of home scrap: Obsolete scrap (includes ingot molds, stools, scrap from old equipment, buildings, etc.)	Consumption of both purchased and home scrap (includes recirculating scrap)	Shipments of scrap	Ending stocks, Dec. 31
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS							
Carbon steel:							
Low-phosphorus plate and punchings	331	--	3	4	336	5	21
Cut structural and plate	858	192	382	12	1,523	16	102
No. 1 heavy melting steel	8,062	1,368	8,565	143	16,941	1,297	1,107
No. 2 heavy melting steel	2,560	234	920	4	3,604	126	291
No. 1 and electric-furnace bundles	5,246	227	1,597	3	7,072	476	402
No. 2 and all other bundles	1,015	36	11	(1)	1,105	8	88
Electric furnace, 1 foot and under (not bundles)	40	46	25	(1)	97	1	24
Railroad rails	169	1	2	--	222	2	2
Turnings and borings	782	10	266	1	1,069	14	76
Slag scrap (70% Fe content)	542	122	2,452	1	2,815	306	184
Shredded or fragmentized	2,774	1,188	175	--	4,043	129	264
No. 1 busheling	1,296	32	185	1	1,466	116	77
All other carbon steel scrap	1,800	660	6,382	11	8,149	840	596
Stainless steel scrap	512	21	478	(1)	1,000	19	76
Alloy steel (except stainless)	126	162	1,019	1	1,256	94	229
Ingot mold and stool scrap	274	232	549	773	1,443	411	314
Machinery and cupola cast iron	2	--	4	1	5	6	1
Cast-iron borings	106	(1)	7	(1)	89	26	11
Motor blocks	--	--	--	--	(1)	--	(1)
Other iron scrap	163	96	456	1	528	169	75
Other mixed scrap	210	74	128	6	437	3	22
Total[2]	26,866	4,701	23,605	962	53,201	4,063	3,964
MANUFACTURERS OF STEEL CASTINGS							
Carbon steel:							
Low-phosphorus plate and punchings	488	2	119	--	566	(1)	43
Cut structural and plate	125	27	14	--	172	--	10
No. 1 heavy melting steel	61	(1)	50	--	111	--	8
No. 2 heavy melting steel	131	--	1	--	140	--	4
No. 1 and electric-furnace bundles	11	1	--	--	8	--	(1)
Electric furnace, 1 foot and under (not bundles)	48	1	6	(1)	55	1	3
Railroad rails	4	--	--	--	3	--	1
Turnings and borings	32	--	11	--	40	2	1
Slag scrap (70% Fe content)	--	--	(1)	--	--	(1)	--
Shredded or fragmentized	28	--	--	--	28	--	(1)
No. 1 busheling	13	--	--	--	8	(1)	2
All other carbon steel scrap	311	67	116	2	474	4	45
Stainless steel scrap	20	1	18	(1)	35	1	7
Alloy steel (except stainless)	59	--	141	(1)	198	3	57
Ingot mold and stool scrap	9	--	(1)	--	9	(1)	(1)
Machinery and cupola cast iron	(1)	--	1	--	3	--	(1)
Cast-iron borings	67	--	33	--	87	--	9
Other iron scrap	105	--	31	(1)	127	4	23
Other mixed scrap	3	--	9	--	12	--	(1)
Total[2]	1,517	100	549	2	2,075	15	213

See footnotes at end of table.

Table 2.—U.S. consumer receipts, production, shipments, and stocks of iron and steel scrap and pig iron in 1985, by grade —Continued

(Thousand short tons)

Grade	Receipts of scrap		Production of home scrap		Consumption of both purchased and home scrap (includes recirculating scrap)	Shipments of scrap	Ending stocks, Dec. 31
	From brokers, dealers, other outside sources	From other own-company plants	Recirculating scrap resulting from current operations	Obsolete scrap (includes ingot molds, stools, scrap from old equipment, buildings, etc.)			
IRON FOUNDRIES AND MISCELLANEOUS USERS							
Carbon steel:							
Low-phosphorus plate and punchings	1,005	113	298	10	1,349	11	141
Cut structural and plate	1,154	6	108	(1)	1,309	1	59
No. 1 heavy melting steel	112	46	289	--	197	244	20
No. 2 heavy melting steel	247	--	23	--	271	1	6
No. 1 and electric-furnace bundles	113	151	43	--	317	--	9
No. 2 and all other bundles	189	78	(1)	--	266	(1)	28
Electric furnace, 1 foot and under (not bundles)	30	3	7	--	36	--	3
Railroad rails	134	--	5	--	141	2	10
Turnings and borings	455	5	2	4	453	8	52
Slag scrap (70% Fe content)	11	--	--	--	9	2	2
Shredded or fragmentized	992	159	114	--	1,271	3	72
No. 1 busheling	447	70	123	--	629	(1)	18
All other carbon steel scrap	366	2	--	--	472	4	51
Stainless steel scrap	27	--	7	(1)	31	4	2
Alloy steel (except stainless)	29	--	4	5	34	5	15
Ingot mold and stool scrap	124	12	153	(1)	307	4	52
Machinery and cupola cast iron	889	8	267	20	1,166	23	59
Cast-iron borings	977	280	85	1	1,306	31	52
Motor blocks	466	29	825	--	1,301	25	52
Other iron scrap	702	183	2,572	1	3,459	53	128
Other mixed scrap	508	39	337	26	890	27	96
Total[2]	8,978	1,182	5,263	67	15,217	449	927
TOTAL—ALL TYPES OF MANUFACTURERS							
Carbon steel:							
Low-phosphorus plate and punchings	1,824	114	420	14	2,251	16	205
Cut structural and plate	2,138	224	503	12	3,005	17	171
No. 1 heavy melting steel	8,236	1,415	8,903	143	17,249	1,541	1,134
No. 2 heavy melting steel	2,938	234	943	4	4,016	127	301
No. 1 and electric-furnace bundles	5,370	379	1,641	3	7,397	476	411
No. 2 and all other bundles	1,204	114	12	(1)	1,372	8	115
Electric furnace, 1 foot and under (not bundles)	119	49	31	(1)	188	2	30
Railroad rails	307	1	10	--	365	4	14
Turnings and borings	1,269	15	282	5	1,561	24	129
Slag scrap (70% Fe content)	553	122	2,454	1	2,824	308	186
Shredded or fragmentized	3,794	1,347	175	--	5,342	132	336
No. 1 busheling	1,756	102	299	1	2,103	117	96
All other carbon steel scrap	2,477	729	6,620	13	9,095	849	693
Stainless steel scrap	558	23	503	(1)	1,066	24	85
Alloy steel (except stainless)	215	162	1,164	6	1,488	101	301
Ingot mold and stool scrap	406	244	703	773	1,759	416	366
Machinery and cupola cast iron	892	8	272	21	1,174	29	60
Cast-iron borings	1,150	280	124	2	1,482	57	73
Motor blocks	466	29	825	--	1,302	25	53
Other iron scrap	970	278	3,059	2	4,115	225	225
Other mixed scrap	720	113	474	32	1,339	30	118
Grand total[2]	37,362	5,983	29,416	1,032	70,493	4,527	5,104

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—U.S. consumer receipts, production, consumption, shipments, and stocks of pig iron and direct-reduced iron in 1985

(Thousand short tons)

	Receipts	Production	Consumption	Shipments	Stocks, Dec. 31
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS					
Pig iron	1,074	49,963	49,833	1,287	188
MANUFACTURERS OF STEEL CASTINGS					
Pig iron	71	--	68	(1)	4
IRON FOUNDRIES AND MISCELLANEOUS USERS					
Pig iron	1,566	--	1,510	69	72
TOTAL—ALL TYPES OF MANUFACTURERS					
Pig iron	2,711	49,963	51,411	1,356	[2]266
Direct-reduced or prereduced iron	359	--	349	W	52

W Withheld to avoid disclosing company proprietary data.
[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Table 4.—Consumption of iron and steel scrap and pig iron in the United States in 1985, by type of furnace or other use

(Thousand short tons)

Type of furnace or other use	Manufacturers of pig iron and raw steel and castings		Manufacturers of steel castings		Iron foundries and miscellaneous users		Total, all types[1]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Blast furnace[2]	2,481	--	--	--	--	--	2,481	--
Basic oxygen process[3]	15,339	44,515	--	--	--	--	15,339	44,515
Open-hearth furnace	2,411	4,737	W	W	--	--	2,411	4,737
Electric furnace[3]	32,252	5	1,965	68	4,411	430	38,628	503
Cupola furnace	20	73	110	--	10,330	427	10,459	501
Other (including air furnace)[4]	698	37	--	--	477	19	1,175	56
Direct castings[5]	--	468	--	--	--	633	--	1,101
Total[1]	53,201	49,833	2,075	68	15,217	1,510	70,493	51,411

W Withheld to avoid disclosing company proprietary data; included with "Electric furnace."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes consumption in blast furnaces producing pig iron.
[3]Includes scrap and pig iron processed in metallurgical blast cupolas and used in oxygen converters.
[4]Includes vacuum melting furnaces and miscellaneous uses.
[5]Includes ingot molds and stools.

Table 5.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States in 1985

(Percent)

Type of furnace	Scrap	Pig iron
Basic oxygen process	25.6	74.4
Open-hearth furnace	33.7	66.3
Electric furnace	98.7	1.3
Cupola furnace	95.4	4.6
Other (including air furnace)	95.5	4.5

Table 6.—Iron and steel scrap supply[1] available for consumption in 1985, by region and State

(Thousand short tons)

Region and State	Receipts of Scrap: From brokers, dealers and other outside sources	Receipts of Scrap: From other own-company plants	Production of Home Scrap: Recirculating scrap resulting from current operations	Production of Home Scrap: Obsolete (includes ingot molds, stools, and scrap from old equipment, buildings, etc.)	Total new supply[2]	Shipments of scrap[3]	New supply available for consumption
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island	1,352	88	391	10	1,840	117	1,723
Pennsylvania	4,498	818	4,629	278	10,224	1,280	8,944
Total[2]	5,850	906	5,020	288	12,064	1,398	10,666
North Central:							
Illinois	3,916	995	2,239	72	7,221	175	7,047
Indiana	3,203	197	6,760	236	10,396	1,038	9,358
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	5,876	984	3,579	31	10,470	224	10,246
Ohio	4,897	1,235	4,690	207	11,029	1,193	9,837
Wisconsin	655	2	444	--	1,100	7	1,093
Total[2]	18,546	3,413	17,711	546	40,217	2,636	37,580
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	4,154	226	2,602	59	7,042	156	6,885
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	6,208	1,126	3,011	86	10,432	276	10,156
Mountain and Pacific:							
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	2,602	311	1,072	53	4,040	60	3,979
Grand total[2]	37,362	5,983	29,416	1,032	73,792	4,527	69,266

[1]New supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped during the year. The plus or minus difference in stock levels at the beginning and end of the year is not taken into consideration.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes scrap shipped, transferred, or otherwise disposed of during the year.

Table 7.—U.S. consumption of iron and steel scrap and pig iron[1] in 1985, by region and State

(Thousand short tons)

Region and State	Pig iron and steel ingots and castings: Scrap	Pig iron and steel ingots and castings: Pig iron	Steel castings: Scrap	Steel castings: Pig iron	Iron foundries and miscellaneous users: Scrap	Iron foundries and miscellaneous users: Pig iron	Total[2]: Scrap	Total[2]: Pig iron
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island	1,103	([3])	64	1	624	45	1,790	47
Pennsylvania	7,898	6,341	155	8	1,124	426	9,177	6,775
Total	9,001	6,341	219	9	1,748	471	10,967	6,822

See footnotes at end of table.

Table 7.—U.S. consumption of iron and steel scrap and pig iron[1] in 1985, by region and State —Continued

(Thousand short tons)

Region and State	Pig iron and steel ingots and castings		Steel castings		Iron foundries and miscellaneous users		Total[2]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
North Central:								
Illinois	5,723	2,488	169	([3])	1,264	214	7,155	2,702
Indiana	8,644	15,926	159	42	791	48	9,593	16,016
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	5,676	4,640	389	1	4,193	518	10,258	5,159
Ohio	7,094	9,600	263	10	2,643	91	10,001	9,700
Wisconsin	--	--	129	1	971	50	1,101	51
Total[2]	27,137	32,654	1,108	54	9,862	921	38,108	33,629
South Atlantic:								
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	5,614	W	27	W	1,274	31	6,915	31
South Central:								
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	8,158	[4]10,837	331	[4]5	1,939	74	10,428	[4]10,916
Mountain and Pacific:								
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	3,291	W	389	W	394	11	4,075	11
Grand total[2]	53,201	49,833	2,075	68	15,217	1,510	70,493	51,411

W Withheld to avoid disclosing company proprietary data; included with "South Central" region.
[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes South Atlantic, Mountain and Pacific regions.

Table 8.—U.S. consumer stocks of iron and steel scrap and pig iron, December 31, 1985, by region and State

(Thousand short tons)

Region and State	Carbon steel (excludes rerolling rails)	Stainless steel	Alloy steel (excludes stainless)	Cast iron (includes borings)	Other grades of scrap	Total scrap stocks[1]	Pig iron stocks
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island	126	20	32	29	3	210	4
Pennsylvania	653	42	124	119	48	985	100
Total[1]	779	62	155	147	50	1,194	104
North Central:							
Illinois	380	--	13	55	1	448	12
Indiana	330	1	14	132	2	479	18
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	488	1	7	104	16	615	27
Ohio	339	10	61	95	7	512	27
Wisconsin	9	2	--	6	([2])	18	4
Total[1]	1,546	14	94	393	26	2,073	89

See footnotes at end of table.

Table 8.—U.S. consumer stocks of iron and steel scrap and pig iron, December 31, 1985, by region and State —Continued

(Thousand short tons)

Region and State	Carbon steel (excludes rerolling rails)	Stainless steel	Alloy steel (excludes stainless)	Cast iron (includes borings)	Other grades of scrap	Total scrap stocks[1]	Pig iron stocks
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	475	6	8	61	9	558	7
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	746	3	20	108	31	908	63
Mountain and Pacific:							
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	275	--	23	69	2	370	3
Grand total[1]	3,822	85	301	777	118	5,104	266

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 9.—U.S. average monthly price and composite price for No. 1 heavy melting scrap in 1985

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price[1]
January	$78.86	$86.48	$80.00	$81.78
February	82.16	88.32	80.00	83.49
March	84.76	91.19	81.43	85.75
April	79.59	83.05	80.57	82.07
May	68.00	72.68	73.82	71.50
June	62.00	69.50	68.25	66.58
July	64.24	72.62	68.29	68.38
August	73.00	77.00	74.00	74.66
September	72.00	74.20	74.00	73.40
October	71.87	73.50	71.52	72.29
November	69.00	69.50	71.00	69.83
December	69.17	72.12	71.00	70.76
Average 1985	72.89	77.43	74.41	74.91
Average 1984[r]	83.12	92.71	87.92	87.91

[r]Revised.
[1]American Metal Market, composite price, Chicago, Pittsburgh, and Philadelphia, Feb. 7, 1986.

Table 10.—U.S. exports[1] of iron and steel scrap, by country

(Thousand short tons and thousand dollars)

Country	1981		1982		1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	737	52,463	307	21,006	539	39,717	779	59,521	446	38,445
Italy	34	2,407	12	2,972	65	4,395	306	27,038	307	30,250
Japan	1,191	117,724	1,530	145,083	2,600	218,337	2,680	264,857	2,110	199,135
Korea, Republic of	1,241	114,736	1,522	115,515	1,476	111,051	1,833	160,892	1,978	160,674
Mexico	896	102,329	380	33,822	419	36,017	484	47,663	597	57,535
Spain	434	34,570	868	61,616	356	22,734	608	55,228	910	72,312
Taiwan	374	59,874	352	57,213	499	75,638	405	54,515	414	45,163
Turkey	364	31,814	639	48,286	700	50,851	807	69,579	955	80,133
Venezuela	55	4,620	45	3,231	20	1,197	392	33,346	471	36,384
Other	[r]1,090	[r]118,106	[r]1,150	[r]121,559	[r]846	[r]76,785	[r]1,204	[r]145,341	1,760	198,153
Total[2]	6,415	638,644	6,804	610,302	7,520	636,723	9,498	917,981	9,950	918,186

[r]Revised.
[1]Excludes rerolling material and ships, boats, and other vessels for scrapping.
[2]Data may not add to totals shown because of independent rounding.

Table 11.—U.S. exports and imports for consumption of iron and steel scrap, by class

(Thousand short tons and thousand dollars)

Class	1981		1982		1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	1,606	141,205	1,883	138,973	1,895	139,935	2,512	215,482	2,766	218,593
No. 2 heavy melting scrap	618	51,630	626	44,032	720	50,081	879	70,906	767	58,537
No. 1 bundles	41	3,476	115	8,619	206	16,486	77	8,258	185	17,172
No. 2 bundles	273	18,993	181	11,310	220	13,727	286	18,836	306	21,160
Stainless steel scrap	63	40,307	131	74,052	80	44,671	164	96,426	180	104,898
Shredded steel scrap	1,923	179,626	2,023	160,169	2,029	154,753	2,775	251,976	2,559	220,320
Borings, shovelings, turnings	486	24,757	577	28,923	532	28,277	800	49,664	875	56,314
Other steel scrap[1]	903	127,937	878	112,130	1,532	164,101	1,416	155,685	1,646	162,484
Iron scrap	501	50,714	389	32,096	306	24,692	590	50,748	666	58,707
Total[2]	6,415	638,644	6,804	610,302	7,520	636,723	9,498	917,981	9,950	918,186
Ships, boats, other vessels (for scrapping)	52	3,643	69	4,440	198	9,623	283	9,503	131	6,627
Rerolling material	57	10,831	53	7,969	34	4,194	58	10,918	110	15,604
Total exports[2]	6,524	653,118	6,925	622,711	7,752	650,540	9,840	938,402	10,191	940,416
Imports for consumption:										
Iron and steel scrap	556	62,126	468	37,572	641	48,219	572	46,946	601	45,620

[1]Includes terneplate and tinplate.
[2]Data may not add to totals shown because of independent rounding.

Table 12.—U.S. exports of rerolling material (scrap), by country

(Thousand short tons and thousand dollars)

Country	1981		1982		1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
China	--	--	--	--	--	--	--	--	19	2,497
Korea, Republic of	--	--	--	--	5	462	--	--	--	--
Mexico	55	10,267	33	5,290	28	3,579	57	8,248	90	12,511
Other	2	564	20	2,679	1	153	1	2,670	1	596
Total	57	10,831	53	7,969	34	4,194	58	10,918	110	15,604

Table 13.—U.S. imports for consumption of iron and steel scrap,[1] by country

Country	1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	55	$175	96	$306
Belgium-Luxembourg	63	49	502	653
Canada	532,241	41,866	562,032	37,242
Germany, Federal Republic of	2,141	131	1,978	524
Japan	3,157	419	6,626	1,162
Mexico	20,990	2,866	24,658	4,057
Netherlands	1	(2)	701	208
Panama	4,235	123	56	26
Sweden	750	104	2	1
United Kingdom	2,261	261	2,931	973
Other	6,115	952	1,672	466
Total[3]	572,010	46,946	601,254	45,620

[1]Includes tinplate and terneplate.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 14.—Iron and steel scrap consumption in selected countries[1]

(Thousand short tons)

Country	1980	1981	1982	1983	1984
North America:					
Canada[2 3 4 5]	9,395	8,233	6,261	6,965	[e]7,000
United States[2 5 6]	83,710	85,097	56,386	61,782	65,702
Latin America:[7]					
Argentina	1,321	1,338	1,569	1,570	1,281
Brazil	7,130	6,052	5,625	6,137	6,971
Chile	209	[e]210	146	209	237
Colombia	211	[e]205	324	369	378
Ecuador	20	[e]25	33	26	21
Mexico	3,425	3,618	3,332	2,383	3,181
Peru	224	[e]180	120	186	343
Uruguay	24	[e]20	34	56	53
Venezuela	1,068	[e]1,090	1,027	457	1,292
Central America, not further detailed	[r]164	[r e]100	82	74	126
Europe:					
European Economic Community:					
Belgium[2]	4,065	4,133	4,566	[5]3,480	[5]3,880
Denmark[8]	894	758	690	644	718
France	8,748	8,040	7,076	7,197	7,135
Germany, Federal Republic of[5]	22,401	21,632	19,339	19,692	20,510
Greece[e]	310	300	300	275	300
Ireland[9]	3	41	76	174	208
Italy[3]	[9]19,825	17,799	16,944	15,861	[e]17,420
Luxembourg	1,738	1,458	1,450	1,508	[e]1,850
Netherlands	2,025	1,961	1,594	1,607	1,797
United Kingdom	10,248	11,424	11,535	[r]10,569	10,578
European Free Trade Association:					
Austria	1,910	1,910	1,807	[3]1,797	[3]1,851
Finland[3]	848	807	758	[10]780	[e]831
Norway[4]	526	[3]559	[3]537	[3]577	[3]638
Portugal	564	[r]486	522	[e]575	[e]600
Sweden[2 3 5]	2,835	2,924	3,145	[e]3,395	[e]3,500
Switzerland	992	[9]948	[9]915	[e]915	[e]915

See footnotes at end of table.

Table 14.—Iron and steel scrap consumption in selected countries[1] —Continued

(Thousand short tons)

Country	1980	1981	1982	1983	1984
Europe —Continued					
Council for Mutual Economic Assistance:					
Bulgaria[e]	860	830	830	820	850
Czechoslovakia[2 3 5]	8,884	8,244	8,186	8,665	8,365
German Democratic Republic[2 3 4 5]	5,833	5,816	5,649	5,682	5,779
Hungary[2 3 5]	2,528	2,425	2,446	2,445	2,705
Poland	11,817	9,598	[r 3]8,983	[r 3]9,796	9,630
Romania[e]	4,300	4,250	4,260	4,270	4,300
U.S.S.R.[e]	56,690	56,900	[r]60,300	[r]63,400	64,500
Other:					
Spain	9,974	9,933	10,642	10,795	[e]11,100
Yugoslavia	2,287	2,324	2,245	2,434	[e]2,500
Africa: South Africa, Republic of[2]	[11]3,974	[11]3,333	[e]3,060	[e]2,600	[e]3,000
Asia:					
China[e]	9,400	9,000	9,400	10,100	10,900
India[e]	4,080	4,100	4,200	4,050	4,060
Japan[5]	48,291	44,616	42,832	44,269	47,934
Korea, Republic of[e]	2,200	2,700	3,300	3,350	3,600
Taiwan[e 12]	1,200	1,100	1,400	1,700	1,700
Turkey	[e]1,900	[9]1,764	[e]1,900	[e]2,300	[e]2,500
Oceania:					
Australia[e]	2,470	2,480	2,070	1,820	2,050
New Zealand[e]	160	155	160	150	180
Total	[r]361,681	[r]350,916	[r]317,456	[r]327,906	344,969

[e]Estimated. [r]Revised.

[1]Unless otherwise specified, figures represent actual reported consumption of iron and steel scrap utilized in the production of pig iron, ferroalloys, crude steel, foundry products, and rerolled steel, as well as other unspecified uses in the steel industry and by other unspecified industries as reported by the United Nations Economic Commission for Europe in its Annual Bulletin of Steel Statistics for Europe 1984, v. 12, New York, 1985, 83 pp., which is the source of all reported data unless otherwise specified. All estimates are by the Bureau of Mines.

[2]Excludes scrap consumed by steel rerollers.

[3]Excludes scrap consumed in iron foundries.

[4]Excludes scrap consumed within the steel industry for purposes other than the manufacture of pig iron, ferroalloys, crude steel, foundry products, and rerolled steel (details on use not available).

[5]Excludes scrap consumed outside the steel industry.

[6]Bureau of Mines.

[7]Except where individually specified as an estimate or as being derived from another source, data are from Instituto Latino Americano del Fierro y el Acero. Statistical Yearbook of Steel Making and Iron Ore Mining in Latin America, 1984. Santiago, 1985, 220 pp. Source does not provide details on what is included; presumably figures include total steel industry ferrous scrap consumption but exclude scrap used outside the steel industry.

[8]Includes scrap used in production of steel casting in shipyards, but excludes scrap, if any, used in production of pig iron and that used in iron foundries.

[9]Organization for Economic Cooperation and Development. The Iron and Steel Industry in 1980, Paris, 1982, 40 pp.; The Iron and Steel Industry in 1981, Paris, 1983, 40 pp.; The Iron and Steel Industry in 1982, Paris, 1984, 52 pp; and The Iron and Steel Industry in 1983, Paris, 1985, 52 pp.

[10]Excludes consumption, if any, in the production of pig iron.

[11]Iron and Steel Statistics Bureau (United Kingdom). International Steel Statistics, Republic of South Africa, 1981, p. 4.

[12]Excludes a substantial tonnage derived from shipbreaking (possibly of the order of several million tons annually for electric-furnace-equipped steel mills).

Table 15.—Iron and steel scrap exports, by selected countries[1]

(Thousand short tons)

Continent, country group, and country	1980	1981	1982	1983	1984
North America:					
Canada	865	632	[r]691	[r]956	876
United States[2] [3]	11,254	6,472	6,857	[r]7,634	9,498
Latin America:					
Mexico[2]	4	2	22	4	[e]10
Europe:					
European Economic Community:					
Belgium-Luxembourg	592	637	549	752	853
Denmark	110	204	130	193	258
France	3,651	3,510	3,397	3,557	4,525
Germany, Federal Republic of	3,392	3,756	3,160	3,282	3,602
Greece	([4])	1	1	1	1
Ireland	93	[r]81	65	23	47
Italy	9	25	19	20	21
Netherlands	1,316	1,380	1,300	1,678	1,851
United Kingdom	3,092	3,712	3,387	4,182	4,758
European Free Trade Association:					
Austria	14	14	10	14	23
Finland	([4])	([4])	([4])	([4])	11
Iceland	3	3	4	[r]11	[2]11
Norway	42	35	35	40	23
Portugal	6	6	10	11	10
Sweden	15	15	20	23	24
Switzerland	71	141	116	[r]165	117
Council for Mutual Economic Assistance:					
Bulgaria	171	87	63	42	53
Czechoslovakia[5]	109	113	[r]107	137	[e]150
German Democratic Republic[5]	54	21	[r]22	23	[e]25
Hungary	34	35	58	55	87
Poland[2]	16	[r]88	[r]284	161	194
Romania[5]	([4])	([4])	([4])	([4])	([4])
U.S.S.R.[2]	2,756	2,681	2,859	3,715	3,756
Other:					
Spain	1	21	1	1	4
Yugoslavia	50	[2]65	70	78	157
Africa:					
Algeria[2]	72	48	62	61	[e]70
Morocco[2]	38	56	57	72	[e]80
South Africa, Republic of[5]	7	2	4	51	[e]50
Asia:					
Brunei	([4])	6	5	10	[e]10
China[5]	11	161	108	40	[e]100
Cyprus	6	([4])	8	9	15
Hong Kong[2]	302	371	327	[r]363	331
India[2]	2	22	[e]20	[e]20	[e]20
Indonesia[2]	1	--	([4])	1	1
Japan	175	206	193	128	161
Korea, North[5]	2	8	15	7	[e]10
Korea, Republic of[2]	10	28	155	314	149
Kuwait	69	27	20	[e]20	[e]20
Malaysia[2]	12	13	7	[e]10	[e]10
Mongolia[5]	22	24	26	24	[e]25
Philippines[2]	2	2	2	1	1
Saudi Arabia	18	58	33	[e]35	[e]35
Singapore[2]	6	2	9	132	120
Taiwan[2]	14	141	443	308	223
Thailand[2]	1	2	9	2	4
United Arab Emirates	3	4	7	[e]10	[e]10
Oceania:					
Australia[2]	[e]600	708	1,249	619	409
New Zealand[2]	49	3	3	3	4
Total	[r]29,142	[r]25,629	[r]25,999	[r]28,998	32,803

[e]Estimated. [r]Revised.

[1]Unless otherwise specified, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe 1984, v. 12, New York, 1985, 83 pp.

[2]Official trade returns of subject country.

[3]Includes rerolling material.

[4]Less than 1/2 unit.

[5]Partial figure; compiled from import statistics of trading partner countries.

Table 16.—Iron and steel scrap imports by selected countries[1]

(Thousand short tons)

Continent, country group, and country	1980	1981	1982	1983	1984
North America:					
Canada	1,119	924	505	r737	[2]1,247
United States[2]	582	556	468	641	577
Latin America:					
Argentina[2]	2	2	2	8	e10
Brazil[2]	24	8	8	(3)	34
Chile	(3)	5	e10	e10	e10
Colombia[2]	14	33	30	51	48
Cuba	[4]95	e100	e100	[4]107	e100
Mexico[2]	257	235	r464	390	e400
Peru[2]	36	40	18	e20	e20
Venezuela[2]	36	55	23	20	e20
Europe:					
European Economic Community:					
Belgium-Luxembourg	947	1,054	978	1,152	1,843
Denmark	239	198	97	74	146
France	503	383	304	338	449
Germany, Federal Republic of	1,658	1,473	1,421	r1,424	1,935
Greece	263	317	478	r573	362
Ireland	9	4	r3	77	97
Italy	8,168	6,107	6,141	4,901	6,047
Netherlands	170	262	244	401	527
United Kingdom	28	23	41	12	37
European Free Trade Association:					
Austria	158	187	420	241	400
Finland	117	68	56	41	36
Norway	58	26	4	17	14
Portugal	164	94	138	r119	132
Sweden	84	272	583	496	925
Switzerland	151	125	118	162	301
Council for Mutual Economic Assistance:					
Bulgaria	(3)	--	--	--	--
Czechoslovakia[4]	62	278	81	173	e200
German Democratic Republic	1,001	764	502	741	1,141
Hungary	4	159	15	31	22
Poland	250	58	6	6	8
Romania	62	--	--	--	--
U.S.S.R.[5]	23	24	27	24	e25
Other:					
Spain	4,835	4,479	5,249	5,227	5,531
Yugoslavia	437	[2]528	560	812	861
Africa:					
Egypt[2]	41	15	14	e15	e15
Morocco	(3)	[2]2	[2]3	[2]3	e3
South Africa, Republic of[2]	31	14	31	8	e10
Asia:					
China[4]	2	(3)	3	2	e3
Hong Kong[2]	103	104	71	30	31
India[2]	124	573	e500	e500	e500
Indonesia[2]	43	69	250	r284	e300
Japan	3,291	1,974	2,232	4,306	4,429
Korea, Republic of[2]	2,130	2,546	1,994	2,090	2,294
Malaysia[2]	5	60	28	e30	53
Pakistan	368	534	173	132	134
Philippines[2]	10	10	28	(3)	2
Singapore[2]	190	86	103	104	87
Taiwan[2]	1,358	971	718	811	637
Thailand[2]	373	460	r430	707	545
Turkey	381	579	825	1,184	1,144
Oceania:					
Australia[2]	1	1	e1	e1	e1
New Zealand[2]	69	5	6	3	3
Total	30,076	26,844	r26,504	r29,236	33,696

eEstimated. rRevised.

[1]Unless otherwise specified, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe 1984, v. 12, New York, 1985, 83 pp.

[2]Official trade returns of subject country.

[3]Less than 1/2 unit.

[4]Partial figures; compiled from export statistics of trading partner countries.

[5]Partial figure; compiled from incomplete returns of subject country and export statistics of trading partner countries.

Kyanite and Related Materials

By Michael J. Potter[1]

Kyanite, andalusite, and sillimanite are anhydrous aluminum silicate minerals that are alike in both composition and use patterns and have the same chemical formula, $Al_2O_3 \cdot SiO_2$. When these minerals are calcined at approximately 2,900° F, they are converted into mullite. Related materials include synthetic mullite, dumortierite, and topaz, also classified as aluminum silicates, although the last two additionally contain substantial proportions of boron and fluorine, respectively. All of these kyanite-group substances can serve as raw materials for manufacturing special high-performance, high-alumina refractories, but there has been no record in recent years of either dumortierite or topaz being used for this purpose in the United States.

Although published statistics were incomplete, France, India, the Republic of South Africa, and the United States appeared to be the leading world producers of kyanite-group minerals. The U.S.S.R. and perhaps a few other industrialized nations also were presumed to produce significant quantities of these materials.

U.S. kyanite output in 1985 was estimated to be approximately the same as that of 1984. Major end uses of kyanite, mullite, and synthetic mullite were in refractories for the ferrous and nonferrous metals industries, where production generally remained flat in 1985.

Domestic Data Coverage.—Domestic production data for kyanite and synthetic mullite are developed by the Bureau of Mines by means of two separate, voluntary, domestic surveys. In the kyanite survey, of the three active mines canvassed, none responded. These mines were operated by two companies. An estimate of total production was made by the Bureau of Mines using last reported production levels adjusted by the trend of the minerals economy.

In the synthetic mullite survey, of the five canvassed operations, three, or 60%, responded and accounted for 12% of the total production data shown in table 1. The percentage of production that was estimated, 88%, was arrived at by using last reported production levels adjusted by the trend of the minerals economy.

Legislation and Government Programs.—The allowable depletion rates for kyanite, established by the Tax Reform Act of 1969 and unchanged through 1985, were 22% for domestic production and 14% for foreign operations.

DOMESTIC PRODUCTION

Kyanite was produced in the United States at three open pit mines, two in Virginia and one in Georgia. Kyanite Mining Corp. operated the Willis Mountain and East Ridge Mines in Buckingham County, VA. Pasco Mining Inc. operated the Graves Mountain Mine in Lincoln County, GA.

There are three types of synthetic mullite. Fused synthetic mullite is made by melting Bayer process alumina and silica, or bauxite and kaolin in an electric furnace at about 3,450° F. High-temperature sintered synthetic mullite is prepared by sintering mixtures of alumina and kaolin, bauxite and kaolin, or alumina, kaolin, and kyanite above 3,180° F. Low-temperature sintered synthetic mullite is made by sintering siliceous bauxite or mixtures of bauxite and kaolin above 2,820° F.

Output of synthetic mullite in 1985 was estimated to be largely of the high-temperature sintered variety, and the two producers of this material were believed to be C-E Minerals Inc. at Americus, GA, and Harbison-Walker Refractories at Eufaula, AL. Electric-furnace-fused mullite was produced by Sohio Electro Minerals Co. at Niagara Falls, NY.

Table 1.—U.S. production of synthetic mullite

Year	Quantity (short tons)	Value (thousands)
1981	42,000	$9,050
1982	27,000	5,950
1983[e]	23,000	4,700
1984[e]	27,000	5,300
1985[e]	27,000	5,450

[e]Estimated.

CONSUMPTION AND USES

Kyanite and related materials were consumed mostly in the manufacture of high-alumina or mullite-class refractories and in lesser quantities as ingredients in ceramic compositions. U.S. kyanite, already ground to minus 35 mesh as required by the flotation process used in its separation and recovery, was marketed either in this raw form or, after heat treatment, as mullite, sometimes further reduced in particle size before use. In the 35- to 48-mesh range, kyanite was used mostly in monolithic refractory applications such as high-temperature mortars or cements, ramming mixes, and castable refractories, or with clays and other ingredients in refractory compositions for making kiln furniture, insulating brick, firebrick, and a wide variety of other articles. More finely ground material, minus 200 mesh, was used in body mixes for sanitary porcelains, wall tile, investment-casting molds, and miscellaneous special-purpose ceramics.

PRICES

Engineering and Mining Journal, December 1985, listed prices for raw kyanite, f.o.b. Georgia, ranging from $92 to $144 per short ton for bulk shipments and $9 more per ton for bagged material. These prices were unchanged from those of 1984.

Prices in 1985, in British pounds, from Industrial Minerals (London) were the same as those of 1984. The price increases in U.S. dollars of 12% in table 2 reflect a corresponding increase in the value of the British pound against the U.S. dollar.[2]

Table 2.—Prices of kyanite and related materials

(Dollars per short ton)

	1984	1985
Andalusite, Transvaal, 52% to 54% Al_2O_3, bulk, c.i.f. main European port	79	89
Andalusite, Transvaal, 60% Al_2O_3, c.i.f. main European port	102	114
Sillimanite, South African, 70% Al_2O_3, bags, c.i.f. main European port	215	241
U.S. kyanite, 59% to 62% Al_2O_3, 35-325 Tyler mesh, raw and/or calcined, 18-ton lots, c.i.f. main European port	102-176	114-197
U.S. kyanite, f.o.b. plant, carlots:		
Calcined	123-172	123-172
Raw	70-137	70-137

Source: Industrial Minerals (London). No. 219, Dec. 1985, p. 101.

FOREIGN TRADE

An estimated one-third of U.S. production of kyanite- and mullite- containing materials was exported, with a substantial quantity going to the Federal Republic of Germany. Based on data from a non-Government source, imports of andalusite in 1985 were insignificant compared with those of 1984.

WORLD REVIEW

During 1984, the last year for which information was available, the European refractories industry experienced difficulty in obtaining enough andalusite to satisfy its requirements. This was especially true with respect to ladle refractories. The shortage was largely due to the shutdown of two South African operations and a brief shutdown of the one French producer. However, the situation was expected to improve when new facilities in the two countries came on stream.

France.—Output of andalusite, which has been second only to that of the Republic of South Africa, was 46,300 short tons in 1983 and 57,300 tons in 1984. The sole producer, Denain Anzin Mineraux, planned to add a new plant to its two existing facilities in mid-1985, which could raise output to at least 70,000 tons per year. Exports in recent years have been largely to the Federal Republic of Germany, Italy, and the United Kingdom. About 20% of French output has been consumed internally.[3]

South Africa, Republic of.—Weedons Minerals (Pty.) Ltd. has been the largest single producer of andalusite in the world, with annual output of approximately 100,000 to 110,000 tons. The company had three processing plants in operation with a fourth being planned, which would presumably raise its production to 130,000 tons per year. Rand London Andalusite Ltd. was producing approximately 3,860 tons per month of andalusite, with new plant facilities scheduled to become operational in 1985. Export markets for Rand London were Australia, Europe, Israel, Japan, and the United States.

Verref Mining (Pty.) Ltd. has an andalusite capacity of 55,000 tons per year; material was marketed worldwide to refractory manufacturers, with Italy being a significant consumer. Hoogeneog Andalusite (Pty.) Ltd. planned to restart production in the near future. A newly installed processing plant was expected to bring production capacity to 22,000 tons per year. When production resumes, 80% of the output is expected to be exported to European markets.[4]

Sweden.—Svenska Kyanite AB, a new kyanite joint venture between Svenska Forshammar AB and Ulf Juval AB, was put into operation in May. The ore deposit contains an average of 30% kyanite, and proven reserves were put at 5 million tons. Beneficiation consists of crushing; grinding; flotation to separate quartz and kyanite; high-intensity magnetic separation to reduce the iron content; and filtration, drying, and packing of the kyanite product. The processing plant capacity was to be approximately 30,000 tons per year of product. The major market was to be the European refractories industry.[5] The high-intensity magnetic separator uses conventional permanent magnets but is as powerful as some electromagnetic wet, high-intensity separators.[6]

United Kingdom.—Imports of kyanite-group minerals in 1984 totaled 58,100 tons; principal countries of origin and percentages supplied were the Republic of South Africa, 48%; France, 26%; and the United States, 18%.[7]

Table 3.—Kyanite: World production, by country[1]

(Short tons)

Country[2] and commodity	1981	1982	1983	1984[p]	1985[e]
Australia: Sillimanite[3]	365	863	133	r e660	550
Brazil: Kyanite	1,753	466	473	r e550	550
China: Unspecified[e]	2,800	2,800	2,800	2,800	2,800
France: Andalusite	e33,100	r46,300	46,300	57,300	55,100
India:					
Andalusite	161	591	2,836	e3,000	3,000
Kyanite	42,200	37,425	42,226	40,812	37,500
Sillimanite	11,303	14,403	8,739	14,746	14,300
Kenya: Kyanite	--	--	6,004	1,102	1,100
Korea, Republic of: Andalusite	99	r36	319	230	220
South Africa, Republic of:					
Andalusite	199,818	171,655	128,503	157,967	205,000
Sillimanite	17,090	11,089	898	1,445	1,600
Spain: Andalusite	6,780	5,627	4,945	3,307	3,900
United States:					
Kyanite	W	W	W	W	W
Synthetic mullite	42,000	27,000	e23,000	e27,000	27,000
Zimbabwe: Kyanite	959	2,433	(4)	(4)	--

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Owing to incomplete reporting, this table has not been totaled. Table includes data available through Apr. 8, 1986.
[2]In addition to the countries listed, a number of other nations produce kyanite and related materials, but output is not reported quantitatively, and no reliable basis is available for estimation of output levels.
[3]In addition, sillimanite clay (also called kaolinized sillimanite) is produced, but output is not reported quantitatively, and available information is inadequate for the formulation of reliable estimates of output levels.
[4]Revised to zero.

TECHNOLOGY

Piedmont Minerals Co. Inc. in North Carolina investigated the possibility of producing an andalusite product from its pyrophyllite-andalusite material. Pilot plant work yielded a product containing over 90% andalusite with an alumina content approaching 60%. Processing steps included fine grinding, heavy-media separation, and flotation. Further work on processing and marketing of the product would have to be carried out before any commercial production. The company can currently produce an andalusite-pyrophyllite product containing 50% to 55% andalusite that is used in refractories.[8]

[1]Physical scientist, Division of Industrial Minerals.
[2]Where necessary, values have been converted from pounds sterling (£) per metric ton to U.S. dollars per short ton at the rate of £1.00=US$1.40 for 1985.
[3]Industrial Minerals (London). Sillimanite Minerals—Europe Places Demands on Andalusite. No. 208, Jan. 1985, pp. 45-46, 62.
[4]Pages 43-45 of work cited in footnote 3.
[5]Industrial Minerals (London). Svenska Kyanite Start-Up. No. 211, Apr. 1985, p. 13.
[6]Mining Journal (London). High Force Magnetic Separator. V. 304, No. 7819, June 28, 1985, p. 461.
[7]Industrial Minerals (London). United Kingdom Industrial Mineral Statistics. No. 211, Apr. 1985, p. 85.
[8]Dickson, T. North American Pyrophyllite-Ceramics Leading the Way. Ind. Miner. (London), No. 218, Nov. 1985, p. 57.

Lead

By William D. Woodbury[1]

Domestic mine output of recoverable lead increased by over 90,000 metric tons in 1985, but was the second lowest production since 1968. Primary refinery output also increased by over 90,000 tons, and although it too was the second lowest since 1968, total refined metal output, including that from secondary sources, was the highest since 1982. Net imports of refined metal for consumption were 50,000 tons less than those of 1984, but were still over 100,000 tons. Total net imports of contained lead in all forms, including scrap, declined significantly, as reported consumption declined by nearly 60,000 tons. The storage battery sector had a good year for the second year in a row and utilized almost three-quarters of the total demand for refined lead. The overall dropoff in domestic demand, in concert with the general worldwide overproduction of lead associated with relatively high levels of silver and zinc mining, resulted in the average U.S. producer sales price declining to its lowest level since 1973.

Table 1.—Salient lead statistics

(Metric tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production:					
Domestic ores, recoverable lead content	445,535	512,516	r449,295	r322,677	413,955
Value thousands	$358,821	$288,579	r$214,745	r$181,745	$174,008
Primary lead (refined):					
From domestic ores and base bullion	440,238	459,865	459,328	330,168	416,091
From foreign ores and base bullion	55,085	52,295	55,227	65,409	71,353
Antimonial lead (primary lead content)	3,008	4,622	W	W	W
Secondary lead (lead content)	641,105	571,276	503,501	r633,374	594,186
Exports (lead content):					
Lead ore and concentrates	33,043	29,104	20,119	11,858	9,987
Lead materials excluding scrap	23,320	55,629	24,351	16,563	37,320
Imports, general:					
Lead in ore and concentrates	58,545	35,807	47,516	68,870	42,665
Lead in base bullion	449	19	53	43	760
Lead in pigs, bars, reclaimed scrap	107,185	99,587	1179,485	167,868	136,697
Stocks, Dec. 31 (lead content):					
At primary smelters and refineries	140,207	125,537	106,661	135,079	127,950
At consumers and secondary smelters	123,216	97,209	100,771	r97,077	93,130
Consumption of metal, primary and secondary	1,167,101	1,075,408	1,148,487	1,207,033	1,148,298
Price: Common lead, average, cents per pound[2]	36.53	25.54	21.68	25.55	19.07
World:					
Production:					
Mine thousand metric tons	r3,365.5	r3,422.5	3,358.6	p3,255.8	e3,391.7
Refinery[3] do	r3,118.8	r3,181.1	3,236.1	p3,156.7	e3,295.5
Secondary refinery do	r2,211.3	r2,038.9	2,021.6	p2,266.8	e2,178.1
Price: London Metal Exchange, pure lead, cash average, cents per pound	33.30	24.66	19.27	20.12	17.84

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Includes Bureau of Mines estimate of 42,000 metric tons of pigs and bars (lead content) of U.S. brands returned from the London Metal Exchange.
[2]Metals Week. Transactions on a delivered basis.
[3]Primary metal production only. Includes secondary metal production where inseparably included in country total.

World production of refined lead, including secondary, was estimated to have increased by 50,000 tons over that of 1984, and to have exceeded total world demand, which was 20,000 tons less than that of 1984, by 10,000 tons. That resulted in a buildup of metal stocks during 1985. Recoverable world mine production, which represented 60% of demand, was estimated to have increased by 136,000 tons from that of 1984. Despite depressed world prices for lead, 80,000 tons of net additional mine capacity was brought on-stream in 1985, mostly through new zinc and/or silver operations. The London Metal Exchange (LME) cash price for the year averaged only 1.2 cents per pound less than that in the United States, not generally favorable to domestic importers, and at 17.8 cents per pound was the lowest since 1972 (13.7 cents).

In the United States, a Federal regulation lowering the permissible amount of lead contained in gasoline additives by over 50% became effective in midyear. Austria banned the sale of leaded regular gasoline effective October 1, 1985, and the European Economic Community issued a directive in March requiring all member countries to ensure the availability and balanced distribution of unleaded gasoline by October 1, 1989. At the beginning of 1985, Austria, Denmark, the Federal Republic of Germany, Norway, Sweden, and Switzerland enforced a limit of 0.57 gram per gallon for all leaded gasoline. Finland enforced this limit on regular grade only, but was to extend it to all grades in January 1986. At yearend, the Environmental Protection Agency (EPA) in the United States was considering an outright ban on all lead in gasoline by 1988.

Domestic Data Coverage.—Domestic data for lead are developed by the Bureau of Mines from five voluntary surveys of U.S. operations. Typical of these are the combined monthly and annual secondary consumer surveys. Of the 297 plants to which a consumer survey request was sent, 94% responded, representing 99% of the total lead consumption shown in tables 1, 12, 13, 14, and 15. Of the 68 plants to which a secondary smelter production survey request was sent, 84% responded, representing 92% of the total refinery production of secondary lead recovered from scrap shown in tables 1, 10, and 11. Production and consumption for the nonrespondents were estimated using reported prior year levels adjusted by general industry trends.

Legislation and Government Programs.—The final phase of EPA's plan, announced in August 1984, to limit the permissible amount of lead in gasoline to 0.1 gram per gallon by January 1, 1988, was moved up to January 1, 1986, and an interim standard of 0.5 gram per gallon went into effect on July 1, 1985. In September, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund) expired, but reauthorization bills had passed both houses of Congress at yearend. Although lead metal was added to the list of potentially hazardous materials to be taxed, a final revenue scheme was not developed by House and Senate Conferees, and no legislation was enacted at yearend. The Senate bill called for using the existing tax rates for petrochemical feedstocks and crude oil, plus an additional manufacturers' (producers') tax on other hazardous materials. The House bill raised the existing feedstock tax rates and set a tax on hazardous waste generated but not on the specific volume of toxic substances per se in the waste. Of most concern to the lead producers by yearend, however, was that the EPA was considering lowering the National Ambient Air-Quality Standard for lead from 1.5 micrograms per cubic meter to 0.5 microgram per cubic meter.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, lead would be categorized in both tier I and tier II; the goal would be 272,156 tons of lead metal equivalent in tier II, but no goal had been set for tier I at yearend. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984. During 1985, the National Defense Stockpile inventory remained at 545,000 tons of lead metal, about 55% of the current authorized goal.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mine production of recoverable lead was significantly higher than that of 1984, which was strike-affected. However, the total was the second lowest since 1968, 1 year before the Viburnum Trend operations in Missouri came fully on-stream. Higher production was not attained because the producers reportedly were fearful of building stocks in the face of the realized decrease in demand that was generally forecast for 1985. Seven Missouri lead mines accounted for about 90% of total domestic production, and together with the lead-producing mines in Colorado, Idaho, Montana, and New York accounted for almost all of the U.S. mine output. Some byproduct lead also was recovered from mining in five other States during the year.

According to AMAX Inc.'s annual report, the Buick Mine in Iron County, MO, equally owned by them as operator and Homestake Mining Co., continued to be the Nation's largest single lead-producing unit, milling 2.07 million tons of ore at an average grade of 6.9% lead, which yielded 137,500 tons of lead in concentrates. The average grade of hoisted ore dropped 1.2% from that of 1984 and was the lowest since 1981. Estimated proven and probable ore reserves of the mine at yearend were 18 million tons at an average grade of 8.0% lead, a decrease of 377,000 tons of contained lead compared with that of yearend 1984 owing to a revised mining plan.

The second largest producing lead mine was the Magmont Mine, in Iron County, MO, jointly owned by Cominco American Incorporated and Dresser Industries Inc. According to Cominco Ltd.'s annual report, a record high 1.04 million tons of ore was milled at an average grade of 7.51% lead, which yielded 100,400 tons of concentrates at an average grade of 73.3% lead. The record high production was attributed to replacement of the original flotation cells, installed in 1968, in the mill's lead flotation circuit with new ones of higher volume. Over 40% of Magmont's total ore production was extracted from Magmont West, which opened in late 1983. Measured and indicated ore reserves at yearend were 6.26 million tons at an average grade of 6.5% lead, 900,000 tons less than that of yearend 1984. Cominco's share of the Magmont Mine's lead production was purchased by ASARCO Incorporated's lead smelter-refinery at Glover, MO, and Dresser's share was tolled by Asarco.

The St. Joe Lead Co. Div. of St. Joe Minerals Corp., Clayton, MO, operated two mine and mill complexes involving four mines in southeastern Missouri on the Viburnum Trend in 1985. St. Joe was the largest U.S. lead mine producer during the year, accounting for about 37% of total domestic production, hoisting 3.2 million tons of ore with an average grade of 5.08% lead, according to parent Fluor Corp.'s annual Securities and Exchange (SEC) Form 10-K covering the fiscal year ending October 31, 1985. The four Missouri mines plus the Balmat zinc mine in New York produced 156,750 tons of lead in concentrates out of an estimated 427,000-ton U.S. total. St. Joe's mine capacity was estimated by the Bureau of Mines to be about 42% of that for the United States in 1985, and its mines had proven published reserves in Missouri on October 31 of 56.8 million tons grading approximately 5% lead, down about 500,000 tons from that reported on October 31, 1984. Development of the Viburnum No. 35 Mine, renamed the Casteel Mine in December, was completed during the year at a total cost of approximately $31.5 million, including mill expansion. St. Joe's Brushy Creek unit in Missouri did not operate during the year.

Approximately 60% of the ore contained in St. Joe's lead ore bodies is situated on properties held under Federal mineral leases for terms of 10 to 20 years for which St. Joe pays a royalty fee of 5% of the gross value of concentrates produced.

Hecla Mining Co.'s annual report stated that its Lucky Friday Mine in Shoshone County, ID, produced at record high capacity during the year and milled 251,124 tons of silver ore, which yielded a record high 31,560 tons of refined lead, an increase of 3,450 tons, or 11%, over the previous record high set in 1984. The concentrates were smelted at Asarco's East Helena, MT, plant. The increase was attributed to a 20% increase in labor productivity owing to equipment upgrading and more mechanization, and testing of an advanced mechanized mining method was begun. Proven and probable ore reserves at Lucky Friday at yearend were 608,000 tons containing 11.9%

lead and 16.6 troy ounces of silver per ton, a slight decrease in contained lead from yearend 1984.

Development work at Asarco's West Fork Mine in Reynolds County, MO, was completed during the year, and production was scaled up, starting with completion of the underground crushing system in September, to reach about 40% of capacity by yearend. The company did not plan to increase the level of production, however, until lead prices improved significantly. About 3,500 tons of lead in concentrates was produced, compared with 6,100 tons at the Leadville Mine in Colorado, an Asarco-operated 50% equity venture, according to the company's annual report. West Fork's proven and probable ore reserves at yearend were estimated to be 13.5 million tons grading 5.5% lead, and the mine's full production capacity was estimated to be 46,000 tons of lead in concentrates per year from a mill throughput of 3,450 tons of ore per day, according to Asarco.

SMELTER AND REFINERY PRODUCTION

Primary.—In the fiscal year ending October 31, the St. Joe smelter-refinery at Herculaneum, MO, the Nation's largest, produced 161,760 tons of refined lead, an increase of over 27,000 tons from that reported for 1984 in parent Fluor's annual SEC Form 10-K. However, the plant was closed for the full month of July for routine maintenance and inventory adjustment. A strike was averted in April, at the last moment, and a new pact was signed by the Teamsters Union covering the 2 years until April 30, 1987.

According to Homestake's annual report, the AMAX-Homestake smelter-refinery at Boss, MO, produced 119,750 tons of refined lead from their Buick Mine mill production and stocks, an increase of about 15,000 tons over output in strike-affected 1984, and only about 10,000 tons below 1983's record. The plant, however, was shut down from October 16 to December 4 in order to compensate for the decreased lead concentrate production at Buick.

Asarco reported that its three smelters, one each at East Helena, MT, El Paso, TX, and Glover, MO, produced 202,120 tons of lead bullion, an increase of 17,400 tons over output in strike-affected 1984. Asarco's two refineries at Omaha, NE, and Glover, MO, produced 204,840 tons of refined lead metal, an increase of 29,400 tons from that of 1984. The El Paso and East Helena smelters shipped their bullion to Omaha, but operations were suspended indefinitely at El Paso at the end of August owing to a lack of dependable supply of foreign concentrates. Feed stocks from Australia, Canada, and Peru did not materialize in 1985, apparently owing to depressed world prices resulting from oversupply.

The U.S. primary industry produced refined lead at 82% of capacity for the year.

Secondary.—The U.S. secondary industry at yearend consisted essentially of 23 companies, which operated 30 plants with refined metal capacities ranging from 5,000 to 80,000 tons per year and which represented 98% of total production. There were also 38 small producers with annual capacities of 1,000 tons or less, which produced specialty alloys, including solders and specialized batteries. During the year, about 250,000 tons of capacity was closed, most permanently, including one plant of 68,000-ton capacity, which had filed for bankruptcy protection in 1984. At yearend, nominal engineered capacity stood at about 800,000 tons compared with about 1,300,000 tons at the end of 1980. However, effective operating capacity was only about 700,000 tons. As a result, the industry operated at 74% of nominal capacity for the year, compared with a revised estimate of about 60% for 1984. Taracorp Inc., which had been 1 of the top 10 producers, and which had filed for bankruptcy protection on October 1, 1982, successfully reestablished itself on July 31, 1985, primarily as a consumer of lead for lead products.

CONSUMPTION AND USES

Despite reported increases in the consumption of lead in traditional areas such as ammunition, cable covering, and casting metals in transportation equipment, overall consumption declined by almost 60,000 tons in 1985, compared with that of 1984. This primarily was attributed to about 25,000 tons less demand by the battery manufacturers, and a decline of over 33,000 tons, or about 42%, in the use of lead for gasoline additives. The use of lead in solder declined for the seventh consecutive year, primarily in applications involving potable water supply systems and food containers. Lead-based paint and ceramic product applications also continued to decline.

According to Battery Council International statistics of domestic shipments plus units exported, production of automotive batteries, the largest specific end use of lead, was only about 304,500 units less than that of 1984; there were 357,000 less units exported in 1985. However, during the year there was a significant reduction of estimated materials in process inventories, which were estimated to represent about 65,000 tons of lead in grids and oxides in battery plants at the end of 1984, and this reduced the 1985 demand. Conversely, the Bureau of Mines estimated that the consumption of lead for grids and oxides in industrial and traction batteries during 1985 increased by over 40% to 145,800 tons. The total use of lead to manufacture each automotive battery was estimated by the Bureau of Mines to be 20.6 pounds per unit, the same as in 1984. This was attributed to the relatively high volume of larger cars and trucks in the original equipment market, which has arrested the trend toward downsizing of batteries in recent years. Exports of automotive batteries totaled 2,233,000 units. The use of lead for storage batteries of all types in the United States reached a record high 73% of the total lead consumed for all products. The use in the industrial and traction battery sector attained a record high 17% of that for all lead-acid batteries. The latter has been the greatest growth sector in lead consumption since 1982, more than doubling in 3 years, primarily for uninterruptible power supply (UPS) systems.

STOCKS

Soft lead stocks at domestic primary refineries increased 36,000 tons during 1985, despite 50,000 tons less net imports for consumption of pig lead than in 1984. This was attributed to the increase of over 90,000 tons in primary refinery production, from which concentrate stocks were reduced by over 40,000 tons, and to the overall decline in domestic consumption. Refined pig lead stocks held by secondary producers and consumers were down only slightly at yearend, compared with those of yearend 1984. Total stocks of contained lead in all forms, excluding scrap, held by all domestic producers and consumers at yearend, were down only 11,000 tons, or 5%.

Stocks of lead and antimonial lead metal in the market economy countries reporting to the International Lead and Zinc Study Group (ILZSG) were approximately 470,000 tons at yearend, about 9% of current total world demand, and 41,000 tons higher than at yearend 1984.[2] At yearend, stocks in LME warehouses totaled 61,000 tons, an increase of 20,000 tons over those of yearend 1984.

PRICES

The U.S. producer price quotations for lead published in Metals Week moved gradually downward from a range of 20 to 23 cents per pound in the last 2 weeks of 1984, to 17 to 22 cents per pound at the end of the first week of March 1985, which represented the widest spread of the year. The average of the week ending March 15 of weighted transactions was 17.1 cents per pound, the lowest of the year. From that point, the range gradually expanded and narrowed during the remainder of the normal slack buying season to 18.5 to 21 cents per pound on July 1, the accepted beginning of the ordering season for late summer-early fall deliveries to the battery manufacturers. Summer quotations in Metals Week generally stayed within that range but narrowed and lowered further on September 10 to 18.5 to 20 cents per pound, as significant anticipated seasonal ordering increases apparently did not materialize. Prices generally stayed in that range through the remainder of the year. The monthly weighted average transactions were within 0.2 cent of 19 cents per pound for every month of the year except for a low of 17.7 cents for March and a high of 19.9 cents for April. March's U.S. average price was the lowest since December 1973 (17.7 cents), and the year's average of 19.1 cents per pound also was the lowest since 1973 (16.3 cents). In constant dollars it was the lowest of the century.

On the LME the highest monthly average cash price for the year was reached in January, at slightly over 19 cents per pound. That was the narrowest spread against the U.S. producers' price, only 0.06 cent, since February 1975 when LME prices were higher than those of the United States. The LME price then dropped steadily through March, and the average for that month of just under 16 cents per pound was the lowest since February 1976 (15.8 cents). The price then rebounded steadily, reaching 19.2 cents for the last week of August, before declining steadily to 17.3 cents for the last week of the year. The LME's average cash price for the year of 17.8 cents per pound was the lowest since 1972 (13.7 cents), and the average spread for the year with the U.S. producers' price of 1.23 cents per pound was the narrowest since 1980, when it was 1.25 cents.

The domestic prices for lead oxides were based on the selling price for pig lead in a given period plus conversion charges. However, premium adjustments were also made by individual producers to reflect differences in manufacturing techniques, freight considerations, quality requirements, and other factors. The average total premium for carload lots, f.o.b. plant, exclusive of container, for litharge was just over 9 cents per pound above the average pig lead price according to shipment values reported to the Bureau of Mines. The conversion charge for red lead was less than 0.5 cent per pound higher than that for litharge. The reason for the narrow spread between litharge and red lead conversion charges was the significant increase in demand for the latter in bulk form by traction and industrial battery manufacturers. Automotive battery manufacturers were also reportedly using more red lead to aid in formation of the batteries, as the percentage of higher grade red lead uses for ceramics, etc., declined.

FOREIGN TRADE

Exports of lead in concentrates of just under 10,000 tons were at the lowest level since lead concentrates were classified separately from mixed ores in 1978. This was attributed to the high level of world production in 1985, much of which represented coproduct or byproduct production from zinc and silver mines, and was available at competitively low prices. Over 75% of the exports of concentrates in 1985 went to Canada, which in turn supplied nearly 70% of the refined pig lead imported for domestic consumption. Exports of pig metal and wrought lead products were almost four times those of 1984, and scrap exports also increased significantly. Taiwan and Brazil were the major markets for U.S. scrap, receiving over 50% of the total, the lead content of which was estimated to be 60%. The Netherlands and the United Kingdom received 70% of the refined pig lead exported, most of which was thought to be destined for LME warehouses.

The United States had net imports for consumption of lead in all forms, including scrap and drosses or other residues, of 60,600 tons, compared with 142,600 tons in 1984 and 125,800 tons in 1983. No concentrates for consumption were received from Peru, a traditional supplier of about two-thirds of that category over recent past years. Honduras, the other significant traditional source, supplied about 60% of that category in 1985. Canada and Mexico supplied almost 80% of the metal in all forms, including scrap, but imports from Australia and Peru, the other traditional significant metal sources, declined dramatically.

Table 2.—U.S. import duties for lead materials, January 1, 1985

(Lead content)

Item	TSUS No.	Most favored nation (MFN)	Least developed developing countries	Non-MFN
Ore	602.10	0.75 cent per pound	Free[1] or current MFN rate.	1.5 cents per pound.
Lead bullion	624.02	3.5% ad valorem	do	10.5% ad valorem.
Other unwrought	624.03	3.5% ad valorem[2]	Current MFN rate only	10.0% ad valorem.
Waste and scrap	624.04	2.7% ad valorem	Free[1] or 2.3% ad valorem.	11.5% ad valorem.

[1]Free if eligible under General System of Preferences.
[2]Established at 3.0% ad valorem (retroactive to July 1, 1983) but not to be less than 1.0625 cents per pound, on Oct. 30, 1984, by the Omnibus Trade Act.

Imports of chrome yellow used for highway markings increased for the fourth consecutive year, but imports of litharge declined significantly as total imports of lead chemicals and compounds declined 15%. Mexico accounted for most of the U.S. imports of litharge and red lead, while Canada supplied over 40% of all other categories, including almost 60% of the chrome yellow. The Federal Republic of Germany and the United Kingdom supplied 30% of the latter category. The Federal Republic of Germany accounted for most of the lead acetate imported; Belgium, China, and the Republic of South Africa equally for most of the lead nitrate; Peru and the Netherlands equally for most of the lead arsenate; and Canada and the Netherlands for all of the other lead salts. Canada and Mexico supplied over 80% of the total U.S. imports of lead chemicals and compounds, including oxides.

WORLD REVIEW

According to the ILZSG statistics, consumption of refined soft lead and antimonial lead in the market economy countries was 3.97 million tons, compared with 4.0 million in 1984 and about 3.8 million in both 1983 and 1982.[3] Estimated world consumption of lead in all forms during 1985 decreased 20,000 tons to 5.46 million from 5.48 million tons in 1984, compared with 5.25 and 5.21 million tons in 1983 and 1982, respectively. However, world primary refinery production increased by 50,000 tons in 1985 over that of 1984. The increase was primarily a result of considerable increases in Australian and U.S. mine production after recovery from lengthy strikes in 1984, which had caused considerable drawdown of world metal stocks. Secondary lead production was over 40% of the world's total refinery output for the second consecutive year, despite a significant dropoff in the United States.

ILZSG forecast that lead consumption during 1986 would be only about 15,000 tons greater than that of 1985 for the market economy countries, but that refined metal production would be about 60,000 tons greater with virtually no change in net exports to the centrally planned economy countries (CPEC) of about 100,000 tons. Mine production was expected to increase in 1986 by over 100,000 tons, with net exports of concentrates to the CPEC staying at about 60,000 tons of contained lead, according to ILZSG.

Despite some announced mine closings, there were several mine expansions, and six new mines were brought on-stream. The net result was an increase of 80,000 tons in world capacity to about 4.2 million tons per year. Primary refinery capacity remained at 4.53 million tons per year, but smelter capacity decreased by 80,000 tons per year to 4.36 million tons per year from yearend 1984.

Australia.—Record high mine production of lead was reported in 1985, which reflected the return to normal after lengthy strikes at three mines during 1984 at Broken Hill, New South Wales, and two mines in Tasmania. Also, increases were reported at EZ Industries Ltd.'s Elura Mine in New South Wales; at Mount Isa Mine in Queensland, the world's largest zinc-lead mine; and at the Woodlawn open pit at Tarago, New South Wales. Woodlawn became a 100% owned subsidiary of Australia Mining & Smelting Ltd. (AM&S) early in the year when it acquired St. Joe International Explorations Ltd.'s one-third vested interest. The open pit reportedly would be depleted in early 1987, but in early 1985 a ramp decline was started in order to further evaluate known lower-level mineralization for a potential continuance of the operation underground. The Woodcutters open pit near Darwin in the Northern Territory came on-stream in late 1985 after completion of the mill and prestripping operations in July. The mine was controlled by a consortium led by Nicron Resources Ltd. Further expansions at several mines were announced for 1986 following development work accomplished in 1985. These included EZ's Elura Mine; AM&S' CSA Mine at Cobar, New South Wales; North Broken Hill Holdings Ltd.'s (NBH) North Mine at Broken Hill, New South Wales; and Aberfoyle Ltd.'s Que River Mine on the west coast of Tasmania. Aberfoyle's production was expected to increase by about one-third at the beginning of 1986 and hold through 1991, and NBH's by about 20% by the end of 1986. Australia's mine capacity at yearend 1985 was estimated to be about 530,000 tons per year of lead in concentrates.

Extensive exploration by Aberfoyle continued at the Hellyer Prospect, 3 kilometers north of the Que River Mine, and a further 4 million tons of ore was inferred. A 1.2-

kilometer adit was driven from a nearby valley to allow underground exploration and bulk sampling in 1986. At Mount Isa Mines Ltd.'s (MIM) silver-lead-zinc Hilton Prospect, 20 kilometers north of Mount Isa, development work continued toward a mid-1986 trial mining operation, and possible phasing in with Mount Isa Mine's production in the late 1980's. Continuing exploratory drilling at Hilton North reportedly confirmed potentially economic silver-lead-zinc mineralization of a similar magnitude to that of Hilton. Mining of the lead carbonate cap of the Hilton ore body began in 1985 for use as a flux in MIM's smelter at Mount Isa. Pancontinental Mining Ltd. acquired MIM's interest in the Lady Loretta deposit in North Queensland in August and later acquired the remaining half of the joint venture from Elf Aquitaine Triako Mines NL. Late in the year, Pancontinental sold a 49% interest to Outokumpu Oy of Finland. Reserves were estimated at 9 million tons grading 14.8% zinc, 6.5% lead, and 95 grams per ton of silver. Exploration continued at the Blendevale Prospect in the northwestern part of Western Australia by the Pillara Joint Venture. Pillara was equally composed of BHP Minerals Ltd., the operator, and the Oscar Range Joint Venture, which was 77% vested by the Shell Co. of Australia and 23% by Trend Exploration Ltd.

Exports of lead concentrate increased during 1985 in line with the increased mine production. Smelter bullion exports decreased 18%, however, in order to rebuild stocks, which were drawn down in 1984 during the strikes, because production was about the same as in 1984. Refined lead exports increased slightly, but refinery production decreased about 2,000 tons, as did domestic consumption.

Canada.—Mine production and total refinery production, including secondary, decreased slightly compared with that of 1984, in response to reduced domestic and world demand. Those conditions, in concert with higher stripping ratios and increased dewatering and exploration costs, negatively affected Pine Point Mines Ltd.'s operation at Yellowknife in the Northwest Territory. Therefore, Pine Point announced in late December a revised mining plan to boost production rates in order to maximize cash flow during 1986 and 1987 by recovering only the most economic ore, and thereby decrease reserves by 5 million tons, allowing for a significant writedown of remaining assets and preproduction expenditures. Truck and shovel mining and underground operations were to continue into 1987, but dragline operations were suspended in 1985. Exploration was to continue on the eastern part of the property, where about 500,000 tons of new reserves reportedly were identified during the year. Pine Point is 51% owned by Cominco Ltd., and its life was not expected to extend beyond the opening of Cominco's Red Dog Mine in Alaska in 1989, according to some analysts. At 60,000 tons of lead in concentrates per year capacity, the Pine Point Mine is Canada's third largest lead producer.

Dome Petroleum Ltd. agreed to sell its subsidiary, Cyprus Anvil Mining Corp., and Faro Mine, situated 235 miles northeast of Whitehorse in the Yukon Territory, to Curragh Resources Corp. The Faro Mine was closed in June 1982, but a complex financial plan involving loan credit lines guaranteed by the Yukon and Federal Governments, and incentive contributions under terms of the Yukon Mineral Recovery Program, should allow the territory's largest mine to reopen in 1986. In addition, the Yukon Government was to buy 122 properties owned by the mine for $1.05 million cash, provide a second mortgage on 152 other properties worth $2.4 million, and pick up the cost of reopening and maintaining the Klondike Highway from Whitehorse to Skagway, Alaska's port. There was also to be a 2-year moratorium on interest payments on the loans, and the Yukon Government reached an agreement in principle with Alaska officials to pay one-half the capital and yearly maintenance costs of that portion of the highway in the United States. Full production of 4 million tons per year would not be reached until 1987, and the open pit reportedly would have a life of 7 years, but several nearby deposits showing potential were under review at yearend. At capacity, about 85,000 tons per year, the operation would surpass Pine Point as Canada's third largest lead producer. Boliden AB of Sweden contracted to be the general sales agent for Faro's production and also acquired a 10% interest in the mine. At yearend, Boliden reportedly located buyers for the 40,000 tons of lead concentrates and 90,000 tons of zinc concentrates, which was the anticipated limited production in 1986.

In November, the Canadian Federal Government proposed a $48 million financial package to Cominco for replacing its smelter at Trail, British Columbia, with two modified Soviet Kivcet-type autogenous flash furnaces, incorporating significant operating cost savings and improved environmental safeguards. Under terms of the agreement the Government, through the Federal Business Development Bank, would purchase a special new preferred share issue, which would be redeemable after 10 years and fully retired within 20 years. The money would be used to begin the $98 million phase 1, consisting of completing one furnace and one oxygen plant and beginning a concentrate dryer by 1988. Completion of the whole project, estimated to cost $189 million, would increase smelting and refining capacity 40,000 tons per year to 176,000 tons per year, including a 6-million-troy-ounce-per-year increase in refined silver capacity to 17 million troy ounces per year. At yearend, Cominco was trying to conclude an agreement on a water rate reduction with the Provincial government.

China.—A contract to construct a QSL process 50,000-ton-per-year lead smelter at Beijing was negotiated with Lurgi Gesellschaften, the construction subsidiary of the Federal Republic of Germany's Metallgesellschaft AG. It would be the first commercial plant in the world to use the QSL technology, which has been under demonstration on a pilot scale by Metallgesellschaft at Duisberg in the Federal Republic of Germany since 1982.

India.—The Government gave approval for Hindustan Zinc Ltd. (HZL) to construct a 35,000-ton-per-year ISF process lead smelter to service the developing Rampura Agucha zinc-lead deposit in Rajasthan. Smelter startup was not expected before 1990, with a first-year production of 21,000 tons. The open pit was expected to start up during 1989 at a capacity of 8,000 tons per year of lead and double HZL's existing mine capacity. Reserves were estimated to be 60 million tons of ore grading 1.9% lead and 13.5% zinc. A significant lead deposit was reportedly discovered in the Jharsi District about 9 kilometers from another known substantial deposit in the Bhupura area.

Iran.—Contract terms reportedly were finalized with Mannesmann Demag Hüttentechnik GmbH of the Federal Republic of Germany for construction of the National Iranian Lead and Zinc Co.'s proposed 40,000-ton-per-year primary lead smelter at Zanjan. In addition, the complex reportedly will have a capacity of 40,000 tons per year for zinc and was scheduled for completion by yearend 1988.

Ireland.—Bula Ltd., which owned the north end of the Navan lead-zinc deposit in County Meath since 1970, was negotiating at yearend 1985 to sell out to Tara Exploration and Development Co. Ltd. whose parent, Tara Mines Ltd., had been exploiting the south end of the ore body at the rate of 2 million tons per year since 1977. Tara was considering an underground linkup should the Government, which owned 49% of Bula, give its permission. Tara reportedly would expand its mill capacity by 450,000 tons per year if it acquired Bula.

Italy.—Società per Azioni Minero-Metallurgiche (SAMIM), the Government metals and minerals combine, increased its share to 64% of Sameton S.p.A., which had been a joint venture with Tonolli S.p.A., a family-owned company. SAMIM also planned to acquire the remaining shares and eventually all of Tonolli's other domestic operations. The equal partnership, originally established in October 1983, controlled most of the country's secondary copper and copper alloy production, plus 60% of its secondary lead capacity, concentrated in nine plants, and additionally produced about 200,000 tons per year of semifinished products including metallic byproducts and compounds. Under Sameton, Italy became a large net importer of copper and lead scrap, as it was created to concentrate on the value-added end of the production chain.

Japan.—Dowa Mining Co. Ltd. reportedly discovered a rich mixed sulfide ore deposit in the Nurukawa District with probable ore reserves of 1 million tons grading 10.3% lead, 21.1% zinc, 2.3% copper, 21 grams per ton of gold, and 318 grams per ton of silver.

Korea, North.—A significant expansion of the existing lead-zinc mine complex at Kemdok was reportedly under way. In recent years, the operation reportedly utilized only two-thirds of the 900,000-ton-per-year estimated capacity of the lead and zinc concentrator. At capacity by 1988, the increased production was to be shipped to a new metallurgical complex under construction at Tanchon, which was thought to be planned for the capability to produce 300,000 tons per year of lead and zinc metal.

Korea, Republic of.—Work continued at Korea Zinc Co.'s expansion of its electrolytic zinc plant with installation of a new electrolytic lead refinery, which was scheduled to open in 1986 at a rated capacity of 35,000 tons per year. A new zinc-lead deposit was reportedly under consideration for development by Young Poong Mining Co. Ltd. near the existing mines at Taebaek, approximately 280 kilometers southeast of Seoul.

Morocco.—Financing reportedly was secured for Société des Fonderies de Plomb de Zellidja's planned expansion of its primary lead smelter-refinery at Oued-El-Heimer. When completed in 1986, the capacity would be increased from 65,000 tons per year to 90,000 tons per year. A new movable Swedish concentrator, with a capacity of 160,000 tons per year, was obtained for use at a potential deposit near Erradidia that could yield 10,000 tons per year of lead in concentrates.

Peru.—Construction continued throughout the year on Peru's first privately owned primary lead smelter-refinery. By 1987, the plant at Sayán, near Lima, would have a capacity of 12,000 tons per year. Trial runs were reportedly begun by Fundición de Concentrados S.A. late in the year. Funding was obtained from the Inter-American Development Bank and the International Bank for Reconstruction and Development. Expansions of two Empresa Minera del Centro del Perú mines, plus one new mine brought on-stream in the private sector, plus another expansion, raised Peru's capacity by 16,000 tons per year to an estimated 221,000 tons per year of lead in concentrates at yearend.

South Africa, Republic of.—Shell South Africa (Pty.) Ltd. initiated development of its new open pit Pering Farm Mine at Reivilo in the Vryburg District of Northern Cape Province. Startup was expected in 1986 with a capacity of 6,000 tons per year of lead and 33,000 tons per year of zinc by 1987. Fry Metals Pty. Ltd. expanded its existing secondary lead smelter-refinery at Germiston, Transvaal, from a capacity of 15,000 tons per year to 25,000 tons per year and closed its 10,000-ton-per-year secondary plant at Berlin, East London, in Eastern Cape Province.

Spain.—A major expansion of Asturiana de Zinc S.A.'s Torrelavega Mine at Reocín, in Santander, reportedly was completed. The underground and open pit complex capacity was raised from 9,000 tons per year to 15,000 tons per year for lead, and from 15,000 tons per year to 70,000 tons per year for zinc.

Tunisia.—Société Tunisienne d'Expansion Minière S.A. continued expansion development work at the existing Fej Hassen Mine and Fej El Ahdoum Mine at Ghardimaou and Le Krib, respectively, which was expected to bring an additional 17,000 tons per year of capacity for lead and 10,000 tons per year of capacity for zinc on-stream by the end of 1986.

Yugoslavia.—Underground development at a new mine at Sastavci-Kizevak, with a projected capacity of 3,000 tons per year of lead, was expected to commence in 1986. Another mine in southern Serbia was expected to come on-stream in 1986 with a capacity of 2,000 tons per year of lead.

TECHNOLOGY

A prototype lead-acid, battery-powered, jumbo ground transporter was placed in service for extensive testing during 1985 by one of the Nation's leading cargo-carrying airlines. The introduction of the 15.5-ton tractor with an integrated roller flatbed was the latest in a rapidly increasing series of heavy-duty, specialized, ground-support electric vehicles coming into widespread use in the airline and ocean shipping industries. For example, battery-powered ground support equipment (GSE) including pushout tractors, baggage tugs, and belt loaders penetrated the airline GSE market in the United States from near zero in 1980 to about 15% of all such vehicles in 1985, according to the Lead Industries Association Inc. The jumbo transporter was the latest of 13 such products introduced by the manufacturer during that time. The vehicle was powered by a 670-ampere-hour, 40-horsepower motor supplied by a 4-ton lead-acid battery system and reportedly could move at up to 12 miles per hour when loaded to its 15-ton maximum capacity.[4]

The Bureau of Mines announced a new process that extracts cobalt from Missouri lead-ore wastes. Although technically feasible, the process is not economic at this time. However, shortage conditions and increased prices for cobalt could create conditions to help make extraction faster than would be possible from new domestic mines, according to the Bureau. The process is based on conventional flotation technology using a special chemical collector in which rising bubbles in the cell concentrate the cobalt-bearing minerals at the top for skimming. It was estimated that as much as 65% of the cobalt, and from 60% to 90% of other trace metals in the tailings, such as silver, could be recovered. In recent times, Missouri lead ores have been at a competitive disadvantage on the world market because they have averaged only about one-half the coproduct and byproduct values of those found in other major lead-producing and exporting nations such as Australia, Canada, Mexico, and Peru. At yearend, research on the flotation process was continuing on a larger scale at an operating mill in cooperation with a commercial lead producer.[5]

A comprehensive coverage of lead-related investigations and an extensive review of current world literature on the extraction and uses of lead and its products were published in quarterly issues of Lead Abstracts, Lead Development Association, London, United Kingdom.

[1]Physical scientist, Division of Nonferrous Metals.
[2]International Lead and Zinc Study Group (London). Lead and Zinc Statistics. ILZSG Monthly Bull., v. 26, No. 9, Sept. 1986, pp. 16-18.
[3]Work cited in footnote 2.
[4]Battery Man. V. 28, No. 4, Apr. 1986, pp. 22-24.
[5]Cornell, W. L., D. C. Holtgrefe, and F. H. Sharp. Recovery of Cobalt and Other Metal Values From Missouri Lead Ore Concentrator Tailings. Paper in Recycle and Secondary Recovery of Metals, ed. by P. R. Taylor, H. Y. Shon, and N. Jarrett (Proc. Int. Symp. on Recycle and Secondary Recovery of Met., Ft. Lauderdale, FL, Dec. 1-4, 1985). Metall. Soc. AIME, 1985, pp. 675-682.

Table 3.—Mine production of recoverable lead in the United States, by State

(Metric tons)

State	1981	1982	1983	1984	1985
Alaska	W	W	W	--	--
Arizona	993	359	r234	W	581
California	W	W	W	W	--
Colorado	11,431	W	W	W	W
Idaho	38,397	W	25,893	W	33,707
Illinois	W	W	W	W	W
Missouri	389,721	474,460	409,280	278,329	371,008
Montana	194	661	1,163	W	846
Nevada	W	W	14	W	(1)
New Mexico	W	W	258	--	W
New York	968	1,065	1,299	W	W
Oregon	W	--	W	--	--
Tennessee	--	--	--	W	W
Utah	1,662	W	--	W	--
Virginia	1,607	--	--	--	--
Washington	--	W	--	--	--
Total	445,535	512,516	r449,295	r322,677	413,955

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."
1Less than 1/2 unit.

Table 4.—Mine production of recoverable lead in the United States, by month

(Metric tons)

Month	1984r	1985
January	42,001	31,778
February	42,838	33,252
March	46,451	37,582
April	20,973	39,256
May	24,135	37,069
June	12,282	32,485
July	24,234	34,451
August	23,588	34,808
September	18,664	30,929
October	22,464	36,882
November	19,575	32,476
December	25,472	32,987
Total	322,677	413,955

rRevised.

Table 5.—Production of lead and zinc, in terms of recoverable metal, in the United States in 1985, by State

(Metric tons)

State	Lead ore: Gross weight (dry basis)	Lead ore: Lead	Lead ore: Zinc	Zinc ore: Gross weight (dry basis)	Zinc ore: Lead	Zinc ore: Zinc	Lead-zinc ore: Gross weight (dry basis)	Lead-zinc ore: Lead	Lead-zinc ore: Zinc
Arizona	--	--	--	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	W	W	W
Idaho	--	--	--	--	--	--	W	W	W
Illinois	--	--	--	--	--	--	--	--	--
Kentucky	--	--	--	W	--	W	--	--	--
Missouri	6,433,706	371,008	49,340	--	--	--	--	--	--
Montana	--	--	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--
New Jersey	--	--	--	W	--	W	--	--	--
New Mexico	--	--	--	--	--	--	--	--	--
New York	--	--	--	W	W	W	--	--	--
Tennessee	--	--	--	W	W	W	--	--	--
Total	6,433,706	371,008	49,340	4,261,858	(1)	161,530	(1)	(1)	(1)
Percent of total lead or zinc	XX	90	22	XX	(1)	71	XX	(1)	(1)

State	Copper-lead, copper-zinc, copper-lead-zinc ores: Gross weight (dry basis)	Copper-lead, copper-zinc, copper-lead-zinc ores: Lead	Copper-lead, copper-zinc, copper-lead-zinc ores: Zinc	All other sources[2] [3]: Gross weight (dry basis)	All other sources[2] [3]: Lead	All other sources[2] [3]: Zinc	Total: Gross weight (dry basis)	Total: Lead	Total: Zinc
Arizona	--	--	--	51,010,198	581	--	51,010,198	581	--
Colorado	--	--	--	37,508	643	W	W	W	W
Idaho	--	--	--	W	W	W	[3]901,337	33,707	W
Illinois	--	--	--	--	W	W	(3)	W	W
Kentucky	--	--	--	--	--	--	W	--	W
Missouri	--	--	--	--	--	--	6,433,706	371,008	49,340
Montana	--	--	--	2,616,424	846	--	2,616,424	846	--
Nevada	--	--	--	73	(4)	--	73	(4)	--
New Jersey	--	--	--	--	--	--	W	--	W
New Mexico	--	--	--	W	W	--	W	W	--
New York	--	--	--	--	--	--	W	W	W
Tennessee	--	--	--	W	--	W	5,373,817	W	104,471
Total	--	--	--	56,435,942	42,947	15,675	67,131,506	413,955	226,545
Percent of total lead or zinc	XX	--	--	XX	10	7	XX	100	100

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Included with "All other sources" to avoid disclosing company proprietary data.
[2]Includes lead and zinc recovered from lead-zinc ore in Colorado and Idaho and lead from zinc ores in New York and Tennessee in order to avoid disclosing company proprietary data. Also includes lead and zinc recovered from copper, gold, gold-silver, molybdenum, and silver ores, from fluorspar, and from mill tailings.
[3]Excludes tonnages of fluorspar in Illinois from which lead and zinc were recovered as byproducts, and molybdenum ore in Idaho from which lead was recovered as a byproduct.
[4]Less than 1/2 unit.

Table 6.—Twenty-five leading lead-producing mines in the United States in 1985, in order of output

Rank	Mine	County and State	Operator	Source of lead
1	Buick	Iron, MO	AMAX Lead Co. of Missouri	Lead ore.
2	Magmont	do	Cominco American Incorporated	Do.
3	Viburnum No. 29	Washington, MO	St. Joe Minerals Corp	Do.
4	Fletcher	Reynolds, MO	do	Do.
5	Casteel Mine (formerly Viburnum No. 35)	Iron, MO	do	Do.
6	Lucky Friday	Shoshone, ID	Hecla Mining Co	Silver ore.
7	Viburnum No. 28	Iron, MO	St. Joe Minerals Corp	Lead ore.
8	Leadville unit	Lake, CO	ASARCO Incorporated	Lead-zinc ore.
9	West Fork	Reynolds, MO	do	Lead ore.
10	Troy unit	Lincoln, MT	do	Copper ore.
11	Balmat	St. Lawrence, NY	St. Joe Minerals Corp	Zinc ore.
12	Star Morning	Shoshone, ID	Star Morning Co	Silver ore.
13	Clayton	Custer, ID	Clayton Silver Mines	Do.
14	Morenci	Greenlee, AZ	Phelps Dodge Corp	Copper ore.
15	Sunnyside	San Juan, CO	Standard Metals Corp	Gold ore.
16	Tiger	Pinal, AZ	McFarland & Hullinger	Gold-silver tailings.
17	Black Pine	Granite, MT	Black Pine Mining Co	Silver ore.
18	Rosiclare	Hardin and Pope, IL	Ozark-Mahoning Co	Fluorspar.
19	Ray	Pinal, AZ	Kennecott	Copper ore.
20	Sunshine	Shoshone, ID	Sunshine Mining Co	Silver ore.
21	Eisenhower	Pima, AZ	ASARCO Incorporated	Copper ore.
22	Canyon Silver	Shoshone, ID	Canyon Silver Lease	Lead-zinc ore.
23	Camp Bird	Ouray, CO	Federal Resources Corp	Silver ore.
24	Galena	Shoshone, ID	ASARCO Incorporated	Do.
25	Bulldog Mountain	Mineral, CO	Homestake Mining Co	Do.

Table 7.—Refined lead produced at primary refineries in the United States, by source material

(Metric tons unless otherwise specified)

Source material	1981	1982	1983	1984	1985
Refined lead:					
From primary sources:					
Domestic ores and base bullion	440,238	459,865	459,328	330,168	416,091
Foreign ores and base bullion	55,085	52,295	55,227	65,409	71,353
Total	495,323	512,160	514,555	395,577	487,444
Calculated value of primary refined lead[1] thousands	$398,908	$288,377	$245,938	$222,821	$204,899

[1]Value based on average quoted price.

Table 8.—Stocks and consumption of new and old lead scrap in the United States, by type of scrap

(Metric tons, gross weight)

Type of scrap	Stocks, Jan. 1	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
1984						
Smelters, refiners, others:						
Soft lead[1]	1,477	31,276	--	31,305	31,305	1,448
Hard lead	2,004	19,124	--	19,506	19,506	1,622
Cable lead	1,924	12,705	--	13,379	13,379	1,250
Battery-lead plates	42,411	[r]673,457	--	[r]686,132	[r]686,132	29,736
Mixed common babbitt	130	1,956	--	1,801	1,801	285
Solder and tinny lead	997	[r]17,284	--	[r]16,144	[r]16,144	[r]2,137
Type metals	591	4,181	--	4,270	4,270	502
Drosses and residues	5,706	[r]66,191	[r]64,086	--	[r]64,086	[r]7,811
Total	55,240	[r]826,174	[r]64,086	[r]772,537	[r]836,623	[r]44,791

See footnotes at end of table.

Table 8.—Stocks and consumption of new and old lead scrap in the United States, by type of scrap —Continued

(Metric tons, gross weight)

Type of scrap	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
1985						
Smelters, refiners, others:						
Soft lead[1]	1,448	31,156	--	31,128	31,128	1,476
Hard lead	1,622	14,352	--	15,280	15,280	694
Cable lead	1,250	3,278	--	3,908	3,908	620
Battery-lead plates	29,736	643,157	--	646,113	646,113	26,780
Mixed common babbitt	285	1,623	--	1,610	1,610	298
Solder and tinny lead	2,137	20,656	--	19,937	19,937	2,856
Type metals	502	3,370	--	3,362	3,362	510
Drosses and residues	7,811	58,460	57,245	--	57,245	9,026
Total	44,791	776,052	57,245	721,338	778,583	42,260

[r]Revised.
[1]Includes remelt lead from cable sheathing plus other soft lead scrap processing.

Table 9.—Secondary metal recovered[1] from lead and tin scrap in the United States

(Metric tons)

	Lead	Tin	Antimony	Other	Total
1984					
Refined pig lead	[r]247,929	--	--	--	[r]247,929
Remelt lead	15,502	--	--	--	15,502
Total	[r]263,431	--	--	--	[r]263,431
Refined pig tin	--	1,097	--	--	1,097
Remelt tin	--	10	--	--	10
Total	--	1,107	--	--	1,107
Lead and tin alloys:					
Antimonial lead	[r]327,803	894	[r]12,292	685	[r]341,674
Lead-base babbitt	1,481	123	162	--	1,766
Solder	18,102	3,653	178	5	21,938
Type metals	2,312	142	329	4	2,787
Other alloys including cable lead	5,068	51	29	2	5,150
Total	[r]354,766	4,863	[r]12,990	696	[r]373,315
Tin content of chemical products	--	301	--	--	301
Grand total	[r]618,197	6,271	[r]12,990	696	[r]638,154
1985					
Refined pig lead	249,904	--	--	--	249,904
Remelt lead	13,361	--	--	--	13,361
Total	263,265	--	--	--	263,265
Refined pig tin	--	1,292	--	--	1,292
Remelt tin	--	10	--	--	10
Total	--	1,302	--	--	1,302
Lead and tin alloys:					
Antimonial lead	287,967	791	9,722	524	299,004
Lead-base babbitt	1,195	88	130	4	1,417
Solder	21,647	3,565	161	10	25,383
Type metals	1,912	122	281	3	2,318
Other alloys including cable lead	3,235	10	6	1	3,252
Total	315,956	4,576	10,300	542	331,374
Tin content of chemical products	--	186	--	--	186
Grand total	579,221	6,064	10,300	542	596,127

[r]Revised.
[1]Most of the figures herein represent actual reported recovery of metal from scrap.

Table 10.—Secondary lead recovered in the United States

(Metric tons unless otherwise specified)

	1981	1982	1983	1984	1985
As metal:					
In soft lead	282,154	240,476	189,602	[r]263,431	263,265
In antimonial lead	304,376	284,367	271,638	[r]327,803	287,967
In other alloys	54,575	46,433	42,261	42,140	42,954
Total:					
Quantity	641,105	571,276	503,501	[r]633,374	594,186
Value[1] thousands	$516,313	$321,663	$240,655	[r]$266,284	$249,808

[r]Revised.
[1]Value based on average quoted price of common lead.

Table 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1984	1985
KIND OF SCRAP		
New scrap:		
Lead-base	44,342	39,715
Copper-base	3,278	3,000
Tin-base	5	5
Total	47,625	42,720
Old scrap:		
Battery-lead plates	[r]486,555	463,418
All other lead-base	[r]87,130	76,047
Copper-base	12,064	12,000
Tin-base	--	1
Total	[r]585,749	551,466
Grand total	[r]633,374	594,186
FORM OF RECOVERY		
As soft lead	[r]263,431	263,265
In antimonial lead	[r]327,803	287,967
In other lead alloys	26,793	27,949
In copper-base alloys	15,342	15,000
In tin-base alloys	5	5
Total	[r]633,374	594,186

[r]Revised.

Table 12.—U.S. consumption of lead, by product

(Metric tons)

SIC code	Product	1984	1985
	Metal products:		
3482	Ammunition: Shot and bullets	47,828	50,233
	Bearing metals:		
35	Machinery except electrical	894	332
36	Electrical and electronic equipment	254	249
371	Motor vehicles and equipment	2,898	3,875
37	Other transportation equipment	631	936
	Total bearing metals	4,677	5,392
3351	Brass and bronze: Billets and ingots	6,954	7,823
36	Cable covering: Power and communication	12,270	15,501
15	Calking lead: Building construction	3,966	2,288
	Casting metals:		
36	Electrical machinery and equipment	1,649	1,842
371	Motor vehicles and equipment	762	1,020
37	Other transportation and equipment	7,913	11,145
3443	Nuclear radiation shielding	5,480	5,407
	Total casting metals	15,804	19,414
	Pipes, traps, other extruded products:		
15	Building construction	11,371	11,457
3443	Storage tanks, process vessels, etc.	2,287	398
	Total pipes, traps, other extruded products	13,658	11,855
	Sheet lead:		
15	Building construction	13,377	11,396
3443	Storage tanks, process vessels, etc.	160	1,602
3693	Medical radiation shielding	1,128	1,833
	Total sheet lead	14,665	14,831
	Solder:		
15	Building construction	6,543	4,469
341	Metal cans and shipping containers	3,275	2,894
367	Electronic components and accessories	5,361	4,187
36	Other electrical machinery and equipment	2,226	2,597
371	Motor vehicles and equipment	7,036	7,227
	Total solder	24,441	21,374
	Storage batteries:		
3691	Storage battery grids, post, etc.	426,300	468,746
3691	Storage battery oxides	439,242	372,194
	Total storage batteries	865,542	840,940
371	Terne metal: Motor vehicles and equipment	6,074	5,088
27	Type metal: Printing and allied industries	2,162	1,623
34	Other metal products[1]	8,284	5,570
	Total metal products	1,026,325	1,001,932
	Other oxides:		
285	Paints	17,360	14,056
32	Glass and ceramic products	46,102	44,146
28	Other pigments and chemicals	13,346	14,561
	Total other oxides	76,808	72,763
2911	Gasoline additives	78,933	45,694
	Miscellaneous uses	24,967	27,909
	Grand total	1,207,033	1,148,298

[1]Includes lead consumed in foil, collapsible tubes, annealing, galvanizing, plating, and fishing weights.

Table 13.—U.S. consumption of lead, by month[1]

(Metric tons)

Month	1984	1985
January	124,906	95,761
February	99,484	102,639
March	103,905	101,880
April	93,737	91,322
May	90,636	93,091
June	101,693	83,348
July	84,107	72,971
August	103,202	111,165
September	102,068	108,911
October	111,290	107,582
November	96,948	96,299
December	95,057	83,329
Total[2]	1,207,033	1,148,298

[1]Monthly totals include monthly reported consumption plus the prorated monthly distribution for companies that report on an annual basis only.
[2]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide.

Table 14.—U.S. consumption of lead in 1985, by State[1]

(Metric tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	49,705	35,827	6,519	447	92,498
Colorado	1,002	310	53	--	1,365
Connecticut	3,612	4,509	--	179	8,300
District of Columbia	5	--	--	--	5
Florida	11,558	7,597	1,252	--	20,407
Georgia	22,500	7,860	4,367	--	34,727
Illinois	29,813	37,550	2,622	603	70,588
Indiana	192,795	30,383	10,932	620	234,730
Kansas	12,245	6,633	4,495	--	23,373
Kentucky	9,949	10,568	2,379	--	22,896
Maryland	85	--	--	2	87
Massachusetts	556	168	24	48	796
Michigan	13,993	12,321	127	--	26,441
Missouri	10,596	18,432	--	--	29,028
Nebraska	3	--	389	716	1,108
New Jersey	48,432	22	812	199	49,465
New York	12,979	5,673	6,780	--	25,432
Ohio	19,256	13,958	3,917	219	37,350
Pennsylvania	93,393	41,458	30,321	1,237	166,409
Rhode Island	1,922	41	12	--	1,975
Tennessee	1,371	8,142	1,628	88	11,229
Virginia and West Virginia	50	484	1,154	--	1,688
Washington	13,257	634	--	--	13,891
Wisconsin	966	121	--	48	1,135
Alabama and Mississippi	9,293	4,865	2,084	1,568	17,810
Arkansas and Oklahoma	1,806	465	15	--	2,286
Hawaii and Oregon	3,532	9,260	623	--	13,415
Iowa and Minnesota	11,278	18,996	4,292	--	34,566
Louisiana and Texas	83,563	20,291	4,379	--	108,233
Montana and Idaho	76	--	--	--	76
New Hampshire, Maine, Vermont, Delaware	14,181	14,317	--	30	28,528
North Carolina and South Carolina	38,060	25,393	4,603	--	68,056
Utah, Nevada, Arizona	202	26	177	--	405
Total	712,034	336,304	93,956	6,004	1,148,298

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide.

Table 15.—U.S. consumption of lead in 1985, by class of product

(Metric tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total[1]
Metal products	68,032	61,412	25,545	6,003	160,992
Storage batteries	502,701	273,767	64,472	--	840,940
Other oxides	72,763	--	--	--	72,763
Gasoline additives	45,694	--	--	--	45,694
Miscellaneous	22,844	1,125	3,939	1	27,909
Total[1]	712,034	336,304	93,956	6,004	1,148,298

[1]Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide.

Table 16.—Production and shipments of lead pigments[1] and oxides in the United States

Product	1984			1985		
	Production (metric tons)	Shipments		Production (metric tons)	Shipments	
		Metric tons	Value[2]		Metric tons	Value[2]
White lead, dry	1,205	1,225	$1,534,515	477	483	$793,506
Red lead	11,629	11,236	10,046,120	W	W	W
Litharge	60,139	56,898	48,468,634	85,372	83,933	52,244,577
Leady oxide	462,329	--	--	380,440	--	--

W Withheld to avoid disclosing company proprietary data.
[1]Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.
[2]At plant, exclusive of container.

Table 17.—Lead content of lead pigments[1] and oxides produced by domestic manufacturers

(Metric tons)

Product	Lead in pigments from pig lead	
	1984	1985
White lead	964	382
Red lead	10,582	W
Litharge	55,929	79,396
Leady oxide	439,213	361,419
Total	506,688	[2]441,197

W Withheld to avoid disclosing company proprietary data; not included in "Total."
[1]Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.
[2]Excludes red lead.

Table 18.—Distribution of red lead shipments in the United States, by industry

(Metric tons)

Industry	1981	1982	1983	1984	1985
Paints	3,172	2,395	2,533	2,384	W
Ceramics	2,307	(1)	(1)	(1)	W
Storage batteries	7,573	(1)	(1)	(1)	W
Other	2,025	11,274	12,364	8,852	W
Total	15,077	13,669	14,897	11,236	W

W Withheld to avoid disclosing company proprietary data.
[1]Withheld to avoid disclosing company proprietary data; included with "Other."

Table 19.—Distribution of litharge shipments in the United States, by industry

(Metric tons)

Industry	1981	1982	1983	1984	1985
Ceramics	34,732	30,980	36,782	37,960	65,413
Chrome pigments	4,247	6,591	5,973	4,367	3,794
Oil refining	227	W	W	W	W
Paints	3,765	3,052	3,256	3,635	3,397
Rubber	1,107	787	933	1,016	739
Other	3,063	10,267	9,596	9,920	10,590
Total	47,141	51,677	56,540	56,898	83,933

W Withheld to avoid disclosing company proprietary data; included with "Other."

Table 20.—U.S. imports for consumption of lead pigments and compounds, by kind

Kind	1984		1985	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
White lead	442	$524	315	$426
Red lead	923	553	710	340
Litharge	12,726	6,314	9,955	4,074
Chrome yellow	2,322	4,223	2,886	4,426
Other lead pigments	342	1,189	536	1,138
Other lead compounds	2,326	2,219	1,870	2,064
Total	19,081	15,022	16,272	12,468

Source: Bureau of the Census.

Table 21.—Stocks of lead at primary smelters and refineries in the United States, December 31

(Metric tons)

Stocks	1981	1982	1983	1984	1985
Refined pig lead	78,836	73,455	58,267	47,696	83,857
Lead in antimonial lead	666	W	W	W	W
Lead-base bullion	4,872	4,252	5,557	5,837	2,945
Lead in ore and matte	55,833	47,830	42,837	81,546	41,148
Total	140,207	125,537	106,661	135,079	127,950

W Withheld to avoid disclosing company proprietary data.

Table 22.—Stocks of lead at consumers and secondary smelters in the United States, December 31

(Metric tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1981	69,636	46,194	6,523	863	123,216
1982	51,036	40,118	5,346	709	97,209
1983	57,881	37,159	5,085	646	100,771
1984	r53,802	37,015	5,326	934	r97,077
1985	50,475	36,374	5,770	511	93,130

rRevised.

Table 23.—Average monthly and annual quoted prices of lead[1]

(Cents per pound)

Month	1984 U.S. producer	1984 London Metal Exchange	1985 U.S. producer	1985 London Metal Exchange
January	25.12	18.01	19.09	19.03
February	24.07	18.33	18.82	16.69
March	25.03	20.82	17.68	15.95
April	26.43	21.83	19.92	17.65
May	25.37	20.54	20.11	17.04
June	28.16	21.95	19.05	17.64
July	30.51	22.37	18.88	18.27
August	28.24	21.18	19.10	18.74
September	24.18	18.20	19.20	18.15
October	22.33	18.67	18.93	17.83
November	25.25	19.96	19.05	17.86
December	21.89	18.83	18.97	17.67
Average	25.55	20.12	19.07	17.84

[1]Metals Week. Quotations for the United States on a nationwide, delivered basis. LME cash average.

Table 24.—U.S. exports of lead, by country

Country	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Ore and concentrates (lead content):				
Canada	11,675	$4,627	7,529	$2,986
Germany, Federal Republic of	--	--	642	734
Haiti	54	40	--	--
Japan	--	--	1,438	365
Mexico	43	13	23	7
Netherlands	--	--	354	410
United Kingdom	66	56	--	--
Other	20	24	1	1
Total	11,858	4,760	9,987	4,503
Drosses and residues including flue dust (lead content):				
Belgium-Luxembourg	2,458	622	1,894	557
Brazil	4,353	1,080	1,831	359
Canada	274	562	3,527	1,186
Denmark	473	496	--	--
Finland	--	--	91	50
France	--	--	35	25
Germany, Federal Republic of	273	162	161	195
Japan	--	--	60	224
Netherlands	3	5	102	63
United Kingdom	1,268	2,421	2,210	2,929
Other	16	4	67	144
Total	9,118	5,352	9,978	5,732
Unwrought lead and lead alloys (lead content):				
Australia	4	4	1	1
Belgium-Luxembourg	113	1,832	206	1,177
Brazil	(1)	5	1,498	421
Canada	2,817	2,181	1,783	1,006
Chile	174	178	385	630
China	8	288	1	26
Dominican Republic	56	42	67	60
Egypt	105	302	346	274
Finland	39	36	--	--
France	3	11	3	9
Germany, Federal Republic of	104	80	14	52
Ghana	100	66	1	5
Haiti	36	27	128	119
Honduras	3	4	--	--
Israel	--	--	544	216
Japan	148	184	71	90
Korea, Republic of	95	169	761	1,052
Mexico	584	766	364	230
Netherlands	66	850	15,511	8,428
Netherlands Antilles	--	--	34	24
Nigeria	--	--	310	195
Panama	--	--	56	51

See footnote at end of table.

Table 24.—U.S. exports of lead, by country —Continued

Country	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Unwrought lead and lead alloys (lead content) —Continued				
Peru	15	$17	90	$109
Philippines	121	128	27	20
Saudi Arabia	16	33	16	51
Singapore	58	65	7	8
Taiwan	90	75	687	316
Thailand	12	15	--	--
United Kingdom	108	115	2,298	1,381
Venezuela	7	39	27	32
Other	78	157	142	217
Total	4,960	7,669	25,378	16,200
Wrought lead and lead alloys (lead content):				
Australia	--	2	4	14
Barbados	--	--	39	43
Belgium-Luxembourg	91	138	--	2
Brazil	--	--	22	30
Canada	495	516	367	656
Denmark	17	25	--	--
Ecuador	4	8	5	11
France	15	34	3	36
Germany, Federal Republic of	11	19	41	178
Honduras	11	23	5	12
Hong Kong	33	50	5	36
India	--	--	2	2
Israel	--	--	2	8
Italy	--	1	1	1
Japan	16	193	26	41
Korea, Republic of	25	95	18	159
Mexico	1,273	5,190	670	2,861
Netherlands	4	6	1	7
Panama	14	33	1	7
Philippines	10	30	--	--
Saudi Arabia	30	84	6	36
Singapore	33	62	41	34
Spain	([1])	1	--	--
Taiwan	98	319	543	236
United Kingdom	185	393	63	98
Venezuela	86	121	60	69
Other	34	202	39	200
Total	2,485	7,545	1,964	4,777
Scrap (gross weight):				
Australia	--	--	18	8
Belgium-Luxembourg	345	388	383	176
Brazil	5,861	1,192	14,475	2,920
Canada	6,117	2,190	3,634	917
Colombia	5,649	548	6,185	882
Denmark	430	516	--	--
Ecuador	59	58	2	7
Germany, Federal Republic of	904	480	1,525	266
Hong Kong	156	77	15	7
India	298	167	450	88
Ireland	--	--	273	77
Italy	--	--	3,528	495
Japan	336	166	1,540	1,002
Korea, Republic of	1,550	331	3,053	978
Mexico	2,873	823	1,832	346
Netherlands	262	293	182	143
Philippines	1,000	239	--	--
Spain	513	73	18	2
Switzerland	--	--	68	20
Taiwan	13,530	2,803	17,262	2,477
Trinidad and Tobago	3,541	520	68	20
United Kingdom	659	400	1,633	891
Venezuela	992	300	3,738	1,067
Other	22	11	67	174
Total	45,097	11,575	59,949	12,963
Grand total	73,518	36,901	107,256	44,175

[1]Less than 1/2 unit.

Source: Bureau of the Census.

Table 25.—U.S. exports of lead

Year	Blocks, pigs, anodes, etc.: Unwrought: Quantity (metric tons)	Blocks, pigs, anodes, etc.: Unwrought: Value (thousands)	Blocks, pigs, anodes, etc.: Unwrought alloys: Quantity (metric tons)	Blocks, pigs, anodes, etc.: Unwrought alloys: Value (thousands)	Wrought lead and lead alloys: Sheets, plates, rods, other forms: Quantity (metric tons)	Wrought lead and lead alloys: Sheets, plates, rods, other forms: Value (thousands)	Wrought lead and lead alloys: Foil, powder, flakes: Quantity (metric tons)	Wrought lead and lead alloys: Foil, powder, flakes: Value (thousands)	Scrap (gross weight): Quantity (metric tons)	Scrap (gross weight): Value (thousands)	Drosses, etc.: Quantity (metric tons)	Drosses, etc.: Value (thousands)
1983	13,244	$8,895	4,440	$2,409	2,406	$6,866	359	$920	50,918	$13,139	3,902	$3,080
1984	3,732	4,849	1,228	2,820	2,156	7,058	329	487	45,097	11,575	9,118	5,352
1985	23,468	14,050	1,910	2,150	1,870	4,635	94	142	59,949	12,963	9,978	5,732

Source: Bureau of the Census.

Table 26.—U.S. imports[1] of lead, by country

(Lead content)

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Ore and concentrates:[2]						
Australia	10,002	$2,865	17,024	$5,689	12,260	$2,407
Bolivia	--	--	816	390	--	--
Canada	6,143	1,234	14,127	5,242	5,195	1,246
Chile	--	--	904	189	765	106
Honduras	8,663	3,945	5,370	2,889	1,568	757
Italy	--	--	5,103	1,664	--	--
Mexico	4	1	2,803	1,630	4,321	1,356
Peru	22,702	7,041	22,718	8,671	15,176	4,017
South Africa, Republic of	--	--	--	--	3,381	1,316
Other	2	1	5	2	--	--
Total	47,516	15,087	68,870	26,366	[3]42,665	11,205
Base bullion:						
Canada	28	12	19	10	713	375
France	--	--	18	8	--	--
Mexico	25	10	6	37	48	23
Other	(4)	1	(4)	2	--	--
Total	53	23	43	57	[3]760	398
Pigs and bars:						
Australia	10,883	3,825	10,884	5,187	3,627	1,758
Belgium-Luxembourg	322	2,273	231	282	15	13
Canada	72,655	31,578	94,893	50,103	90,056	33,783
Denmark	--	--	11	4	--	--
France	--	--	--	--	20	9
Germany, Federal Republic of	1,022	7,020	1,528	4,205	542	3,080
Italy	113	79	418	316	--	--
Mexico	34,861	14,071	39,502	19,158	33,771	13,271
Netherlands	11	84	116	92	10	23
Peru	10,096	3,526	9,205	4,349	5,150	1,770
South Africa, Republic of	--	--	496	275	--	--
Spain	--	--	3,184	1,635	--	--
United Kingdom	716	898	974	943	337	807
Other	53	92	123	58	--	--
Total	130,732	63,446	161,565	86,607	[3]133,529	54,514
Reclaimed scrap, including drosses:[5]						
Australia	2,272	347	1,302	359	--	--
Bahamas	90	6	--	--	--	--
Canada	2,718	861	2,311	1,099	1,118	454
Mexico	1,551	371	2,638	864	2,035	720
United Kingdom	93	20	48	23	--	--
Other	29	106	3	13	15	34
Total	6,753	1,711	[3]6,303	2,358	3,168	1,208

See footnotes at end of table.

Table 26.—U.S. imports[1] of lead, by country —Continued

(Lead content)

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Pigs and bars:						
London Metal Exchange (return of U.S. brands)[6]	42,000	$16,945	--	--	--	--
Grand total	227,054	97,212	236,781	$115,388	180,122	$67,325

[1]Data are "general imports"; that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2]Also includes other lead-bearing materials containing greater than 5 troy ounces of gold per short ton, or greater than 100 troy ounces of total precious metals per short ton.
[3]Data do not add to total shown because of independent rounding.
[4]Less than 1/2 unit.
[5]Also includes other lead-bearing materials containing greater than 10% by weight of copper, lead, or zinc (any one).
[6]Bureau of Mines estimate.

Source: Bureau of the Census.

Table 27.—U.S. imports for consumption of lead, by country

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Ore and concentrates (lead content):[1]						
Canada	483	$112	1,843	$477	--	--
Chile	--	--	--	--	765	$106
Honduras	1,522	674	4,121	2,201	1,568	757
Italy	--	--	1,569	467	--	--
Mexico	4	1	2,654	1,550	317	116
Peru	17,742	4,924	19,695	7,226	--	--
Other	2	1	5	2	--	--
Total[2]	19,753	5,712	29,888	11,923	2,649	979
Base bullion (lead content):						
Canada	28	12	19	10	713	375
France	--	--	18	8	--	--
Mexico	25	10	6	37	48	23
Other	([3])	1	([3])	2	--	--
Total[2]	53	23	43	57	760	398
Pigs and bars (lead content):						
Australia	14,508	4,604	9,978	4,364	91	443
Belgium-Luxembourg	322	2,273	231	282	15	14
Canada	72,655	31,578	94,815	50,062	90,056	33,783
Denmark	--	--	11	4	--	--
France	--	--	--	--	20	9
Germany, Federal Republic of	1,022	7,020	1,528	4,205	542	3,080
India	--	--	907	447	1,361	664
Italy	113	79	419	316	--	--
Mexico	34,861	14,071	39,502	19,158	33,771	13,271
Netherlands	11	84	116	92	10	23
Peru	10,096	3,526	9,205	4,349	5,150	1,770
South Africa, Republic of	--	--	496	275	--	--
Spain	--	--	3,184	1,635	--	--
United Kingdom	716	898	974	943	337	807
Other	53	92	121	58	--	--
Total[2]	134,357	64,225	161,489	86,189	131,353	53,864
Reclaimed scrap, etc. (lead content):[4]						
Australia	6	6	27	30	--	--
Bahamas	90	6	--	--	--	--
Canada	2,443	831	2,311	1,099	1,118	454

See footnotes at end of table.

Table 27.—U.S. imports for consumption of lead, by country —Continued

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Reclaimed scrap, etc. (lead content)[4] —Continued						
Guatemala	14	$6	--	--	--	--
Mexico	1,551	371	2,638	$864	2,035	$720
United Kingdom	93	20	48	23	--	--
Other	15	100	3	13	15	38
Total[2]	4,212	1,340	5,026	2,029	3,168	1,212
Sheets, pipe, shot, other forms:						
Belgium-Luxembourg	16	32	90	107	44	57
Canada	228	238	471	837	419	627
Germany, Federal Republic of	216	1,189	315	1,693	149	576
Italy	--	--	([3])	2	1	13
Mexico	10	64	669	853	164	147
Peru	--	--	--	--	121	61
Spain	--	--	--	--	36	11
United Kingdom	3	14	51	128	1,027	809
Other	23	95	72	424	20	216
Total[2]	496	1,632	1,667	4,044	1,981	2,517
Pigs and bars (lead content):						
London Metal Exchange (return of U.S. brands)[5]	42,000	16,945	--	--	--	--
Grand total[2]	200,871	89,877	198,108	104,241	139,911	58,970

[1]Also includes other lead-bearing materials containing greater than 5 troy ounces of gold per short ton, or greater than 100 troy ounces of total precious metals per short ton.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Also includes other lead-bearing materials containing greater than 10% by weight of copper, lead, or zinc (any one).
[5]Bureau of Mines estimate.

Source: Bureau of the Census.

Table 28.—U.S. imports for consumption of lead

(Thousand metric tons and thousand dollars)

Year	Ore and concentrate (lead content) Quantity	Ore and concentrate (lead content) Value	Base bullion (lead content) Quantity	Base bullion (lead content) Value	Pigs and bars (lead content) Quantity	Pigs and bars (lead content) Value	Sheets, plates, strip, other forms Quantity	Sheets, plates, strip, other forms Value
1981	27	20,196	([1])	340	100	87,026	([1])	564
1982	19	8,784	([1])	28	95	58,633	([1])	646
1983	20	5,712	([1])	23	[2]176	[2]81,170	1	1,628
1984	30	11,923	([1])	57	161	86,189	2	3,720
1985	3	979	1	398	131	53,864	2	2,394

Year	Waste and scrap (lead content) Quantity	Waste and scrap (lead content) Value	Dross, skimmings, residues, n.s.p.f. (lead content) Quantity	Dross, skimmings, residues, n.s.p.f. (lead content) Value	Powder and flakes Quantity	Powder and flakes Value	Total value
1981	2	1,568	1	652	([1])	162	110,508
1982	4	1,473	1	282	([1])	48	69,894
1983	3	980	1	360	([1])	4	89,877
1984	4	1,665	1	363	([1])	324	104,241
1985	2	1,068	1	144	([1])	123	58,970

[1]Less than 1/2 unit.
[2]Includes Bureau of Mines estimate of 42,000 metric tons of U.S. brands returned from the London Metal Exchange with an estimated value of $16,945,000.

Source: Bureau of the Census.

Table 29.—U.S. imports for consumption of miscellaneous products containing lead[1]

Year	Gross weight (metric tons)	Lead content (metric tons)	Value (thousands)
1982	1,423	639	$10,596
1983	2,312	1,131	13,720
1984	2,671	1,363	17,299
1985	3,377	1,453	22,124

[1]Babbitt metal, solder, white metal, and other lead-containing combinations.

Source: Bureau of the Census.

Table 30.—Lead: World mine production of lead in concentrates, by country[1]

(Thousand metric tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	[r]5.0	[r]5.0	[r]3.0	[r]4.0	3.0
Argentina	32.7	30.1	31.7	28.5	29.0
Australia	388.1	455.3	480.6	440.7	491.0
Austria	4.3	4.1	4.3	4.2	6.1
Bolivia	16.8	12.4	11.8	7.4	7.5
Brazil	21.7	19.4	18.8	16.7	19.0
Bulgaria[e]	116.0	95.0	95.0	95.0	95.0
Burma	16.1	16.1	23.1	21.9	22.0
Canada	332.0	341.2	251.5	264.3	278.0
Chile	.2	[r]1.6	1.7	4.3	[3]2.5
China[e]	160.0	160.0	160.0	160.0	160.0
Colombia	[r].2	[r].2	.2	.1	.1
Congo (Brazzaville)	7.7	4.1	[e]6.0	[e]2.0	4.0
Czechoslovakia	3.4	3.1	3.2	3.1	3.2
Ecuador	.2	.2	.2	.2	.2
Finland	[r]1.6	1.9	2.1	2.5	2.4
France	17.2	5.9	1.5	2.3	1.6
Germany, Federal Republic of	21.6	23.5	23.5	21.0	[3]20.5
Greece[e]	[r]23.0	19.0	20.0	[r]22.0	20.0
Greenland	[r]26.9	[r]26.5	22.0	17.7	[3]17.8
Honduras	12.6	15.1	19.3	20.5	21.3
Hungary[e]	.5	.6	.7	.7	.7
India	15.3	[e]16.6	[e]25.7	24.8	[3]28.0
Iran[e]	20.0	25.0	[r]20.0	[r]20.0	20.4
Ireland	[r]28.8	[r]36.0	33.6	37.2	34.0
Italy	[r]21.3	16.2	23.6	20.8	[3]15.6
Japan	46.9	45.9	46.9	48.7	[3]50.0
Korea, North[e]	110.0	95.0	75.0	[r]110.0	110.0
Korea, Republic of	13.4	12.2	12.2	10.8	8.8
Mexico	148.9	170.2	184.3	202.6	200.0
Morocco	[r]117.7	103.6	97.9	100.7	101.0
Namibia	46.9	32.9	38.5	33.3	[3]34.6
Nigeria[e]	.2	.3	.3	.3	.3
Norway	3.0	[e]3.7	4.1	3.5	3.4
Peru	192.7	175.8	212.6	205.3	[3]209.9
Philippines	1.1	--	--	--	--
Poland	[r]44.2	[r]45.3	47.0	52.8	53.0
Romania[e]	25.0	27.0	30.0	30.0	28.0
South Africa, Republic of	98.9	90.3	87.5	94.8	[3]98.4
Spain	80.2	73.3	82.0	96.6	[3]86.7
Sweden	[r]85.0	[r]80.0	78.2	80.5	73.5
Thailand	17.3	18.6	21.0	16.7	20.0
Tunisia	5.7	5.0	4.6	4.1	[3]3.6
Turkey	[r]8.4	[r]10.7	9.1	14.6	14.4
U.S.S.R.[e]	425.0	430.0	435.0	440.0	440.0
United Kingdom	7.0	4.0	3.8	2.4	3.0
United States	459.0	530.3	465.6	334.5	[3]424.4
Yugoslavia	118.6	113.1	114.0	113.6	110.0
Zambia	17.2	21.2	25.9	18.1	15.8
Total	[r]3,365.5	[r]3,422.5	3,358.6	3,255.8	3,391.7

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 24, 1986.
[2]In addition to the countries listed, Uganda may produce lead, but available information is inadequate to make reliable estimates of output levels.
[3]Reported figure.

Table 31.—Lead: World smelter production, by country[1]

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina:					
Primary (refined)	19.0	17.0	16.0	[e]19.0	18.0
Secondary (refined)	15.6	14.6	15.0	[e]17.0	16.0
Total	34.6	31.6	31.0	36.0	34.0
Australia:					
Primary:					
Bullion for export	162.6	181.6	182.6	179.5	[2]183.3
Refined	207.7	218.8	196.3	198.8	[2]196.2
Secondary (refined)[e]	31.5	28.3	[r]27.0	21.5	15.9
Total	401.8	428.7	405.9	399.8	395.4
Austria:					
Primary	3.3	3.4	4.2	1.7	1.7
Secondary	12.8	14.5	12.9	16.5	16.8
Total	16.1	17.9	17.1	18.2	18.5
Belgium:					
Primary[e 3]	60.2	52.9	[r]54.4	[r]71.5	59.6
Secondary[4]	28.0	28.0	30.0	30.0	28.0
Total	88.2	80.9	84.4	101.5	87.6
Brazil:					
Primary (refined)	34.7	21.9	20.6	26.0	27.0
Secondary (refined)	[r]29.0	[r]26.3	28.9	37.7	40.0
Total	[r]63.7	[r]48.2	49.5	63.7	67.0
Bulgaria:[e]					
Primary	115.0	114.0	112.0	112.0	112.0
Secondary[4]	4.0	4.0	4.0	4.0	4.0
Total	119.0	118.0	116.0	116.0	116.0
Burma: Primary (refined)	4.1	7.8	7.6	7.0	[2]9.6
Canada:					
Primary (refined)	168.5	174.3	178.1	173.0	172.7
Secondary (refined)	69.7	64.6	63.9	79.0	66.8
Total	238.2	238.9	242.0	252.0	239.5
China:[e]					
Primary (refined)	150.0	155.0	165.0	165.0	165.0
Secondary (refined)	25.0	20.0	30.0	30.0	30.0
Total	175.0	175.0	195.0	195.0	195.0
Colombia: Secondary (refined)[e]	3.0	3.0	3.0	3.0	3.0
Cyprus: Secondary (refined)[e]	2.5	2.5	2.5	2.5	2.0
Czechoslovakia: Secondary (refined)	21.0	21.0	21.0	21.1	21.5
Denmark: Secondary (refined)	24.0	15.9	10.0	13.0	4.5
Finland: Secondary (refined)	4.5	4.4	6.0	4.5	4.4
France:					
Primary (refined)	128.6	122.7	114.9	117.9	132.3
Secondary	[r]35.3	[r]22.4	37.4	24.9	36.4
Total	[r]163.9	[r]145.1	152.3	142.8	168.7
German Democratic Republic: Secondary (refined)[e 4]	[r]43.0	[r]38.0	[r]36.0	[r]35.0	36.0
Germany, Federal Republic of:					
Primary	107.5	110.7	116.2	102.3	[2]109.7
Secondary	254.8	239.7	236.3	254.9	246.8
Total	362.3	350.4	352.5	357.2	[2]356.5
Greece:					
Primary (refined)	21.0	3.2	--	([5])	15.0
Secondary (refined)	4.0	--	--	--	--
Total	25.0	3.2	--	([5])	15.0
Guatemala: Secondary (refined)	.1	.1	.1	.1	.1
Hungary: Secondary (refined)[e]	.1	.1	.1	.1	.1

See footnotes at end of table.

Table 31.—Lead: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
India:					
Primary (refined)	14.3	[e]14.4	15.0	15.2	[2]15.6
Secondary (refined)	11.1	[e]8.8	6.6	[r] [e]10.0	10.0
Total	25.4	[e]23.2	21.6	[r] [e]25.2	25.6
Ireland: Secondary (refined)[e]	10.0	10.0	10.0	10.0	10.0
Italy:					
Primary (refined)	35.6	36.4	37.0	37.6	[2]29.5
Secondary (refined)	97.4	97.3	89.4	102.9	95.0
Total	133.0	133.7	126.4	140.5	124.5
Jamaica: Secondary (refined)[e]	1.0	1.0	1.0	1.0	1.0
Japan:					
Primary	190.7	192.8	198.9	207.9	[2]218.3
Secondary (refined)	141.6	119.1	118.3	129.2	[2]133.3
Total	332.3	311.9	317.2	337.1	[2]351.6
Korea, North: Primary (refined)[e]	65.0	60.0	60.0	[r]95.0	95.0
Korea, Republic of:[e]					
Primary (refined)	7.2	9.5	10.5	[r]12.0	14.5
Secondary (refined)	7.5	6.6	7.3	[r]8.3	7.9
Total	14.7	16.1	17.8	20.3	22.4
Malaysia: Secondary (refined)	[e]3.5	3.0	[e]4.0	[r] [e]9.0	8.8
Mexico:					
Primary	156.7	145.4	166.8	174.8	175.0
Secondary (refined)[e]	38.0	34.0	[r]29.0	[r]25.0	25.0
Total	194.7	179.4	195.8	199.8	200.0
Morocco:					
Primary (refined)	50.1	56.5	55.2	46.1	46.0
Secondary (refined)[e]	2.1	2.0	2.0	2.0	2.0
Total[e]	52.2	58.5	[r]57.2	[r]48.1	48.0
Namibia: Primary (refined)	41.7	40.6	35.4	28.9	[2]38.5
Netherlands:					
Primary[e]	2.5	2.5	2.5	2.5	3.0
Secondary (refined)	[r]33.9	[r]27.7	23.6	33.6	37.6
Total	[r]36.4	[r]30.2	26.1	36.1	40.6
New Zealand: Secondary (refined)[e]	7.0	6.0	6.0	6.0	6.0
Nigeria: Secondary (refined)[e]	2.0	2.0	2.0	2.0	3.0
Pakistan: Secondary (refined)[e]	1.0	1.0	1.0	1.0	1.0
Peru:					
Primary (refined)	79.2	77.0	67.7	70.3	[2]81.9
Secondary (refined)[e]	5.0	5.0	5.0	5.0	5.0
Total	84.2	82.0	72.7	75.3	86.9
Philippines: Secondary (refined)	4.0	6.0	6.0	4.0	4.0
Poland:[e]					
Primary (refined)	47.0	55.0	56.5	58.4	61.1
Secondary (refined)[4]	22.0	23.8	24.5	25.0	26.2
Total	69.0	78.8	81.0	83.4	[2]87.3
Portugal: Secondary (refined)	5.3	4.0	6.0	6.0	6.0
Romania:					
Primary (refined)[e]	[r] [2]40.7	40.5	40.0	39.0	39.0
Secondary (refined)[e]	5.0	5.2	9.3	10.0	10.0
Total	[r]45.7	45.7	49.3	[e]49.0	49.0
South Africa, Republic of: Secondary (refined)	26.9	30.4	23.6	21.9	20.0
Spain:					
Primary (refined)[3]	[r]83.0	99.5	107.8	110.1	110.0
Secondary (refined)	34.1	32.1	36.0	49.9	45.0
Total	[r]117.1	131.6	143.8	160.0	155.0

See footnotes at end of table.

Table 31.—Lead: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Sweden:					
Primary	[r]21.8	[r]63.7	62.8	65.7	66.0
Secondary	[r]21.5	[r]20.4	17.8	23.4	20.0
Total	[r]43.3	[r]84.1	80.6	89.1	86.0
Switzerland: Secondary (refined)	4.0	3.0	2.0	2.0	2.0
Taiwan: Secondary (refined)[e]	30.0	35.0	38.0	[r]44.3	44.4
Thailand: Secondary (refined)	.5	.9	3.2	6.2	6.0
Trinidad and Tobago: Secondary (refined)[e]	2.0	2.0	2.0	2.0	2.0
Tunisia:					
Primary (refined)	17.5	15.3	10.4	8.4	10.0
Secondary (refined)[e]	.5	.5	.5	.5	.5
Total[e]	18.0	15.8	10.9	[r]8.9	10.5
Turkey: Primary (refined)	[r]2.5	[r]3.1	4.0	4.0	3.6
U.S.S.R.:[e]					
Primary (refined)	480.0	485.0	490.0	495.0	495.0
Secondary (refined)	235.0	245.0	255.0	260.0	265.0
Total	715.0	730.0	745.0	755.0	760.0
United Kingdom:					
Primary[6]	26.5	34.1	40.7	36.1	36.0
Secondary (refined)	198.0	[r]175.2	185.3	191.3	[2]158.9
Total	224.5	[r]209.3	226.0	227.4	194.9
United States:					
Primary (refined)	498.3	516.8	514.6	395.6	[2]487.4
Secondary (refined)	641.1	571.3	503.5	633.4	[2]594.2
Total	1,139.4	1,088.1	1,018.1	1,029.0	[2]1,081.6
Venezuela: Secondary (refined)	12.0	15.0	15.0	17.0	18.0
Yugoslavia:					
Primary	74.0	74.0	93.1	[r e]95.0	110.0
Secondary	46.5	35.0	34.0	35.0	40.0
Total	120.5	109.0	127.1	[r e]130.0	150.0
Zambia: Primary (refined)	9.9	14.6	14.6	8.8	9.2
Grand total	[r]5,383.8	[r]5,295.7	5,282.4	5,451.8	5,526.8
Of which:					
Primary	[r]3,126.4	[r]3,220.0	3,251.4	3,180.1	3,346.7
Secondary	[r]2,257.4	[r]2,075.7	2,031.0	2,271.7	2,180.1

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 24, 1986. Figures presented represent, to the extent possible, production of unrefined lead, including bullion and impure lead derived from new and old scrap. The figures for secondary lead for a number of countries are undoubtedly high, but insufficient information is available to separate reprocessed scrap lead from lead merely remelted. Countries for which this is the case have been footnoted. (See footnote 4.) For those countries from which unrefined lead production is not reported, but where available information suggests that there is little if any import or export of bullion for refining and refined lead output has been reported, it is so noted parenthetically because it is believed that the difference between smelter output and refined output is negligible.

[2]Reported figure.

[3]Data not reported, derived from reported primary refined lead output minus imports of lead bullion plus exports of lead bullion and checked against use of lead content of domestically produced ores plus lead content of imported ores (estimated) minus lead content of exported ores (estimated).

[4]Some part of the total entered may be merely remelt, and as such probably should not be included here, but a substantial part of the total presumably was reprocessed to qualify as a secondary smelter product. Available information is inadequate to permit differentiation, and the total has been included, although it is recognized that this produces a slightly inflated figure.

[5]Revised to zero.

[6]Production from Imperial Smelting Furnace at Avonmouth only.

Table 32.—Lead: World refinery production, by country[1]

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina:					
Primary	19.0	17.0	16.0	[e]19.0	18.0
Secondary	15.6	14.6	15.0	[e]17.0	16.0
Total	34.6	31.6	31.0	[e]36.0	34.0
Australia:					
Primary	207.7	218.8	196.3	198.8	196.2
Secondary[e]	31.5	28.3	[r]27.0	21.5	15.9
Total	239.2	247.1	223.3	220.3	212.1
Austria:					
Primary	[r]5.0	[r]10.4	12.0	7.2	4.5
Secondary	[r]11.6	[r]11.1	11.5	13.4	14.7
Total	[r]16.6	[r]21.5	23.5	20.6	19.2
Belgium:					
Primary	73.9	66.0	96.3	89.6	77.6
Secondary	36.0	33.7	37.8	38.1	37.4
Total	109.9	99.7	134.1	127.7	115.0
Brazil:					
Primary	34.7	21.9	21.0	26.0	27.0
Secondary	[r]29.0	[r]26.3	29.0	37.7	40.0
Total	[r]63.7	[r]48.2	50.0	63.7	67.0
Bulgaria:[e]					
Primary	101.2	100.3	98.6	98.6	98.0
Secondary	17.8	17.7	17.4	17.4	18.0
Total	119.0	118.0	116.0	116.0	116.0
Burma:					
Primary	4.1	7.8	7.6	7.0	[2]9.6
Secondary[e]	([3])	([3])	([3])	([3])	--
Total	4.1	7.8	7.6	7.0	9.6
Canada:					
Primary	168.5	174.3	178.1	173.0	172.7
Secondary	69.7	64.6	63.9	79.0	66.8
Total	238.2	238.9	242.0	252.0	239.5
China:[e]					
Primary	150.0	155.0	165.0	165.0	165.0
Secondary	25.0	20.0	30.0	30.0	30.0
Total	175.0	175.0	195.0	195.0	195.0
Colombia: Secondary[e]	3.0	3.0	3.0	3.0	3.0
Cyprus: Secondary[e]	2.5	2.5	2.5	2.5	2.0
Czechoslovakia: Secondary	21.0	21.0	21.0	21.1	21.5
Denmark: Secondary	24.0	15.9	10.0	13.0	[2]4.5
Finland: Secondary	4.5	4.4	6.0	4.5	4.4
France:					
Primary	128.6	122.7	115.0	117.9	132.3
Secondary	99.4	85.9	99.4	88.8	98.9
Total	228.0	208.6	214.4	206.7	231.2
German Democratic Republic: Secondary[e]	[r]43.0	[r]38.0	[r]36.0	[r]35.0	36.0
Germany, Federal Republic of:					
Primary	189.5	201.6	217.0	191.9	193.5
Secondary	158.8	148.9	135.5	165.3	163.0
Total	348.3	350.5	352.5	357.2	356.5
Greece:					
Primary	21.0	3.2	--	([3])	15.0
Secondary	4.0	--	--	--	--
Total	25.0	3.2	--	([3])	15.0
Guatemala: Secondary	.1	.1	.1	.1	.1
Hungary: Secondary[e]	.1	.1	.1	.1	.1

See footnotes at end of table.

Table 32.—Lead: World refinery production, by country[1] —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
India:					
Primary	14.3	[e]14.4	15.0	15.2	[2]15.6
Secondary	11.1	[e]8.8	6.6	[r e]10.0	10.0
Total	25.4	[e]23.2	21.6	[r e]25.2	25.6
Ireland: Secondary[e]	10.0	10.0	10.0	10.0	10.0
Italy:					
Primary	35.6	36.4	37.0	37.6	[2]29.5
Secondary	97.4	97.3	89.4	102.9	95.0
Total	133.0	133.7	126.4	140.5	124.5
Jamaica: Secondary[e]	1.0	1.0	1.0	1.0	1.0
Japan:					
Primary	175.4	183.1	203.3	233.8	[2]233.7
Secondary	141.6	119.1	118.3	129.2	[2]133.3
Total	317.0	302.2	321.6	363.0	[2]367.0
Korea, North:[e]					
Primary (refined)	[r]65.0	[r]60.0	[r]60.0	[r]95.0	95.0
Secondary	(3)	(3)	(3)	(3)	--
Total	65.0	60.0	60.0	[r]95.0	95.0
Korea, Republic of:[e]					
Primary	7.2	9.5	10.5	[r]12.0	14.5
Secondary	7.5	6.6	7.3	[r]8.3	7.9
Total	14.7	16.1	17.8	20.3	22.4
Malaysia: Secondary	[e]3.5	3.0	[e]4.0	[r e]9.0	8.8
Mexico:					
Primary	150.6	137.2	162.5	162.2	165.0
Secondary[e]	38.0	34.0	[r]29.0	[r]25.0	25.0
Total[e]	188.6	171.2	[r]191.5	[r]187.2	190.0
Morocco:					
Primary	50.1	56.5	55.2	46.1	46.0
Secondary[e]	2.1	2.0	2.0	2.0	2.0
Total[e]	52.2	58.5	[r]57.2	48.1	48.0
Namibia: Primary	41.7	40.6	35.4	28.9	[2]38.5
Netherlands:					
Primary	(3)	[r]4.8	2.0	(3)	--
Secondary	[r]33.9	[r]27.7	23.6	33.6	37.6
Total	33.9	[r]32.5	25.6	33.6	37.6
New Zealand: Secondary[e]	7.0	6.0	6.0	6.0	6.0
Nigeria: Secondary[e]	2.0	2.0	2.0	2.0	3.0
Pakistan: Secondary[e]	1.0	1.0	1.0	1.0	1.0
Peru:					
Primary	79.2	77.0	67.7	70.3	[2]81.9
Secondary[e]	5.0	5.0	5.0	5.0	5.0
Total[e]	84.2	82.0	72.7	75.3	86.9
Philippines: Secondary	4.0	6.0	6.0	4.0	4.0
Poland:					
Primary[e]	48.3	55.2	56.7	58.4	61.1
Secondary[e]	20.7	23.6	24.3	25.0	26.2
Total	69.0	78.8	81.0	83.4	[2]87.3
Portugal: Secondary	5.3	4.0	6.0	[e]6.0	6.0
Romania:					
Primary[e]	[r 2]40.7	40.5	40.0	39.0	39.0
Secondary[e]	5.0	5.2	[r]9.3	10.0	10.0
Total	[r]45.7	45.7	49.3	[e]49.0	49.0
South Africa, Republic of: Secondary	26.9	30.4	23.6	21.9	20.0

See footnotes at end of table.

Table 32.—Lead: World refinery production, by country[1] —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Spain:					
Primary	[r]83.0	99.5	107.8	110.1	110.0
Secondary	34.1	32.1	36.0	49.9	45.0
Total	[r]117.1	131.6	143.8	160.0	155.0
Sweden:					
Primary	7.0	29.6	34.8	49.8	48.6
Secondary	22.0	19.9	18.8	23.4	[2]20.0
Total	29.0	49.5	53.6	73.2	[2]68.6
Switzerland: Secondary	4.0	3.0	2.0	2.0	2.0
Taiwan: Secondary[e]	30.0	35.0	38.0	[r]44.3	44.4
Thailand: Secondary	.5	.9	3.2	6.2	6.0
Trinidad and Tobago: Secondary[e]	2.0	2.0	2.0	2.0	2.0
Tunisia:					
Primary	17.5	15.3	10.4	8.4	10.0
Secondary[e]	.5	.5	[r].5	.5	.5
Total[e]	18.0	15.8	[r]10.9	[r]8.9	10.5
Turkey: Primary	[r]2.5	[r]3.1	4.0	[e]4.0	3.6
U.S.S.R.:[e]					
Primary	480.0	485.0	490.0	495.0	495.0
Secondary	235.0	245.0	255.0	260.0	265.0
Total	715.0	730.0	745.0	755.0	760.0
United Kingdom:					
Primary	135.4	131.0	136.9	147.1	[2]140.5
Secondary	198.0	175.2	185.3	191.3	[2]158.9
Total	333.4	306.2	322.2	338.4	[2]299.4
United States:					
Primary	498.3	516.8	514.6	395.6	[2]487.4
Secondary	641.1	571.3	503.5	633.4	[2]594.2
Total	1,139.4	1,088.1	1,018.1	1,029.0	[2]1,081.6
Venezuela: Secondary	[r]12.0	[r]15.0	15.0	17.0	18.0
Yugoslavia:					
Primary	73.9	72.0	54.8	45.4	62.0
Secondary	12.5	10.2	42.7	37.4	38.0
Total	86.4	82.2	97.5	82.8	[2]100.0
Zambia: Primary	9.9	14.6	14.6	8.8	9.2
Grand total	[r]5,330.1	[r]5,220.0	5,257.7	5,423.5	5,473.6
Of which:					
Primary	[r]3,118.8	[r]3,181.1	3,236.1	3,156.7	3,295.5
Secondary	[r]2,211.3	[r]2,038.9	2,021.6	2,266.8	2,178.1

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 24, 1986. Data included represent the total output of refined lead by each country, whether derived from ores and concentrates (primary) or scrap (secondary), and include the lead content of antimonial lead, but exclude, to the extent possible, simple remelting of scrap.

[2]Reported figure.

[3]Revised to zero.

Lime

By Lawrence Pelham[1]

Lime output, including that for Puerto Rico, was essentially unchanged from that of 1984 at 15.7 million short tons and valued at $812 million.

Output of agricultural lime increased 5%; construction, chemical, and industrial lime was essentially unchanged; and refractory lime decreased 22%.

Domestic Data Coverage.—Domestic production data for lime are developed by the Bureau of Mines from two separate, voluntary surveys of U.S. operations. Typical of these surveys is the annual "Lime" survey. Of the 116 operations to which the annual survey request was sent, all responded, representing 100% of the total sold or used by producers shown in tables 1 and 2.

Table 1.—Salient lime statistics

(Thousand short tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:[1]					
Number of plants	150	147	139	r129	115
Sold or used by producers:					
Quicklime	16,142	11,701	12,383	13,134	12,997
Hydrated lime	2,279	2,037	2,066	2,302	2,314
Dead-burned dolomite	435	337	418	487	378
Total[2]	18,856	14,075	14,867	15,922	15,690
Value[3] thousands	$884,197	$696,207	$757,611	$811,183	$809,000
Average value per ton	$46.89	$49.46	$50.96	$50.95	$51.70
Lime sold	14,271	10,856	12,083	13,064	13,409
Lime used	4,585	3,219	2,784	2,858	2,281
Exports[4]	28	23	28	25	19
Imports for consumption[4]	504	348	283	247	194
Consumption[5]	19,332	14,400	15,122	16,144	15,777
World: Production	128,921	120,364	121,919	p125,630	e123,531

eEstimated. pPreliminary. rRevised.
[1]Excludes regenerated lime. Excludes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Selling value, f.o.b. plant, excluding cost of containers.
[4]Bureau of the Census.
[5]Measured by sold or used plus imports minus exports.

DOMESTIC PRODUCTION

Lime sold or used by producers, including Puerto Rico, was essentially unchanged at 15.7 million tons. Captive lime used by producers decreased 9% to 2.6 million tons.

Production of quicklime and hydrated lime was essentially unchanged at 13.4 million tons and 2.3 million tons, respectively. Production of dead-burned dolomite decreased 22%.

Six States produced over 1 million tons each and accounted for 56% of total lime output. They were, in descending order, Ohio, Kentucky, Missouri, Pennsylvania, Alabama, and Texas. Production increased 5% in Alabama and 7% in Kentucky, and was relatively unchanged in Texas and

Missouri, but decreased 7% in Ohio and 8% in Pennsylvania.

Seventy-five companies produced lime. Leading producing companies, in descending order, were Dravo Lime Co. with one plant each in Alabama, Kentucky, Louisiana, and Texas; Marblehead Lime Co. with two plants in Illinois and one each in Indiana, Michigan, Pennsylvania, and Utah; Mississippi Lime Co. in Missouri; Martin Marietta Corp. in Ohio; Genstar Lime Co. with two plants in California, two plants in Nevada, and one each in Arizona and Utah; Allied Chemical Corp. with two plants in New York; Black River Lime Co. in Kentucky; Allied Products Co. in Alabama; Bethlehem Steel Corp. with two plants in Pennsylvania; and Republic Steel Corp. in Ohio. These 10 companies, operating 25 plants, accounted for 53% of the total lime production.

The number of plants producing lime in the United States and Puerto Rico decreased from 130 (revised) in 1984 to 116 in 1985. Seven lime plants each produced more than 400,000 tons of lime and together accounted for 34% of the total lime output. Leading individual plants, in descending order, were Mississippi Lime's Ste. Genevieve plant in Missouri, Dravo Lime's Maysville plant in Kentucky, Martin Marietta Chemical Div.'s Woodville plant in Ohio, Allied Chemical's Syracuse Works in New York, Marblehead Lime's Buffington plant in Indiana, Black River Lime's Carntown plant in Kentucky, and Marblehead Lime's South Chicago plant in Illinois. Sixteen plants each produced from 200,000 to 400,000 tons of lime and together accounted for 28% of the total.

New Plants, Expansions, and Changes.— In February, Ash Grove Cement Co. began operating at its plant in Springfield, MO, a kiln that had been converted from a vertical shaft kiln of English Priest design to the Parsons single-shaft, parallel-flow calciner system. The conversion was made to improve product quality and reduce operating cost. The kiln has a design capacity of 300 tons per day of lime with a fuel efficiency under 4 million British thermal units per ton.[2]

Holly Sugar Corp. installed in Brawley, CA, the first Fuller-Bechkenbach mixed-feed-type shaft kiln to be built in the United States. The mixed-feed-type kiln is one of several Bechkenbach shaft kiln designs licensed by Fuller Co., Bethlehem, PA, from Warmestelle Steine und Erden of Düsseldorf, Federal Republic of Germany. The production quality and fuel efficiency of these kilns are believed to be the highest of any shaft kiln in North America.[3]

Western Lime & Cement Co. began operating a new 250-ton-per-day kiln system at its plant in Marblehead, WI. The new kiln provided a substantial increase in capacity over that of the two shaft kilns it replaced at Marblehead and Knowles, WI, which had a combined output of 180 tons per day, and completed the company's planned fuel conversion from gas to coal.[4]

Florida Crushed Stone Co. continued construction of a 350,000-ton-per-year lime plant near Brooksville, Hernando County, FL.

Fourteen fewer plants reported production in 1985 than in 1984. In California, American Crystal Sugar Co.'s Clarksburg kiln was idle. In Colorado, The Great Western Sugar Co. closed five plants. In Connecticut, Pfizer Inc. had closed permanently its Canaan plant in the first quarter of 1984. In Florida, Ideal Basic Industries Inc. did not operate its Port St. Joe kiln. In Kansas, the Kemp plant of Great Western Sugar was idle, as was its Billings plant in Montana and its Scotts Bluff and Gering plants in Nebraska. In Pennsylvania, the Reedsville plant of Honey Creek Lime Co. was idle. In Texas, the Chemical Lime Co. idled its Marblefall plant.

Table 2.—Lime sold or used by producers in the United States, by State[1]

State	1984					1985				
	Plants	Hydrated (thousand short tons)	Quicklime (thousand short tons)	Total[2] (thousand short tons)	Value (thousands)	Plants	Hydrated (thousand short tons)	Quicklime (thousand short tons)	Total[2] (thousand short tons)	Value (thousands)
Alabama	5	146	1,018	1,163	$50,560	5	113	1,103	1,216	$52,295
Arizona	3	--	359	359	17,304	3	W	W	476	21,226
Arkansas, Louisiana, Oklahoma	4	112	213	325	17,635	4	W	W	W	W
California	11	W	W	406	26,827	10	W	W	367	24,733
Colorado, Nevada, Wyoming	[r]12	W	W	230	16,674	6	W	W	188	15,398
Connecticut	1	--	W	W	W	--	--	--	--	--
Florida	3	W	W	171	9,379	2	W	W	W	W
Hawaii, Oregon, Washington	5	[r]26	[r]330	[r]357	23,539	5	W	W	356	24,318
Idaho	3	--	87	87	5,616	3	--	93	93	5,803
Illinois, Indiana, Missouri	8	416	2,879	3,295	155,853	8	436	2,848	3,283	160,121
Iowa, Kansas (1984), Nebraska, South Dakota	6	W	W	227	12,207	4	W	W	W	W
Kentucky, New York, Tennessee, West Virginia	6	97	2,281	[r]2,378	113,313	6	W	W	2,489	122,644
Maryland	1	4	3	7	419	1	6	3	10	608
Massachusetts	2	16	155	171	12,426	2	15	144	159	10,935
Michigan	[r]8	W	W	622	30,092	8	W	W	535	24,790
Minnesota	4	W	W	W	W	4	--	W	W	W
Montana	3	--	89	89	5,097	2	--	W	W	W
North Dakota	3	--	59	[r]59	5,912	3	--	56	56	5,562
Ohio	[r]9	W	W	1,859	87,951	9	W	W	1,730	84,142
Pennsylvania	10	402	1,218	1,620	90,182	9	344	1,148	1,492	85,269
Puerto Rico	1	35	--	35	4,531	1	23	--	23	3,249
Texas	8	555	602	1,157	61,214	7	587	605	1,192	65,927
Utah	4	W	W	297	16,471	4	W	W	225	11,912
Virginia	5	97	465	562	24,799	5	127	506	633	28,103
Wisconsin	5	105	266	373	19,892	5	99	243	341	19,001
Other[3]	([4])	324	3,596	110	7,819	([4])	587	6,627	846	46,214
Total[2]	[r]130	2,336	13,620	15,956	815,714	116	2,337	13,376	15,713	812,249

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes States indicated by symbol W.
[4]Included with data for each individual State.

Table 3.—Lime sold or used by producers in the United States,[1] by size of plant

Size of plant	1984 Plants	1984 Quantity (thousand short tons)	1984 Percent of total	1985 Plants	1985 Quantity (thousand short tons)	1985 Percent of total
Less than 10,000 tons	20	115	1	9	54	(2)
10,000 to 25,000 tons	25	423	3	24	409	3
25,000 to 50,000 tons	18	663	4	16	625	4
50,000 to 100,000 tons	r20	1,723	11	18	1,292	8
100,000 to 200,000 tons	19	2,769	17	26	3,774	24
200,000 to 400,000 tons	r22	5,668	36	16	4,320	28
More than 400,000 tons	6	4,595	29	7	5,239	33
Total	r130	15,956	3100	116	15,713	100

rRevised.
1Excludes regenerated lime. Includes Puerto Rico.
2Less than 1/2 unit.
3Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Lime was consumed in every State. Leading consuming States, in descending order, were Pennsylvania, Ohio, Indiana, Texas, and Michigan, each of which consumed more than 1 million tons. These five States accounted for 46% of the total lime consumed.

Leading quicklime consuming States, in descending order, were Pennsylvania, Ohio, and Indiana, each of which consumed more than 1 million tons. These three States accounted for 34% of the total quicklime consumed. Leading hydrated lime consuming States, in descending order, were Texas, Pennsylvania, Illinois, and Ohio, each of which consumed more than 100,000 tons. These four States accounted for 45% of the total hydrated lime consumed.

Lime sold or used by producers was for chemical and industrial uses, 88%; construction, 9%; refractories, 2.4%; and agriculture, 0.5%. Captive lime was used mainly in the production of steel in basic oxygen furnaces (BOF), 31%; and for sugar refining, 20%.

Leading individual uses of lime, in decreasing order, were for BOF steel, water purification, sulfur removal from stack gases, paper and pulp, and electric-furnace steel, which together accounted for 58% of the total consumption.

Lime consumption in the steel industry decreased slightly to 5.4 million tons and accounted for 34% of all lime consumed in the United States. Lime used for agriculture increased slightly, whereas lime used in construction and in paper and pulp manufacture remained about the same. Environmental uses of lime continued to increase: Lime used for water purification increased 8%; sulfur removal from stack gases, 9%; sewage treatment, 21%; and mine or plant acid water treatment, 5%.

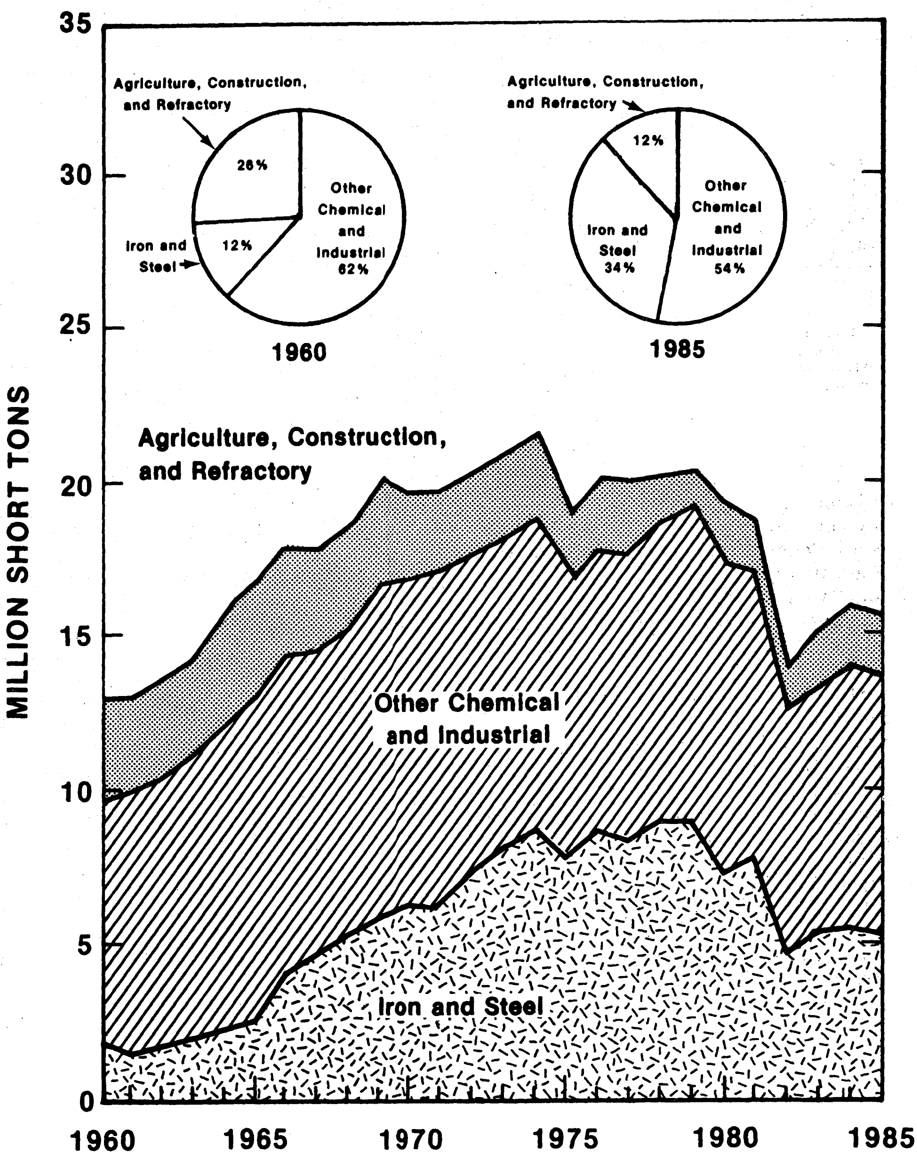

Figure 1.—Trends in major uses of lime.

Table 4.—Destination of shipments of lime sold or used by producers in the United States, by State[1]

(Thousand short tons)

State	1984			1985		
	Quicklime	Hydrated lime	Total[2]	Quicklime	Hydrated lime	Total[2]
Alabama	370	54	424	437	50	487
Alaska	(3)	2	2	(3)	1	1
Arizona	244	32	275	211	61	272
Arkansas	78	28	106	79	32	111
California	399	84	483	383	87	470
Colorado	95	14	110	63	17	80
Connecticut	34	10	43	30	10	40
Delaware	37	5	42	30	5	35
District of Columbia	13	34	47	17	33	50
Florida	373	65	438	375	41	416
Georgia	213	61	274	233	59	292
Hawaii	4	2	6	5	1	6
Idaho	101	3	104	99	3	102
Illinois	552	112	664	519	137	655
Indiana	1,520	41	1,562	1,483	36	1,518
Iowa	73	18	91	75	17	92
Kansas	65	16	81	62	20	82
Kentucky	471	19	490	534	22	556
Louisiana	238	127	365	243	118	361
Maine	15	1	16	14	3	17
Maryland	241	20	261	266	18	284
Massachusetts	67	14	80	62	10	72
Michigan	1,165	32	1,197	993	33	1,026
Minnesota	190	19	209	183	17	200
Mississippi	117	28	146	126	28	154
Missouri	148	40	188	141	48	189
Montana	62	11	73	33	13	46
Nebraska	66	5	71	35	6	41
Nevada	72	8	80	86	5	91
New Hampshire	3	1	3	2	(3)	2
New Jersey	126	61	186	111	52	163
New Mexico	25	28	53	133	31	164
New York	631	45	676	634	39	673
North Carolina	192	24	216	204	30	234
North Dakota	103	11	114	106	4	110
Ohio	1,483	135	1,618	1,504	121	1,625
Oklahoma	91	12	104	110	14	124
Oregon	128	15	143	104	12	116
Pennsylvania	1,601	234	1,835	1,558	210	1,768
Rhode Island	5	2	6	5	2	7
South Carolina	109	14	123	108	19	128
South Dakota	12	9	21	25	3	28
Tennessee	188	77	265	121	120	241
Texas	624	548	1,172	595	571	1,166
Utah	270	11	281	210	11	220
Vermont	(3)	1	1	(3)	1	1
Virginia	95	55	150	193	21	215
Washington	262	14	276	251	12	263
West Virginia	490	26	516	406	36	441
Wisconsin	93	48	141	99	46	146
Wyoming	43	15	58	56	18	74
Other[4]	1	24	25	1	--	1
Total[2]	13,598	2,314	15,912	13,354	2,302	15,657
Exports:						
Canada	18	7	25	18	8	26
Other countries	4	15	19	4	25	29
Total	22	22	44	22	33	55
Grand total[2]	13,620	2,336	15,956	13,376	2,337	15,713

[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes Puerto Rico and U.S. possessions.

Table 5.—Lime sold or used by producers in the United States, by use[1]

(Thousand short tons and thousand dollars)

Use	1984				1985			
	Sold	Used	Total[2]	Value	Sold	Used	Total[2]	Value
Agriculture	79	--	79	4,848	83	--	83	5,524
Chemical and industrial:								
Steel, BOF	3,593	797	4,390	202,015	3,369	804	4,173	207,795
Water purification	W	W	1,401	71,978	W	W	1,509	75,273
Sulfur removal from stack gases	1,213	--	1,213	56,371	1,317	--	1,317	65,587
Paper and pulp	W	W	1,135	53,811	W	W	1,112	55,354
Steel, electric	W	W	929	44,167	W	W	945	47,057
Sewage treatment	W	W	669	36,901	W	W	848	42,491
Alkalies	W	W	647	31,657	W	W	645	32,121
Sugar refining	44	573	617	41,869	42	514	557	27,778
Magnesia from seawater or brine	W	W	564	27,586	W	W	408	10,673
Copper ore concentration	W	W	367	18,288	W	W	307	15,282
Acid water, mine or plant	W	W	270	14,507	W	W	283	14,098
Steel, open-hearth	W	W	256	11,043	W	W	252	12,534
Calcium carbide	W	W	226	9,736	W	W	229	11,418
Glass	128	--	128	6,172	130	--	130	6,463
Magnesium metal	W	W	192	12,141	W	--	W	W
Aluminum and bauxite	156	--	156	8,261	112	--	112	5,600
Precipitated calcium carbonate	W	W	131	9,118	W	--	W	6,367
Ore concentration, other	71	--	71	3,606	82	--	82	4,106
Oil and grease	50	--	50	3,049	49	--	49	2,619
Tanning	30	--	30	1,668	40	--	40	2,010
Petroleum refining	29	--	29	1,452	29	--	29	1,437
Food products, animal or human	39	--	39	2,265	24	--	24	1,209
Oil well drilling	16	--	16	1,092	16	--	16	1,797
Citric acid	37	--	37	866	W	--	W	W
Metallurgy, other	11	--	11	505	10	--	10	513
Fertilizer	23	--	23	1,190	6	--	6	302
Calcium silicate	11	--	11	599	--	--	--	--
Gelatin	5	--	5	320	--	--	--	--
Brick, sand-lime	4	(3)	5	274	3	--	3	186
Paint	2	--	2	163	1	--	1	62
Other[4]	5,789	1,389	391	23,063	6,224	1,098	783	41,527
Total[2]	11,252	2,759	14,011	695,733	11,454	2,416	13,870	691,660
Construction:								
Road stabilization	608	--	608	33,499	601	--	601	39,437
Soil stabilization	243	--	243	13,625	263	--	263	17,275
Mason's lime	W	W	235	14,894	W	W	259	16,987
Finishing lime	236	--	236	20,424	204	--	204	13,403
Other[5]	56	--	56	3,299	53	--	53	3,509
Total[2]	W	W	1,379	85,741	W	W	1,381	90,611
Refractory dolomite	W	W	487	29,391	W	W	378	24,454
Grand total[2]	13,099	2,858	15,956	815,714	13,119	2,594	15,713	812,249

W Withheld to avoid disclosing company proprietary data.
[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.
[4]Includes briquetting, brokers, chrome, commercial hydrators, desiccants, explosives, ferroalloys, fiberglass, glue, insecticides, ladle desulfurizing, manganese, pelletizing, pharmaceuticals, rubber, silica brick, soap, starfish control, wire drawing, unspecified uses, and uses indicated by symbol W in "Chemical and industrial" lime only.
[5]Includes asphalt antistripping.

PRICES

The average value of lime sold or used by producers, as reported to the Bureau of Mines on an f.o.b.-plant basis, was essentially unchanged at $51.69 per ton. Values were $49.87 for chemical and industrial lime, $64.69 for refractory dolomite, $65.61 for construction lime, and $66.55 for lime used in agriculture.

The average value of quicklime sold was essentially unchanged at $46.46 per ton. Values were $45.88 for chemical lime, $49.02 for lime used in agriculture, $54.88 for construction lime, and $60.24 for refractory dead-burned dolomite.

The average value of hydrated lime sold increased less than $2.00 to $67.56 per ton. Values were $65.96 for both chemical lime and lime used in agriculture and $69.32 for construction lime.

FOREIGN TRADE

U.S. exports of lime decreased 22% to 19,400 tons. Of the total exports, Canada received 79%, Guyana received 6%, and Mexico received 5%. The remaining 10% went to 33 countries.

Imports, principally from Canada, 84%, and Mexico, 16%, were 194,057 tons, a decrease of 22%.

Table 6.—U.S. exports of lime

	Quantity (short tons)	Value (thousands)
1982	22,541	$3,199
1983	28,154	4,815
1984	24,714	6,805
1985	19,383	5,155

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of lime

	Hydrated lime		Other lime		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1982	60,108	$3,305	288,266	$13,503	348,374	$16,808
1983	58,811	3,431	223,752	11,345	282,563	14,776
1984	59,906	3,669	187,579	9,722	[1]247,484	13,391
1985	48,827	3,407	145,230	8,810	194,057	12,217

[1]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—The Government agency Department of Energy, Mines and Resources, Ottawa, Canada, reported preliminary statistics on Canadian lime production at 2.2 million tons valued at $137 million. Of the total, 2.0 million tons was quicklime and 0.2 million tons was hydrated lime. Canada imported 17,500 tons of lime from the United States and exported 158,000 tons, primarily to the United States. The principal consumers of lime in Canada were the steel, paper and pulp, and mining industries. Markets for lime use in environmental control were insignificant.

Japan.—Total lime production in Japan was approximately 10.5 million tons in 1984, including 8.5 million tons of quicklime and 2.0 million tons of hydrated lime. Usage was 53% for iron and steel manufacture, 26% for chemical purposes, 10% for construction and agriculture, and 11% for other uses. Since 1979, lime had been used in Japan as a "nonexplosive demolition agent." An example of this use was in the demolition of old buildings; rock and concrete structures were broken without using any explosives. In iron and steel manufacture, preliminary treatment of melting pig iron became more common, employing a lime flux for desilication, desulfurization, and dephosphorization.

[1]Physical scientist, Division of Industrial Minerals.
[2]Pit & Quarry. V. 77, No. 11, 1985, pp. 32-34.
[3]Dorman, W. D. Holly Sugar Sets New Shaft Kiln Standards. Pit & Quarry, v. 77, No. 11, 1985, pp. 54-56.
[4]Herod, S. Western Lime & Cement Starts New Chapter in its Growth Record. Pit & Quarry, v. 77, No. 11, 1985, pp. 41-43.

Table 8.—Quicklime and hydrated lime, including dead-burned dolomite: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	45	45	45	45	45
Australia[3]	964	[e]1,045	1,120	[e]1,100	1,100
Austria	1,140	1,132	1,257	1,391	1,430
Belgium	2,372	1,683	1,951	2,392	1,540
Brazil[e]	5,500	5,500	5,500	5,500	5,500
Bulgaria	1,938	1,958	1,801	1,682	1,760
Burundi	([4])	([4])	([4])	([4])	([4])
Canada	2,816	2,422	2,460	2,498	[5]2,200
Chile	714	711	797	858	880
Colombia[e]	1,430	1,430	1,430	1,430	1,430
Costa Rica[e]	8	10	11	11	11
Cuba	154	[r]161	169	166	165
Cyprus	12	[r]12	9	[e]9	8
Czechoslovakia	3,565	3,404	3,417	3,436	[5]3,557
Denmark (sales)	[r]109	109	119	141	142
Dominican Republic[e]	44	44	44	44	44
Egypt	101	[e]105	103	[e]107	107
Fiji Islands	5	4	[e]3	[e]3	3
Finland	422	396	379	[e]390	390
France	3,710	3,300	3,247	3,450	3,300
German Democratic Republic	3,793	3,869	3,812	3,965	4,000
Germany, Federal Republic of	8,726	7,604	7,574	7,651	7,700
Guatemala	27	[e]27	30	56	56
Hungary	834	[r]932	906	907	[5]880
India[e]	440	440	440	[r]550	550
Iran[e]	550	600	700	700	700
Ireland	51	51	[r] [e]65	75	80
Israel	88	55	45	[e]55	55
Italy	2,543	2,389	2,228	[e]2,300	2,200
Jamaica	146	126	134	127	127
Japan (quicklime only)	8,848	8,573	8,197	8,547	8,160
Jordan	22	66	294	247	247
Kenya	[e]30	24	38	23	40
Korea, Republic of[e]	220	220	220	220	220
Kuwait	24	11	[r] [e]15	17	17
Lebanon	[5]67	55	22	11	11
Libya	259	248	287	[e]287	300
Malawi	([6])	2	2	2	2
Malta	7	8	6	[e]6	6
Martinique[e]	[5]6	6	6	6	6
Mauritius	8	8	[e]8	[e]8	8
Mexico[e]	[5]4,960	4,400	4,000	4,400	4,400
Mongolia[e]	55	65	70	72	80
Mozambique[e]	11	11	11	11	11
Nepal[e]	11	11	11	[5]8	[5] [7]8
New Zealand[e]	190	190	180	165	175
Nicaragua[e]	33	6	[5]5	3	[5]4
Norway[e]	145	145	145	145	110
Paraguay	63	59	81	94	90
Peru[e]	[5]37	40	40	40	40
Philippines	94	73	56	55	50
Poland	4,607	4,476	4,543	4,686	4,500
Portugal[e]	[r] [5]300	[r]275	250	220	230
Romania	4,125	4,180	3,994	[e]4,100	4,100
Saudi Arabia[e]	190	[r]190	10	[r]12	13
South Africa, Republic of (sales)	2,380	2,232	2,085	2,325	[5]2,220
Spain	1,158	[e]1,200	[e]1,100	1,199	1,200
Sweden	[r]718	[r]649	681	[r] [e]680	680
Switzerland	63	51	47	45	45
Taiwan	[r]198	[r]152	145	130	115
Tanzania[e]	7	7	[5]3	3	3
Tunisia	514	[e]550	640	[e]660	660
Turkey	1,000	1,000	1,100	[e]1,100	1,100
Uganda	[r]93	[r]82	455	[r] [e]550	550
U.S.S.R	31,306	31,636	32,520	32,520	32,520
United Arab Emirates[e]	45	45	50	50	50
United Kingdom[e]	[r]2,750	[r]2,750	[r]2,750	[r]2,750	2,750
United States including Puerto Rico (sold or used by producers)	18,890	14,112	14,902	15,956	[5]15,713
Uruguay	[e]55	15	11	9	9
Venezuela	2	2	[e]2	[e]2	2

See footnotes at end of table.

Table 8.—Quicklime and hydrated lime, including dead-burned dolomite: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Yugoslavia	2,826	2,657	2,810	[r] [e]2,850	2,750
Zaire	136	114	118	121	121
Zambia	221	204	213	256	255
Total	[r]128,921	[r]120,364	121,919	125,630	123,531

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 24, 1986.
[2]Lime is produced in many other countries besides those listed. Argentina, China, Iraq, Pakistan, and Syria are among the more important countries for which official data are not available.
[3]Data are for years ending June 30 of that stated.
[4]Less than 1/2 unit.
[5]Reported figure.
[6]Revised to "Not available." General information is inadequate to formulate a reliable estimate of output, if any.
[7]Data are for year ending mid-July of that stated.

Lithium

By James P. Searls[1]

The United States remained the world's largest producer of lithium minerals and chemicals, although the two domestic producers reduced production. Estimated consumption declined, despite a very significant increase in imports, primarily because of a decrease in demand for lithium carbonate by the aluminum smelting industry. Exports also decreased, and producers' stocks increased. Estimated world production increased because of significant increases in Australian and Canadian production of lithium ores and Chilean production of lithium carbonate from brines.

Domestic Data Coverage.—Domestic production data for lithium are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the two operations to which a survey request was sent, both responded, representing 100% of total production. However, production and stock data were withheld from publication to avoid disclosing company proprietary data.

Table 1.—Salient lithium statistics

(Short tons of contained lithium)

	1981	1982	1983	1984	1985
United States:					
Production[1]	W	W	W	W	W
Producers' stock changes[1]	W	W	W	W	W
Imports[2]	150	30	35	90	410
Shipments of Government stockpile surplus[3]	--	2	1	1	1
Supply[1 4]	6,900	5,000	6,000	6,600	5,500
Supply[e 5]	5,800	4,300	4,800	6,100	5,000
Exports[e 6]	2,600	2,300	2,600	2,900	2,500
Consumption:					
Apparent	W	W	W	W	W
Estimated	3,200	2,000	2,200	3,200	2,500
Rest of world: Production[e 1]	2,800	2,600	2,600	3,300	3,600

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Mineral concentrate and carbonate.
[2]Compounds, concentrate, ores, and metal.
[3]Lithium hydroxide monohydrate.
[4]Production minus inventory increase.
[5]Based primarily on monitoring at the carbonate stage and assuming a 15% lithium loss during conversion of concentrate to chemicals.
[6]Compounds.

Legislation and Government Programs.—The General Services Administration reported four sales of lithium hydroxide monohydrate from excess stocks in the National Defense Stockpile. This material was excess from a 1960's nuclear weapons program. The stockpile originally contained 46,000 short tons of material, about 75% of which was depleted of lithium 6 and possibly contained 8 to 9 parts per million of mercury. In 1985, 8 tons of depleted material was sold. At yearend, one account contained 15,885 pounds of depleted material, and a second account contained 11,500 tons of virgin material and 28,448 tons of depleted material, for a total of 39,956 tons of material.

DOMESTIC PRODUCTION

Two companies continued to produce lithium products in the United States. Foote Mineral Co., 87.5% owned by Newmont Mining Corp., mined lithium ore from a pegmatite dike in North Carolina. The ore was purified and converted to lithium carbonate and related lithium compounds. Foote also produced lithium compounds from subsurface brines in Nevada. Lithium Corp. of America (Lithco), owned by Gulf Resources & Chemical Corp. at the beginning of the year, mined lithium ore from a pegmatite dike in North Carolina. On July 19, Gulf Resources sold Lithco to FMC Corp.

Foote reported total domestic production of 9,230 tons of lithium carbonate equivalent, or 1,735 tons of contained lithium, a decrease of about 30%.[2] Foote produced downstream lithium chemicals, metal, and related products in Frazer, PA; Sunbright, VA; and New Johnsonville, TN.

CONSUMPTION AND USES

Major consumers of lithium minerals and chemicals were the aluminum, ceramics and glass, grease, and synthetic rubber industries. These markets were related primarily to transportation, i.e., the aircraft and automotive industries. Ceramics and glass were also used in industrial and consumer applications. The decrease in estimated consumption of lithium minerals and chemicals was due primarily to permanently reduced activity in the aluminum smelting industry.

The addition of lithium carbonate to the cryolite bath in aluminum potlines was the largest end use for lithium. The lithium carbonate converts to lithium fluoride, which lowers the melting point of the bath, allowing a lower operating pot temperature, as well as increasing the electrical conductivity of the bath. These changes allowed more flexibility to the operators of the potlines to either increase production, reduce power consumption, or increase current efficiency.

As an additive in ceramics and glass, the second largest end use, lithium lowers melting points, reduces the coefficient of thermal expansion, and replaces toxic compounds. The largest ceramics end use was in the manufacture of thermal-shock-resistant cookware. Low-iron petalite and spodumene were used for both their lithia (LiO_2) and alumina (Al_2O_3) contents.

Lithium-based greases, the third largest end use, were the preferred greases for many uses because of their low hardening point, high dropping point, and good water resistance. They were used extensively in military, industrial, automotive, aircraft, and marine applications.

Aluminum-lithium alloys were used experimentally in 1985 and had potential for greater use in the aircraft and aerospace industries because of their mechanical properties. These alloys contained 2% to 3% lithium and offered lower density, a higher elastic modulus, and excellent corrosion resistance compared with that of conventional aluminum alloys. A French firm was arranging financing for an aluminum-lithium plant at yearend. The British subsidiary of a U.S. firm announced plans to increase its lithium metal production capacity while a British aerospace firm had plans for a prototype aircraft with unspecified components of aluminum-lithium. This group of alloys face active competition from the composite materials, which use such materials as boron, graphite, or aramid fibers imbedded in plastic.

Lithium batteries, in several forms, were competing with other types of batteries in both the primary (nonrechargeable) and secondary (rechargeable) markets.

Anhydrous lithium chloride was used as a feedstock material to prepare lithium metal. Small quantities of lithium were consumed in the form of butyllithium, which was a catalyst in synthetic rubber production, and as lithium hypochlorite, which was a sanitizing agent in the food processing and bottling industries, as well as in swimming pools. Other small consumption but important lithium end uses included lithium carbonate prescribed for treatment of manic-depressive mental disorder, lithium acetate dihydrate as an ester interchange catalyst in polyester production, and lithium metal as a gas scavenger in speciality copper and copper alloy melts.

STOCKS

Yearend producers' stocks of both lithium carbonate and marketable ore increased moderately.

PRICES

Prices for the large-volume lithium products, lithium carbonate and lithium hydroxide monohydrate, declined during the year.

Table 2.—Domestic yearend producers' prices of lithium and lithium compounds

(Dollars per pound)

	1984	1985
Lithium bromide, 54% brine: 2,268-pound lots, delivered in drums	4.06	3.92
Lithium carbonate, technical: Truckload lots, delivered	1.54	1.50
Lithium chloride, anhydrous, technical: Truckload lots, delivered	3.32	3.32
Lithium fluoride	4.90	4.96
Lithium hydroxide monohydrate: Truckload lots, delivered	1.93	1.93
Lithium metal ingot, battery-grade: 1,000-pound lots, f.o.b	32.50	32.50
Lithium metal ingot, standard-grade: 1,000-pound lots, f.o.b	22.70	24.20
Lithium sulfate, anhydrous	3.09	3.21
N-butyllithium in n-hexane (15%): 3,000-pound lots, delivered	14.75	15.10

Source: U.S. lithium producers.

FOREIGN TRADE

U.S. exports of lithium carbonate decreased 23%, owing to the entrance onto the world market of the Chilean capacity in the middle of 1984. Exports of lithium hydroxide and other lithium compounds were essentially unchanged.

U.S. imports, relative to those of 1984, displayed some large changes. Imports of petalite from Zimbabwe increased by more than four orders of magnitude, and imports of spodumene from Canada increased by over 13 times. Imports of lithium carbonate from Chile increased by 262%. Lithium metal was imported from the United Kingdom for the first time.

Table 3.—U.S. exports of lithium chemicals, by compound and country

Compound and country	1984		1985	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value
Lithium carbonate:				
Argentina	57,200	$85,730	--	--
Brazil	83,039	114,949	264,475	$341,203
Canada	1,238,183	1,941,641	1,898,790	2,964,347
Colombia	--	--	2,000	4,240
France	--	--	39,600	97,218
Germany, Federal Republic of	8,819,070	10,954,569	3,921,495	4,862,449
India	33,050	52,121	25,866	40,465
Japan	4,691,902	6,803,317	5,611,356	7,709,487
Korea, Republic of	154,822	216,578	210,937	239,644
Mexico	431,520	633,692	377,181	548,249
Netherlands	132,000	174,240	153,974	199,590
New Zealand	31,240	51,154	26,409	55,075
South Africa, Republic of	46,205	69,180	80,609	129,384
Taiwan	139,592	219,464	204,250	276,050
United Arab Emirates	264,022	406,108	40,000	65,200
United Kingdom	154,013	213,767	22,000	29,260
Venezuela	1,748,006	2,476,585	1,037,414	1,444,475
Other	r44,672	r73,860	--	--
Total	18,068,536	24,486,955	13,916,356	19,006,336
Lithium hydroxide:				
Argentina	430,312	766,887	67,813	123,412
Australia	102,400	183,440	319,380	608,218
Bahamas	--	--	926	1,250
Belgium	70,400	126,720	165,440	297,792
Brazil	709,068	1,229,638	855,313	1,535,846
Canada	4,225	8,758	5,622	9,899

See footnotes at end of table.

Table 3.—U.S. exports of lithium chemicals, by compound and country —Continued

Compound and country	1984 Gross weight (pounds)	1984 Value	1985 Gross weight (pounds)	1985 Value
Lithium hydroxide —Continued				
Chile	76,084	$158,111	29,544	$54,053
Colombia	26,750	47,811	140,275	257,198
Ecuador	16,191	32,576	4,409	8,112
France	162,800	315,400	86,857	156,940
Germany, Federal Republic of	1,397,344	2,273,650	1,356,448	2,162,298
Honduras	4,400	9,020	2,075	4,510
India	440,291	612,000	331,778	555,031
Indonesia	135,000	285,492	75,000	158,529
Iran	--	--	4,409	8,025
Israel	45,686	80,949	12,043	21,219
Italy	22,000	39,600	--	--
Japan	1,899,638	3,143,978	1,741,088	3,044,939
Kenya	--	--	18,238	54,330
Korea, Republic of	110,994	169,145	116,582	216,221
Malaysia	3,799	7,024	4,200	7,686
Mexico	405,954	728,345	534,586	970,551
Netherlands	610,860	1,086,390	341,230	602,616
New Zealand	20,940	34,533	6,614	13,170
Nigeria	--	--	9,240	16,203
Pakistan	44,267	87,701	25,312	41,321
Peru	--	--	26,738	43,384
Philippines	67,100	116,413	75,633	136,322
Saudi Arabia	--	--	11,000	20,500
Singapore	101,411	190,720	118,948	216,297
South Africa, Republic of	149,610	297,187	259,678	460,063
Spain	118,800	207,840	156,200	262,108
Taiwan	91,172	144,586	74,996	134,082
Thailand	26,781	49,388	16,066	26,839
United Arab Emirates	--	--	8,576	15,750
United Kingdom	776,283	1,445,110	731,748	1,249,180
Venezuela	78,372	139,726	88,559	160,032
Yugoslavia	1,102	1,985	30,864	55,560
Other	r47,920	r87,532	--	--
Total	8,197,954	14,107,655	7,853,428	13,709,486
Other:				
Argentina	143	757	6,118	22,961
Australia	29,485	64,814	10,222	24,194
Austria	--	--	24,428	42,750
Belgium	2,160	4,578	530	64,224
Brazil	29,721	63,924	51,221	86,941
Canada	844,280	1,372,335	940,596	1,910,884
Chile	9,825	33,980	3,968	8,478
China	--	--	27,143	47,500
Colombia	13,274	25,255	7,584	12,637
Costa Rica	--	--	527	1,130
Denmark	2,485	30,033	5,830	4,628
France	33,384	94,588	42,822	171,826
Germany, Federal Republic of	879,079	1,277,981	883,906	1,241,254
India	3,086	13,401	1,096	1,700
Israel	5,235	139,984	1,687	46,075
Italy	23,255	43,357	6,157	12,085
Japan	986,107	2,006,854	530,978	1,653,141
Jordan	--	--	15,000	15,000
Korea, Republic of	133,861	203,754	83,768	118,083
Liberia	--	--	10,079	11,631
Libya	--	--	5,270	7,300
Mexico	67,131	186,307	324,759	684,533
Netherlands	219,641	279,400	181,357	242,981
Pakistan	26,734	47,420	52,575	89,530
Saudi Arabia	27	6,310	8,000	15,488
Singapore	--	--	11,983	31,827
South Africa, Republic of	8,999	31,136	5,675	9,309
Spain	4,772	4,198	--	--
Switzerland	--	--	6,500	834,000
Taiwan	121,150	170,540	3,647	31,740
Turkey	7,962	23,361	--	--
United Arab Emirates	--	--	6,360	5,049
United Kingdom	1,943,834	3,502,675	2,338,742	4,878,809
Venezuela	22,570	30,287	9,640	52,334
Yugoslavia	198	65,676	215	73,000
Other	r12,050	r41,751	--	--
Total	5,430,448	9,764,656	5,608,383	12,453,022

r Revised.

Source: Bureau of the Census.

Table 4.—U.S. imports for consumption of lithium-bearing materials, by commodity and country

Commodity and country	1984 Gross weight (pounds)	1984 Value (thousands) Customs	1984 Value (thousands) C.i.f.	1985 Gross weight (pounds)	1985 Value (thousands) Customs	1985 Value (thousands) C.i.f.
Lithium ores:						
Australia[1]	119,049	$15	$20	164,794	$20	$23
Canada[1]	180,000	9	9	2,596,545	314	314
Peru	62	1	1	--	--	--
Zimbabwe	124	3	3	6,670,868	841	940
Total	r299,235	r28	r33	9,432,207	1,175	1,277
Lithium compounds:						
Australia	4,198	35	39	--	--	--
Belgium	2,197	6	7	4,933	4	4
Canada	3,425	36	36	--	--	--
Chile	750,014	842	891	2,713,783	3,468	3,655
China	100,200	138	151	18	1	2
Denmark	50	3	3	--	--	--
France	6,131	765	770	13,820	1,712	1,722
Germany, Federal Republic of	42,594	292	305	45,503	150	160
Japan	91	25	26	3,379	137	141
Mexico	15	1	1	--	--	--
Switzerland	15	(2)	(2)	--	--	--
United Kingdom	15,117	81	85	21,923	85	90
Total[3]	924,047	2,226	2,313	2,803,359	5,557	5,774
Lithium salts:						
Chile	220	(2)	1	--	--	--
France	1	(2)	(2)	--	--	--
Germany, Federal Republic of	9	4	4	--	--	--
Japan	1	(2)	(2)	--	--	--
Total[3]	231	5	5	--	--	--
Lithium metal:						
Germany, Federal Republic of	334	12	12	100	4	4
United Kingdom	--	--	--	41,503	456	466
Total	334	12	12	41,603	460	470

rRevised.
[1]Spodumene concentrate.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.
Source: Bureau of the Census as adjusted by the Bureau of Mines.

WORLD REVIEW

The separate owners of two high-grade, low-iron spodumene deposits were considering adding lithium carbonate plants at the minesites, in Canada and Australia, during the year. Also, three brine resources in South America were being considered for lithium carbonate production, given the success of the first brine operation in Chile. It was not clear, as the year ended, whether future demand would be sufficient to justify the development of additional lithium carbonate supplies.

Australia.—A feasibility study was expected to be completed by January 1986 on a proposed 11-million-pound-per-year Li_2CO_3 plant that would use Greenbushes Tin Ltd. (GTL) spodumene as the raw material. A 15-year initial mining plan was developed, based on spodumene reserves of 3.3 million tons containing 4.0% Li_2O. The joint venture partners, GTL, Metallgesellschaft AG, and C. Itoh & Co. Ltd., were expected to reach a decision in mid-1986.[3] Meanwhile, GTL was exporting low-iron spodumene to the ceramics and glass industries.

Austria.—Mineral Exploration GmbH continued exploration of the Koralpe pegmatite deposit. Reserve estimates increased to 11 million tons of spodumene grading 1.6% Li_2O.[4] Flotation tests demonstrated that concentrates of 6% Li_2O could be obtained.

Bolivia.—The Bolivian Congress created a state agency, Complejo Industrial de los Recursos Evaporíticos del Salar de Uyuni (CIRESU), to manage development of the Salar de Uyuni, a potential source of lithium, potassium, and boron compounds.[5] CIRESU was authorized to explore, exploit, industrialize, and market through contracts, joint ventures, and partnerships. Drilling was also scheduled for the Laguna Colorda area in the southwestern corner, near the Chilean border, to outline a geothermal resource as an electricity generating site. This potential source of electricity, required for any industrialization of the Salar de Uyuni, is about 150 kilometers south of the salar. The $11.5 million funding for the drilling was supplied by the United Nations Development Program and the Government of Italy.

Canada.—In 1984, the Tantalum Mining Corp. of Canada Ltd. (TANCO) began producing a low-iron ceramic-grade spodumene concentrate. In 1985, TANCO started construction of a $6.4 million ore processing plant at its Bernic Lake, Manitoba, mine.[6] The plant, with design capacity of 22,000 tons per year of spodumene concentrate, was scheduled to be finished in mid-1986.

Chile.—The Government-owned Corporación de Fomento de la Producción (CORFO), Molibdenos y Metales S.A. (a private Chilean firm), and AMAX Inc. (a multinational U.S. firm) formed a joint venture, Minera Salar de Atacama (MINSAL), to study the feasibility of a second production site on the Salar de Atacama.[7] Initial production of potash and boric acid was proposed pending expiration of Foote's exclusive right to produce lithium carbonate. The Foote and CORFO joint venture, Sociedad Chilena de Litio Ltda., completed its first full year of lithium carbonate production and announced plans to study the feasibility of increasing capacity to 20 million pounds per year.[8]

France.—Pechiney obtained financing for its planned aluminum-lithium alloy plant near Issoire, south of Clermont-Ferrand.[9] The facility was planned to produce 3,800 tons per year of alloys starting in 1987.

Japan.—Lithco entered into a joint venture with Honjo Chemical Co. for the manufacture of lithium chemicals in Japan.[10] Since 1960, the companies had cooperated in marketing U.S. produced lithium chemicals to Japan. Initial production of n-butyllithium was expected in mid-1986, with other products to be added as required.

United Kingdom.—Lithium Corp. of Europe, a subsidiary of Lithco, announced an expansion of production capacity for lithium chloride and metallic lithium at the Liverpool (Bromborough) plant.[11] The expansion anticipated growth in demand, primarily from the aircraft industry, for aluminum-lithium alloys. British Aerospace Ltd. planned to have an experimental craft with aluminum-lithium components in the air in 1986.[12] The experiment is a first step toward development of the "European Fighter Aircraft," a five-country program for joint production and use by 1995. The A-5J *Vigilante* of the U.S. Navy was the first airplane built with aluminum-lithium skin on its wings for weight reduction.

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[1]Physical scientist, Division of Industrial Minerals.
[2]Foote Mineral Co. 1985 10-K Report. FMC Corp., the new owner of Lithco, did not report specific lithium data in its 1985 10-K report.
[3]Greenbushes Tin Ltd. (Australia). Quarterly Report. Fourth quarter ending June 30, 1985, p. 2.
[4]Mining Magazine. Mining in Austria. V. 153, No. 4, 1985, p. 294.
[5]———. Bolivian Geothermal Project. V. 153, No. 2, 1985, p. 89.
[6]Metal Bulletin (London). TANCO To Reopen—But Not for Tantalum. No. 6994, 1985, p. 15.
[7]Industrial Minerals (London). Lithium Reserves and the Chilean Factor. No. 215, 1985, p. 19.
[8]Mining Journal (London). SCL Lithium Expansion Plans. V. 305, No. 7825, 1985, p. 103.
[9]Metal Bulletin (London). Pechiney Lithium Finance Agreed. No. 7033, 1985, p. 15.
[10]Lithium Corp. of America. News Release. Gastonia, NC, Sept. 11, 1985.
[11]Metals Week. Lithco Expanding Capacity in Europe. V. 56, No. 14, 1985, p. 6.
[12]Metal Bulletin (London). Lithium Alloys Take to the Air. No. 6988, 1985, p. 19.

Table 5.—Lithium minerals and brine: World production, by country[1]

(Short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina (minerals not specified)	28	125	168	24	22
Australia, spodumene[3]	--	[e]90	1,100	7,200	[4]12,300
Brazil:					
Amblygonite	305	73	125	54	83
Lepidolite	2	82	1	([5])	--
Petalite	2,293	2,528	2,086	526	550
Spodumene	268	376	128	317	330
Canada, spodumene[e 6]	--	--	--	90	1,200
Chile (carbonate from subsurface brine)	--	--	--	2,326	[4]4,969
China (minerals not specified)[e 7]	15,400	15,400	16,500	16,500	16,500
Namibia (minerals not specified)	1,392	1,146	860	970	2,160
Portugal, lepidolite	990	[r]998	601	[e]660	720
Rwanda, amblygonite[e]	([5])	--	--	--	--
U.S.S.R. (minerals not specified)[e 7]	60,600	60,600	60,600	60,600	60,600
United States, spodumene and subsurface brine	W	W	W	W	W
Zimbabwe (minerals not specified)	18,126	10,788	21,157	25,270	27,700

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 20,1986.
[2]In addition to the countries listed, other nations may produce small quantities of lithium minerals, but output is not reported and no valid basis is available for estimating production levels.
[3]Data are for years ending June 30 of that stated.
[4]Reported figure.
[5]Revised to zero.
[6]Estimates from U.S. imports from Canada.
[7]These estimates denote only an approximate order of magnitude; no basis for more exact estimates is available. Output by China and the U.S.S.R. has never been reported.

Magnesium

By Deborah A. Kramer[1]

Both domestic production and consumption of primary magnesium in 1985 decreased from those of 1984, owing principally to a decline in demand for magnesium for aluminum alloying. Magnesium alloy manufacturers continued to introduce high-purity versions of conventional alloys, which led to an increased demand for magnesium in structural applications in the automotive and aerospace industries. The United States remained a net exporter of magnesium, although both exports and imports of magnesium materials declined.

Domestic Data Coverage.—Domestic consumption data for magnesium metal are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the 159 operations to which a survey request was sent, 82% responded, representing 88% of the primary magnesium consumption shown in tables 1 and 3. Consumption for the 28 nonrespondents was estimated using reported prior year consumption levels.

Table 1.—Salient magnesium statistics

(Short tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production:					
Primary magnesium	153,782	102,197	115,431	159,207	149,614
Secondary magnesium	46,256	43,232	46,329	r48,357	45,523
Exports	34,855	39,613	46,690	48,337	40,322
Imports for consumption	6,897	4,784	6,350	9,381	9,271
Consumption, primary	91,461	74,599	81,976	r89,887	83,502
Price per pound	$1.25-$1.34	$1.34	$1.38	$1.43-$1.48	$1.48-$1.53
World: Primary production	r339,731	r279,568	286,204	p360,236	e360,504

eEstimated. pPreliminary. rRevised.

Legislation and Government Programs.—The Environmental Protection Agency issued final regulations under the Clean Water Act for specified nonferrous metals forming operations. These regulations limit the discharge of pollutants by existing and new operations into navigable waters and into publicly owned water treatment works. Effluent discharges from magnesium operations were to be regulated for ammonia, chromium, fluoride, and zinc contaminants. Daily and monthly effluent limits for these contaminants varied according to type of operation and effluent source.[2]

DOMESTIC PRODUCTION

Primary magnesium production was about 80% of annual capacity. Three companies produced primary magnesium metal: AMAX Magnesium Corp., Rowley, UT; The Dow Chemical Co., Freeport, TX; and Northwest Alloys Inc., a subsidiary of Aluminum Co. of America, Addy, WA. AMAX and Dow produced magnesium from natural brines by the electrolytic process, and Northwest Alloys produced metal from dolomite using the silicothermic process.

Dow announced plans to spend $40 million to modernize its magnesium and aluminum production facilities over the next 3 years. Although the modernization at Dow's Freeport plant will not increase production capacity, the company intended to improve energy efficiency, labor productivity, raw material yields, and product quality through the use of new production and foundry technology.

Interstrat Resources Inc., a Vancouver, Canada-based firm, obtained financing to begin a feasibility study on its Pine Flat Mountain magnesium-nickel-cobalt-chromium property on the California-Oregon border. The feasibility study was to be conducted by Davy McKee Corp. and was expected to concentrate on the following areas: geology and geostatistical analysis, mining, process development, engineering, and environmental impact. Reserves at the Pine Flat Mountain laterite deposit were estimated to be over 25 million short tons grading 24.5% magnesium oxide, 0.78% nickel, 0.61% cobalt, and 1.13% chromium. Davy McKee prepared a preliminary evaluation, which indicated that a 4,000-ton-per-day processing complex could produce 80,000 tons of magnesium metal, 12,000 tons of nickel, 1,000 tons of cobalt, and 20,000 tons of chromium annually, for a minimum 10-year mine life. The study stated that such a plant would cost $230 million.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1981	1982	1983	1984	1985
KIND OF SCRAP					
New scrap:					
Magnesium-base	2,833	2,455	2,873	r3,192	1,664
Aluminum-base	19,240	17,346	18,718	r18,402	17,915
Total	22,073	19,801	21,591	r21,594	19,579
Old scrap:					
Magnesium-base	5,593	5,314	5,311	r5,232	5,104
Aluminum-base	18,590	18,117	19,427	21,531	20,840
Total	24,183	23,431	24,738	r26,763	25,944
Grand total	46,256	43,232	46,329	r48,357	45,523
FORM OF RECOVERY					
Magnesium alloy ingot[1]	4,230	4,228	4,232	r4,229	4,231
Magnesium alloy castings (gross weight)	806	746	952	r980	483
Magnesium alloy shapes	13	--	--	--	--
Aluminum alloys	38,755	36,587	39,451	r41,072	39,459
Zinc and other alloys	9	11	20	r12	9
Chemical and other dissipative uses	55	3	4	r9	3
Cathodic protection	2,388	1,657	1,670	r2,055	1,338
Total	46,256	43,232	46,329	r48,357	45,523

rRevised.
[1]Includes secondary magnesium content of both secondary and primary alloy ingot.

CONSUMPTION AND USES

Primary magnesium consumption declined from that of 1984, chiefly owing to a decrease in consumption for the major end use, aluminum alloying. Although total demand decreased, magnesium consumption for structural uses, principally diecasting and extrusions, and as a reducing agent for titanium increased significantly. Primary magnesium demand for iron and steel desulfurization was estimated to be 8,000 tons.

Automobile manufacturers continued to replace some aluminum parts with magnesium components. Ford Motor Co. announced that it intended to use die-cast magnesium transfer case housings for its 1987 model year F-Series pickup trucks and full-size Bronco vehicles. The transfer cases, weighing about 14 pounds, will replace 21-pound aluminum transfer cases and were expected to increase domestic magnesium consumption by 2 to 2.5 million pounds per year. Magnesium clutch housings, similar to those used in the 1984 models of Ford's Ranger II and Bronco trucks, were expected to be installed in Ford's compact-size Aerostar vans.

Photoengraving Inc. reportedly substituted magnesium for zinc on its steel-backed dry offset printing plates used in printing preformed packaging. Advantages of the magnesium plate include sharper printed image, longer plate life, reduced cost of etching solution, and faster etching time.[3]

Tracor MBA, a subsidiary of Tracor Inc., reportedly began production of atomized magnesium powder at its Camden, AR, plant. Initially, the company planned to use the powder in production of infrared flares, but expected to market the powder when production reached 500 pounds per day.

Oregon Metallurgical Corp. installed four additional electrolytic cells at its Albany, OR, facility to recover magnesium from magnesium chloride generated during titanium sponge production at a cost of $1.8 million. Space was provided for an additional eight cells. The 4 completed cells increased the company's total to 25, with a recovery capacity of 3,500 tons of magnesium per year.

Increased demand for magnesium was the reason for Dow's decision to add a third extrusion press and expand its manufacturing facility at Aurora, CO. The expansion reportedly will increase Dow's extruding capacity by nearly one-third.

Table 3.—U.S. consumption of primary magnesium, by use

(Short tons)

Use	1981	1982	1983	1984	1985
For structural products:					
Castings:					
Die	2,812	1,600	1,937	[r]595	2,457
Permanent mold	917	663	16	1,666	909
Sand	1,222	1,337	1,388	1,932	1,634
Wrought products:					
Extrusions	5,786	7,059	7,093	5,828	7,756
Sheet and plate	4,547	2,981	4,313	[r]4,378	4,182
Other (includes forgings)	43	88	29	40	11
Total	15,327	13,728	14,776	[r]14,439	16,949
For distributive or sacrificial purposes:					
Alloys:					
Aluminum	50,518	39,878	46,026	[r]48,673	40,850
Copper	5	7	4	4	4
Zinc	9	3	3	[r]4	3
Other	7	3	--	--	1
Cathodic protection (anodes)	6,449	5,964	5,686	[r]4,777	4,748
Chemicals	5,315	4,823	5,664	[r]5,501	3,824
Nodular iron	3,755	2,541	2,200	[r]2,408	1,698
Reducing agent for titanium, zirconium, hafnium, uranium, beryllium	9,071	5,901	4,711	6,689	8,126
Other[1]	1,005	1,751	2,906	7,392	7,299
Total	76,134	60,871	67,200	[r]75,448	66,553
Grand total	91,461	74,599	81,976	[r]89,887	83,502

[r]Revised.
[1]Includes scavenger, deoxidizer, and powder.

STOCKS

Consumer stocks of primary magnesium ingot declined from 6,920 tons (revised) at yearend 1984 to 6,168 tons at yearend 1985. Stocks of magnesium alloy ingot decreased from 585 tons (revised) at yearend 1984 to 428 tons at yearend 1985. Primary producer stocks of magnesium rose from 27,116 tons at yearend 1984 to 36,736 tons at yearend 1985.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States

(Short tons)

	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
1984:[r]						
Cast scrap	1,222	5,597	363	5,232	5,595	1,224
Solid wrought scrap[1]	41	694	694	--	694	41
Total	1,263	6,291	1,057	5,232	6,289	1,265
1985:						
Cast scrap	1,224	5,078	15	5,104	5,119	1,183
Solid wrought scrap[1]	41	430	439	--	439	32
Total	1,265	5,508	454	5,104	5,558	1,215

[r]Revised.
[1]Includes borings, turnings, drosses, etc.

PRICES

At the beginning of the year, the price for primary magnesium ingot was quoted by Dow and AMAX at $1.48 per pound and remained at that level until early December. At that time, Dow announced an increase of its price to $1.53 per pound, effective December 9 for noncontract customers and as terms permit for contract customers. AMAX also announced that it would increase its primary ingot price to match Dow's, effective January 1, 1986. At yearend, the quoted price for primary magnesium ingot was $1.48 to $1.53 per pound.

Diecasting alloy producer prices were quoted at $1.26 to $1.30 per pound at the beginning of 1985. Along with price increases for primary ingot, Dow increased its price for diecasting alloy from $1.30 to $1.40, effective December 9, and AMAX increased its price from $1.26 to $1.29, effective January 1, 1986. Dow later announced a price reduction to $1.33 effective January 20. At yearend, the prices quoted by the producers for diecasting alloy were $1.26 to $1.40. Both companies cited increased production costs as the reason for the price hikes. These were the first price increases announced since July 1984.

FOREIGN TRADE

Exports of magnesium declined 17% in both quantity and value from those of 1984. Japan and the Netherlands continued to be the primary destinations, together accounting for 55% of U.S. exports. The United States remained a net exporter of magnesium.

Magnesium imports in 1985 decreased slightly from those of 1984, both in quantity and value. Canada and Norway were the primary import sources, together accounting for 54% of the total.

Table 5.—U.S. exports and imports for consumption of magnesium

Year	EXPORTS					
	Waste and scrap		Metals and alloys in crude form		Semifabricated forms, n.e.c.	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983	638	$1,681	43,992	$111,988	2,060	$11,045
1984	1,249	3,362	44,880	120,804	2,208	12,495
1985	795	2,071	37,484	100,128	2,043	11,401

Year	IMPORTS FOR CONSUMPTION							
	Waste and scrap		Metal		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, other forms (magnesium content)	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983	1,935	$2,537	2,034	$4,637	2,143	$6,151	238	$2,939
1984	2,160	3,656	3,136	8,604	3,596	10,791	489	2,620
1985	2,874	4,778	1,992	5,525	3,651	12,774	754	2,010

Source: Bureau of the Census.

Table 6.—U.S. exports of magnesium, by country

Country	Waste and scrap		Primary metals, alloys		Semifabricated forms, n.e.c., including powder	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1984						
Argentina	--	--	580	$1,498	23	$101
Australia	--	--	2,045	5,246	227	1,095
Austria	--	--	404	1,170	13	259
Belgium-Luxembourg	--	--	--	--	17	169
Brazil	--	--	344	903	3	18
Canada	688	$1,578	4,910	13,328	595	2,043
China	--	--	1,390	3,887	--	--
Colombia	--	--	59	166	3	17
Egypt	--	--	--	--	10	31
France	(1)	2	(1)	1	49	859
Germany, Federal Republic of	225	559	469	1,557	30	338
India	--	--	109	307	11	49
Israel	--	--	2	11	57	328
Italy	--	--	26	78	107	1,013
Japan	59	10	12,042	28,856	106	802
Korea, Republic of	38	113	297	821	1	22
Mexico	90	232	2,920	7,541	132	609
Netherlands	30	62	17,759	50,707	481	1,624
New Zealand	--	--	54	130	1	23
Norway	--	--	43	769	4	59
Saudi Arabia	--	--	1	3	10	22
Singapore	94	765	38	142	10	30
South Africa, Republic of	--	--	612	1,694	45	277
Spain	--	--	--	--	31	337
Sweden	--	--	3	7	36	288
Taiwan	22	21	122	375	11	54
United Kingdom	(1)	13	139	420	144	1,541
Venezuela	--	--	326	589	1	11
Other	3	7	186	598	r50	r476
Total	1,249	3,362	44,880	120,804	2,208	12,495

See footnotes at end of table.

Table 6.—U.S. exports of magnesium, by country —Continued

Country	Waste and scrap		Primary metals, alloys		Semifabricated forms, n.e.c., including powder	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1985						
Argentina	--	--	240	$634	8	$43
Australia	--	--	1,710	3,960	269	1,433
Austria	--	--	308	916	6	78
Belgium-Luxembourg	--	--	53	157	15	93
Brazil	--	--	131	326	2	19
Canada	377	$875	4,880	12,805	684	2,462
China	--	--	3,132	8,326	--	--
Colombia	--	--	24	63	37	98
Egypt	--	--	386	1,048	2	4
France	1	2	--	--	17	414
Germany, Federal Republic of	325	1,005	139	442	29	334
India	--	--	505	1,382	3	20
Israel	--	--	5	34	44	221
Italy	--	--	3	16	83	739
Japan	9	8	11,149	28,602	177	1,017
Korea, Republic of	--	--	354	1,054	91	396
Mexico	19	45	2,462	6,350	162	878
Netherlands	--	--	10,773	30,609	39	212
New Zealand	--	--	36	87	1	21
Norway	--	--	109	293	6	68
Saudi Arabia	--	--	7	30	23	59
Singapore	--	--	2	3	30	63
South Africa, Republic of	--	--	429	1,219	37	156
Spain	--	--	21	10	14	213
Sweden	--	--	6	15	12	172
Taiwan	--	--	225	664	19	43
United Kingdom	64	136	11	65	141	1,523
Venezuela	--	--	127	333	1	15
Other	--	--	257	685	91	607
Total	795	2,071	37,484	100,128	2,043	11,401

[r]Revised.
[1]Less than 1/2 unit.

Source: Bureau of the Census.

Table 7.—U.S. import duties for magnesium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1985	Jan. 1, 1987	Jan. 1, 1985
Unwrought metal	628.55	12% ad valorem	8% ad valorem	100% ad valorem.
Unwrought alloys	628.57	6.7% ad valorem	6.5% ad valorem	60.5% ad valorem.
Wrought metal	628.59	5 cents per pound on magnesium content plus 2.8% ad valorem.	4.5 cents per pound on magnesium content plus 2.5% ad valorem.	40 cents per pound on magnesium content plus 20% ad valorem.

WORLD REVIEW

Canada.—Norsk Hydro A/S, based in Norway, planned to construct a 55,000-ton-per-year primary magnesium plant in Bécancour, Quebec, at a cost of $220 million. The company reportedly awarded a contract for the feasibility study on plant construction, and construction was expected to begin in the first half of 1989. Norsk initially expected to use imported magnesium oxide as a raw material for the process, but planned to develop raw material production in Quebec in the future. Norsk planned to market the magnesium in the United States and chose Canada rather than the United States for the plantsite because of lower energy prices. The location in Canada also would reduce the company's shipping costs of exporting magnesium to the United States from Norway.[4]

Webster Manufacturing Ltd., a wholly owned subsidiary of CAE Industries Ltd., was awarded a long-term $70 million contract by General Motors Corp. (GM) to manufacture die-cast magnesium steering column brackets for the new GM W-body car. Construction of a new facility in Strathroy, Ontario, to house new diecasting machines, a tool-and-die shop, and a machine shop was expected to begin late in the year.

China.—The China National Nonferrous Metals Industry Corp. reportedly planned to import magnesium technology and equipment to modernize its primary magnesium plant in Qinghai Province. Most of the magnesium in China is used for titanium production.

India.—Tamil Nadu Chemical Products Corp. of Madras reportedly planned to construct a primary magnesium plant with a 600-ton-per-year capacity in Valinokkam, Ramanathapuram District. Because India's annual magnesium demand of about 1,500 to 2,000 tons was met almost exclusively from imports, domestic production of the metal was expected to reduce costs. Construction of the new plant, which would be the first in the world to use sea bitterns as a raw material, was expected to begin in late 1987.

Japan.—Primary magnesium demand in Japan was almost 24,000 tons in 1985, an increase of 4% from that of 1984. Imports of over 17,000 tons supplied most of this demand, with 72% of the imports received from the United States and 20% from Norway. Exports from Japan were about 2,800 tons, and 75% of this material was exported to the U.S.S.R. Over one-half of the magnesium demand in Japan was for rolled products.[5]

Table 8.—Magnesium: World primary production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Brazil	--	--	--	1,100	2,200
Canada[e]	[2]9,370	8,700	6,600	8,800	7,700
China[e]	7,700	7,700	7,700	7,700	7,700
France	8,006	10,593	12,208	14,299	14,300
Italy	[r]11,900	[r]10,960	8,473	8,257	[2]8,667
Japan	6,247	6,123	6,643	7,830	[2]9,323
Norway	52,472	39,598	32,897	54,343	60,000
U.S.S.R.[e]	86,000	89,000	91,000	94,000	96,000
United States	153,782	102,197	115,431	159,207	[2]149,614
Yugoslavia	4,254	4,697	5,252	[e]4,700	5,000
Total	[r]339,731	[r]279,568	286,204	360,236	360,504

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 3, 1986.
[2]Reported figure.

Table 9.—Magnesium: World secondary production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Japan	31,345	23,887	14,343	17,258	23,000
U.S.S.R.[e]	9,000	9,000	9,000	9,000	9,000
United Kingdom	2,100	1,940	[r] [e]1,900	([2])	NA
United States	46,256	43,232	46,329	[r] 48,357	[3]45,523
Total	88,701	78,059	71,572	74,615	77,523

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 3, 1986.
[2]Revised to not available.
[3]Reported figure.

TECHNOLOGY

Scientists at Dow developed wear-resistant prototype components, primarily for the automotive industry, manufactured from a magnesium-alumina composite material. Because of their poor wear resistance, magnesium alloys generally are not used in applications where two surfaces rub together. By a proprietary mixing technique, 1% to 10% alumina, by weight, was added to molten AZ91 magnesium alloy, and the resulting composite was cast using standard techniques for die or permanent mold castings. The added alumina provides wear resistance and does not increase the weight of the casting significantly. Several components, including an oil pump and camshaft cover and a cog-tooth timing belt pulley, reportedly were developed and were tested under actual operating conditions.[6]

Dow introduced a high-purity version of its diecasting alloy, AM60, that was used in some automotive wheels and in archery bows and fishing rod handles. Dow maintained that the high-purity alloy, which minimizes contaminants such as copper, iron, and nickel, has corrosion resistance that is equal to or better than comparable aluminum alloys. High-purity AM60 reportedly has better elongation and impact properties than other diecasting compositions, and it increases Dow's line of high-purity alloys, including AZ91D, a diecasting alloy, and AZ91C/HP, a sand-casting alloy.

Researchers at Magnesium Elektron Ltd. in the United Kingdom reportedly developed a new casting alloy WE54 primarily for applications in the aerospace industry. The new alloy, which was designed to improve temperature stability and elevated temperature properties of conventional magnesium alloys, was composed of magnesium, yttrium, neodymium, and zirconium. Special melting techniques were devised for this alloy, because it could not be melted using conventional fluxes without high yttrium losses. Possible applications for WE54 include components for airframes, engines, flight equipment, weapons, and high-performance automobiles.[7]

A die-cast magnesium insert permitted driving a military vehicle up to 30 miles at 30 miles per hour with two of its four tires deflated. The insert was developed for the U.S. Army's aluminum body, 1-1/4-ton, 4-by-4 high-mobility multipurpose wheeled vehicle (Hummer), and it resembles an additional wheel within the tire and is mounted on the rim. Over the next 5 years, 55,000 Hummers were scheduled to be built, and all were expected to be equipped with the insert.[8]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Federal Register. Nonferrous Metals Forming and Metal Powders Point Source Category; Copper Forming Point Source Category; Effluent Limitations Guidelines; Pretreatment Standards, and New Source Performance Standards. V. 50, No. 164, Aug. 23, 1985, pp. 34242-34334.

[3]Pennington, N. Magnesium Structural Uses Show New Growth Potential. Mod. Met., v. 41, No. 1, Feb. 1985, pp. 51-64.

[4]Kolrud, J. Norsk Hydro Looks To Expand Into North America. Met. Bull. Mon. (London), No. 180, Dec. 1985, p. 69.

[5]Japan Metal Journal. V. 16, No. 13, Mar. 13, 1986, p. 9.

[6]Shook, S. Prototype Evaluation of Reinforced Magnesium Composite Parts. Paper in Proc. 42d Annual World Magnesium Conference, New York, NY (May 19-21, 1985). Int. Magnesium Assoc., Dayton, OH, 1985, pp. 19-25.

[7]Unsworth B., and J. King. Foundry Alloys Evolve To Meet Aerospace Demands. Met. Bull. Mon. (London), No. 180, Dec. 1985, pp. 74-77.

[8]Work cited in footnote 3.

Magnesium Compounds

By Deborah A. Kramer[1]

Magnesium compounds shipped or used by producers in 1985 declined dramatically from those of 1984. Shipments of caustic-calcined magnesia declined to their lowest level in 20 years, and refractory magnesia shipments reached their lowest level in more than 40 years. Over the past 3 years, imported material supplied an increasingly greater share of the domestic magnesium compound demand. The increased reliance on imports was due, in part, to the strength of the U.S. dollar.

Natural brines continued to be the dominant source of domestically produced magnesium compounds. Magnesium oxide and other compounds were produced from seawater by five companies in California, Delaware, Florida, and Texas; from well brines by three companies in Michigan; and from lake brines by two companies in Utah. Magnesite was mined by one company in Nevada, and olivine was mined by two companies in North Carolina and Washington.

Domestic Data Coverage.—Domestic data for magnesium compounds shipped and used are developed by the Bureau of Mines from a voluntary survey of U.S. operations entitled "Magnesium Compounds." Of the 18 operations to which a survey request was sent, 83% responded, representing 59% of the total magnesium compounds shipped and used shown in table 3. Data for the three nonrespondents were estimated using prior year production levels and other factors.

Table 1.—Salient magnesium compound statistics

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Caustic-calcined and specified magnesias:[1]					
Shipped by producers:[2]					
Quantity	160	148	143	r142	100
Value	$58,420	$56,363	$57,416	r$42,257	$33,772
Exports: Value[3]	$14,559	$10,925	$8,426	$14,026	$9,773
Imports for consumption: Value[3]	$2,177	$2,055	$5,476	$9,594	$10,407
Refractory magnesia:					
Shipped by producers:[2]					
Quantity	616	453	456	374	290
Value	$146,903	$112,101	$98,473	$87,945	$81,149
Exports: Value	$4,727	$2,721	$1,955	$3,641	$5,529
Imports for consumption: Value	$22,990	$14,162	$11,495	r$23,715	$29,767
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	435	337	418	487	p411
Value	$23,789	$19,136	$24,454	$29,391	p$24,804
World: Production (magnesite)	r12,478	r12,554	12,253	p13,121	e13,208

eEstimated. pPreliminary. rRevised.

[1]Excludes caustic-calcined magnesia used in the production of refractory magnesia.

[2]Includes magnesia used by producers.

[3]Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Seawater and well and lake brines continued to be the primary source of domestically produced magnesium compounds. Magnesium compounds also were recovered from magnesite and dolomite.

As part of a restructuring plan, Kaiser Aluminum & Chemical Corp. sold its refractories division, including its seawater plant at Moss Landing, CA, to a group of the company's employees. A new company was reorganized under the name National Refractories & Minerals Corp. to operate the plant.

Olivine was mined from deposits in North Carolina and Washington. Shipments declined significantly to about one-half those of 1984. Olivine was ground to various grades for consumption by the foundry, refractory, and steel industries.

National Olivine Corp., Dillsboro, NC, filed for bankruptcy late in 1984, and all the company's equipment and property was sold in May 1985. The State was suing for enough money to finance the property reclamation, which was estimated to cost at least $75,000. National Olivine had property leases in the Buck Creek area, which reverted to Appalachian Resources Inc.

Table 2.—Magnesium compound producers, by raw material source, location, and production capacity in 1985

Raw material source and producing company	Location	Capacity (short tons of MgO equivalent)
Magnesite: Basic Inc	Gabbs, NV	150,000
Lake brines:		
Great Salt Lake Minerals & Chemicals Corp	Ogden, UT	100,000
Kaiser Aluminum & Chemical Corp	Wendover, UT	50,000
Well brines:		
The Dow Chemical Co	Ludington, MI	300,000
Do	Midland, MI	75,000
Martin Marietta Chemicals	Manistee, MI	350,000
Morton Chemical Co	do	5,000
Seawater:		
Barcroft Co	Lewes, DE	5,000
Basic Magnesia Inc	Port St. Joe, FL	100,000
The Dow Chemical Co	Freeport, TX	75,000
Merck & Co. Inc	South San Francisco, CA	15,000
National Refractories & Minerals Corp	Moss Landing, CA	150,000
Total		1,375,000

CONSUMPTION AND USES

Most of the domestic magnesium compound production was used in the manufacture of refractory products such as refractory brick. Magnesia and magnesia-based bricks were used primarily by the iron and steel industry for furnace linings. Demand for refractory magnesia fell moderately during the past 3 years; however, total shipments of refractory magnesia decreased rapidly and in 1985 were less than 64% of those of 1982. Consequently, domestic demand was met, in part, by an increase in imports over the past 3 years.

Total shipments of caustic-calcined and specified magnesias decreased to about 70% of those of 1984. These compounds were used in diverse industries including agriculture, chemical processing, and construction. Animal feed, accounting for 36% of the total shipments of caustic-calcined magnesia, was the largest consuming industry in 1985. Representing 31% of the total domestic shipments of caustic-calcined magnesia were, in declining order, the sectors of ceramics, petroleum additives, stack-gas scrubbing, and rayon. The following uses, in declining order, accounted for the remaining 33% of the total shipments: rubber, refractories, chemical, oxychloride and oxysulfate cements, electrical heating rods, insulation and wallboard, water treatment, sugar and candy, medicine and pharmaceuticals, fertilizer, foundry, uranium processing, and pulp and paper.

Table 3.—U.S. magnesium compounds shipped and used

	1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Caustic-calcined[1] and specified (USP and technical) magnesias	r141,634	r$42,257	99,517	$33,772
Magnesium hydroxide (100% $Mg(OH)_2$)[1]	r356,985	r41,400	263,712	68,975
Magnesium sulfate (anhydrous and hydrous)	49,776	13,214	55,863	14,813
Precipitated magnesium carbonate[1]	r5,194	r875	3,746	702
Refractory magnesia	374,280	87,945	290,271	81,149

rRevised.

[1]Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

PRICES

Yearend prices for magnesium compounds, published in the Chemical Marketing Reporter, did not change from those published at yearend 1984. Prices for magnesium compounds at yearend 1985 were as follows: magnesia, natural, technical, heavy, 85% and 90% (f.o.b. Nevada), $232 and $265 per short ton, respectively; magnesium chloride, hydrous, 99%, flake, $290 per ton; magnesium carbonate, light, technical (freight equalized), $0.73 to $0.83 per pound; magnesium hydroxide, National Formulary (NF), powder (freight equalized), $0.78 per pound; and magnesium sulfate, technical, $0.115 per pound.

FOREIGN TRADE

Exports of crude and processed magnesite decreased slightly in quantity from those of 1984. Canada remained the primary destination, but its share of the U.S. export market for magnesium compounds declined dramatically from 76% in 1984 to 53% in 1985.

Table 4.—U.S. exports of magnesite and magnesia, by country

Country	Magnesite and magnesia, dead-burned				Magnesite, n.e.c., including crude caustic-calcined, lump or ground			
	1984		1985		1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	--	--	562	$180	54	$48
Australia	--	--	--	--	135	186	469	260
Belgium-Luxembourg	--	--	--	--	444	448	414	310
Brazil	--	--	--	--	42	97	58	165
Canada	14,439	$3,273	16,391	$3,704	23,115	8,032	8,277	3,191
Colombia	1,208	147	1,511	216	129	155	72	101
France	--	--	--	--	220	174	5,761	1,800
Germany, Federal Republic of	--	--	--	--	544	423	447	351
Israel	--	--	--	--	1,132	789	973	505
Italy	--	--	--	--	315	349	137	124
Korea, Republic of	--	--	--	--	325	233	249	182
Mexico	--	--	6	1	1,047	398	804	545
Netherlands	--	--	--	--	663	r507	557	472
New Zealand	--	--	172	82	88	r131	30	45
Saudi Arabia	327	62	2,872	525	--	--	--	--
Spain	--	--	--	--	227	235	107	68
Sweden	809	83	--	--	197	145	270	188
Taiwan	22	3	38	5	3	121	172	104
United Kingdom	--	--	--	--	133	180	125	193
Venezuela	--	--	3,306	893	2,265	999	2,444	895
Other	r470	r73	509	103	r467	r244	147	226
Total	17,275	3,641	24,805	5,529	32,053	14,026	21,567	9,773

rRevised.

Source: Bureau of the Census.

Total imports of crude and processed magnesite were at their highest level in more than 30 years, increasing more than 15% over those of 1984. For caustic-calcined magnesia, Canada remained the largest import source, accounting for about 62% of the total quantity. Four countries, China, Greece, Ireland, and the United Kingdom, accounted for about 74% of the total quantity of U.S. imports of dead-burned magnesia. In addition, other magnesium compounds valued at more than $10 million were imported.

Table 5.—U.S. import duties for magnesium compounds

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Crude magnesite	522.61	65 cents per ton	Free	$10.50 per ton.
Caustic-calcined magnesite	522.64	$2.10 per ton	$2.10 per ton	$21.00 per ton.
Refractory magnesia (containing not over 4% lime).	531.01	0.17 cent per pound.	0.16 cent per pound.	0.75 cent per pound.
Refractory magnesia (containing over 4% lime).	531.04	6% ad valorem	6% ad valorem	30% ad valorem.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by country

Country	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Lump or ground caustic-calcined magnesia:[1]				
Australia	--	--	296	$52
Canada	r30,126	$5,961	40,937	7,482
China	r1,574	157	5,871	415
Czechoslovakia	r2,900	184	2,755	175
Greece	r7,448	1,026	4,831	756
Japan	r497	24	--	--
Mexico	r926	108	2,111	274
Spain	r6,503	1,537	7,441	905
Turkey	r4,801	566	1,323	300
Other	r118	r31	144	48
Total	r54,893	9,594	65,709	10,407
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4% lime:				
Brazil	9,573	1,528	3,161	444
China	30,556	4,138	44,478	5,274
Greece	48,844	7,056	37,793	5,874
Ireland	13,984	3,569	24,729	6,822
Japan	8,129	2,550	15,049	3,964
Mexico	6,345	1,667	6,684	1,772
Netherlands	7,209	1,806	4,947	1,347
South Africa, Republic of	552	273	122	601
United Kingdom	3,337	424	25,870	3,345
Other	1,255	r704	717	324
Total	129,784	r23,715	163,550	29,767
Containing over 4% lime:				
Austria	3,739	976	2,981	733
Belgium-Luxembourg	--	--	115	37
Canada	18,352	1,007	11,239	1,267
Germany, Federal Republic of	547	131	533	160
Greece	2,205	290	--	--
Mexico	394	34	736	94
United Kingdom	141	33	20	4
Other	--	--	33	13
Total	25,378	2,471	15,657	2,308
Total dead-burned and grain magnesia and periclase	155,162	r26,186	179,207	32,075

rRevised.
[1]In addition, crude magnesite was imported as follows, in short tons and thousand dollars: 1984—Australia, 119 (revised) ($30); Canada, 45 (revised) ($9); the Federal Republic of Germany, 20 ($7); Japan, 556 (revised) ($184); Mexico, 12 ($1); and the United Kingdom, 6 ($1). 1985—Austria, 20 ($6); Canada, 49 ($12); the Federal Republic of Germany, 22 ($6); Italy, 1,234 ($300); Japan, 19 ($7); and the United Kingdom, 6 ($1).

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate[1] (precipitated)		Magnesium chloride (anhydrous)		Magnesium chloride (other)		Magnesium sulfate (epsom salts and kieserite)		Magnesium salts and compounds, n.s.p.f.[2]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983	6,725	$5,355	185	$235	15	$11	1,761	$282	39,405	$2,539	1,938	$1,358
1984	6,121	4,918	284	395	63	17	2,987	347	34,255	2,621	2,443	1,738
1985	4,891	5,638	247	351	125	21	2,975	368	25,691	1,902	2,822	1,805

[1]In addition, magnesium carbonate, not precipitated, was imported as follows, in short tons and thousand dollars: 1983—12 ($28); 1984—33 ($63); and 1985—110 ($125).
[2]Includes magnesium silicofluoride or fluosilicate and calcined magnesia.

Source: Bureau of the Census.

WORLD REVIEW

Australia.—Queensland Metal Corp. NL reportedly discovered a large shallow magnesite deposit in central Queensland estimated to contain over 500 million tons of material, with a mean grade of 44.2% magnesium oxide. A prefeasibility study was conducted by Fluor Australia Pty. Ltd. to assess geology, magnesite processing, magnesium metal production, mining, and marketing. Because this is a shallow deposit, it was expected that low-cost surface mining methods may be suitable for ore recovery. Construction of a 110,000-ton-per-year dead-burned magnesia plant was expected to begin in late 1986 or early 1987.[2]

China.—A West German firm, Krupp Polysius AG, and an Austrian company, Refractories Consulting and Engineering GmbH, were expected to begin construction of a magnesite sintering plant in May 1986. The plant, with an annual capacity of 55,000 tons, was to be constructed in Liaoning Province for the Liaoning Magnesite Co.'s Haicheng Mine. Plant completion was scheduled for 1988.

Egypt.—The Egyptian Salt and Minerals Co. planned to construct a plant to recover mineral salts from Lake Quarun in Fayoum Province. The plant, scheduled to be completed in 1988 at a cost of $80 million, will have an annual capacity of 45,000 tons of magnesium oxide and also was expected to produce sodium chloride, sodium sulfate, and sodium sulfide.

Greece.—Grecian Magnesite Ltd. S.A. planned to invest $20 million to improve the efficiency of its magnesite operations. The investment reportedly included expanding the company's annual capacity for dead-burned and caustic-calcined magnesites from 220,000 to 300,000 tons. Improvement of transportation and storage facilities and development of new products also were scheduled as part of the company's modernization plan.

Mining Trading and Manufacturing Ltd. also announced that it will modernize its plants and increase production capacity. The company, which produced both raw and caustic-calcined magnesites, intended to replace equipment and increase annual production from 65,000 to 75,000 tons.[3]

Japan.—In April 1985, Asahi Glass Co. began commercial production of high-purity magnesium oxide and magnesium hydroxide from seawater. The company reportedly constructed a plant to produce 3,000 tons per year of 99.1% magnesium hydroxide and 2,000 tons per year of 99.6% magnesium oxide. High-purity magnesium hydroxide is used primarily as a flame retardant filler material, and high-purity magnesium oxide has applications as a resin filler for use in electronics, in ceramics, and as an optical glass material.[4]

Pakistan.—A joint venture between the Pakistan Industrial Development Corp. and the Al-Ghurair business house of the United Arab Emirates to construct a magnesia refractories plant was planned. Magnesite from the Hazara division of Pakistan was expected to provide the raw material for the 17,000-ton-per-year plant.

Spain.—A review of the magnesite and dolomite producers was published. Caustic-calcined and dead-burned magnesites were produced by three companies. Magnesitas Navarras S.A. had an annual capacity of 65,000 tons of caustic-calcined magnesite and 70,000 tons of dead-burned magnesite at its plant in Zubiri. Magnesitas de Rubián S.A. produced caustic-calcined magnesite for the agricultural market at its 75,000-ton-per-year plant in Monte Castelo. The third producer, Magnesitas Españolas S.A. mined a small quantity of crude magnesite at its operation in Puerto de la Cruz Verde. Spain was a net exporter of magnesite, although special grades of magnesia, such as seawater magnesia for magnesia-carbon bricks and fused magnesite, were imported.[5]

Yugoslavia.—A 27,000-ton-per-year magnesium oxide sintering plant reportedly began full-scale production in late January at Kraljevo, Serbia. The plant, owned by Magnohrom, refined low-grade ore into 99% magnesium oxide.

Table 8.—Magnesite: World production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Australia	29,151	32,707	24,267	[r] [e]28,000	28,000
Austria	1,277,414	1,136,927	1,108,668	1,304,484	1,312,000
Brazil[2]	314,055	248,607	254,634	259,043	259,000
Canada[e] [3]	76,000	75,000	74,000	76,000	75,000
China[e]	2,200,000	2,200,000	2,200,000	2,200,000	2,200,000
Colombia[e]	1,800	1,800	1,800	1,800	1,800
Czechoslovakia	732,000	740,752	729,729	728,000	739,000
Greece	[r]1,060,072	[r]1,066,051	981,618	1,173,111	1,200,000
India	499,798	448,718	478,482	456,388	463,000
Iran[e] [4]	4,400	5,500	5,500	5,500	5,500
Kenya	[r]11	--	NA	343,098	330,000
Korea, North[e]	2,095,000	2,095,000	2,095,000	2,095,000	2,095,000
Mexico	13,357	24,793	25,559	33,537	33,000
Nepal	[e]22,000	[e]22,000	16,552	16,097	16,500
New Zealand	340	([5])	--	--	--
Pakistan	1,710	[r]1,276	2,202	4,105	5,300
Poland	12,436	[r]18,739	17,747	[e]18,000	18,000
South Africa, Republic of	62,343	35,193	24,868	36,441	28,300
Spain	525,132	588,187	658,230	762,294	717,000
Turkey	[r]864,167	[r]1,013,653	792,698	797,261	800,000
U.S.S.R.[e]	2,290,000	2,370,000	2,400,000	2,400,000	2,400,000
United States	W	W	W	W	W
Yugoslavia	330,336	362,060	335,064	359,353	[6]459,663
Zimbabwe	66,352	[r]66,866	26,534	23,856	22,000
Total	[r]12,477,874	[r]12,553,829	12,253,152	13,121,368	13,208,063

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1]Figures represent crude salable magnesite. In addition to the countries listed, Bulgaria produced magnesite, but output is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels. Table includes data available through May 6, 1986.

[2]Series reflects output of marketable concentrates. Production of crude ore was as follows, in short tons: 1981—681,228; 1982—556,667; 1983—535,723; 1984—551,000 (estimated); 1985—551,000 (estimated).

[3]Magnesitic dolomite and brucite. Figures are estimated on the basis of reported tonnage dollar value.

[4]Year beginning Mar. 21 of that stated.

[5]Revised to zero.

[6]Reported figure.

TECHNOLOGY

A description of Veitscher Magnesitwerke AG's underground magnesite mine in Brietenau, Austria, was included in a review of the Austrian mining industry. A room-and-pillar system was used for mining the ore, and then the ore was crushed and sintered in a rotary kiln or shaft kiln before being sold. Average annual production for this mine was estimated to be about 500,000 tons.[6]

Mining methods and processing of olivine at A/S Olivin's operation at Aaheim, Norway, were reviewed. Olivin reportedly supplied almost one-half of the world's 5-million-ton olivine demand.[7]

An overview of the fused minerals industry was published, including a discussion of the production, consumption, and uses of fused magnesia. Fused magnesia was used primarily in electrical insulation and refractory applications. Magnesia-alumina spinel material ($MgAl_2O_4$) for refractory applications was produced by fusing high-purity magnesia and Bayer alumina.[8]

[1]Physical scientist, Division of Nonferrous Metals.
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Manganese

By Thomas S. Jones[1]

World production of manganese ore increased to possibly the highest level since the peak year of 1980. Ore production rose in several market economy countries, with Gabon reaching a record high output. U.S. production consisted only of some manganiferous material for brick coloring. There were no U.S. imports of ore from the Republic of South Africa for the first time since shortly before World War II.

Prices of manganese materials were generally static, as supply capabilities continued to exceed demand. Price changes were insignificant both for the increase in price of metallurgical ore on international markets and the decrease in price of ferromanganese imported into the United States.

Further evolution of the manganese potential of the Carajás region of Brazil was marked by the beginning of exports of metallurgical ore. Projects were also under way there for production of manganese ferroalloys, metal, and chemicals in plants to be fed with Carajás ore.

U.S. consumption of ferromanganese decreased by about the same moderate extent as the decline in domestic raw steel production. The rate of manganese consumption in steelmaking also decreased slightly. The U.S. Government extended through 1986 its contract for upgrading ore in the National Defense Stockpile into high-carbon ferromanganese. This program continued aid to a domestic industry that still consisted of only two firms in 1985. Statistics on world production of manganese ferroalloys are presented in the "Ferroalloys" chapter.

Domestic Data Coverage.—Domestic production data for manganese are developed by the Bureau of Mines from three separate, voluntary surveys of U.S. operations. Typical of these surveys is the "Manganese and Manganiferous Ores" survey. Of the four operations to which a survey request was sent, all responded, representing 100% of the total production shown in table 3.

Table 1.—Salient manganese statistics

(Thousand short tons)

	1981	1982	1983	1984	1985
United States:					
Manganese ore (35% or more Mn):					
Imports for consumption	639	238	368	338	387
Consumption	1,077	609	531	[r]615	[e]545
Manganiferous ore (5% to 35% Mn):					
Production (shipments)	175	32	34	88	20
Ferromanganese:					
Production	193	119	86	W	W
Exports	15	10	8	7	7
Imports for consumption	671	493	342	409	367
Consumption	821	439	446	492	466
World: Production of manganese ore	[r]25,967	[r]26,701	24,190	[p]26,027	[e]26,922

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—Continuing the program of upgrading stockpiled metallurgical manganese ore into high-carbon ferromanganese, the General Services Administration (GSA) in August extended through December 31, 1986, its stockpile upgrading contract with Elkem Metals Co. Under the extension, 58,600 tons[2] of ore was to be converted into ferromanganese at an estimated cost of $15.3 million. GSA suspended sales of excess materials from the stockpile on October 1 to comply with a statutory restriction prohibiting such sales when the balance in the National Defense Stockpile Transaction Fund exceeds $250 million. Natural battery and metallurgical manganese ore were among the excess stockpile materials for which offers for disposal were withdrawn until further notice. Sales prior to the suspension and changes in stockpile inventories of manganese materials in 1985 are shown below. The change for medium-carbon ferromanganese was just an inventory adjustment.

Material	Sales (short tons)		Change in yearend inventory (short tons)
	Stockpile grade	Nonstockpile grade	
Natural battery ore	4,000	--	-6,317
Chemical ore	--	--	-18,977
Metallurgical ore	--	--	-165,431
Medium-carbon ferromanganese	--	--	+137

Table 2.—U.S. Government stockpile goals and yearend inventories for manganese materials in 1985

(Short tons)

Material	Stockpile goals	Physical inventory, Dec. 31				
		Uncommitted			Sold, pending shipment	Grand total[1]
		Stockpile grade	Nonstockpile grade	Total		
Natural battery ore	62,000	171,593	33,561	205,154	6,648	211,802
Synthetic manganese dioxide	25,000	3,011	--	3,011	--	3,011
Chemical ore	170,000	171,717	89	171,806	1,732	173,539
Metallurgical ore	2,700,000	2,279,408	942,679	3,222,087	168,061	3,390,148
High-carbon ferromanganese	439,000	624,310	--	624,310	--	624,310
Medium-carbon ferromanganese	--	29,057	--	29,057	--	29,057
Silicomanganese	--	23,574	--	23,574	--	23,574
Electrolytic metal	--	14,172	--	14,172	--	14,172

[1]Data may not add totals shown because of independent rounding.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, manganese would be categorized in tier II, and the goal would be about 870,000 tons of manganese metal equivalent. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The Environmental Protection Agency (EPA) determined in August that the then-present ambient air concentrations of manganese did not pose a significant risk to public health; therefore, regulation directed specifically at manganese was unnecessary at that time under the Clean Air Act. This determination was without effect on existing regulation of particulate matter and did not preclude State and/or local air pollution control agencies from specifically regulating manganese emission sources.[3] EPA also issued a compilation of information on the ways in which manganese may be emitted into the atmosphere from various industrial sources and the potential for manganese release from each source.[4]

The U.S. Congressional Office of Technology Assessment (OTA) ranked manganese within a first group of strategic materials for the United States, along with chromium, cobalt, and the platinum-group metals. OTA concluded that the best prospect for reducing U.S. manganese import vulnerability was through improved steel production technology that would lower the amount of manganese required per ton of steel. OTA also concluded that the potential for reducing uncertainty about supply from the Republic of South Africa was good because of the existence of several alternative suppliers.[5]

Under the Trade and Development Program of its International Development Cooperation Agency, the U.S. Department of State conducted a symposium at which possibilities were suggested for joint Brazilian-U.S. ventures in manganese. Two potential ferromanganese operations were identified, one in the Carajás region of north-central Brazil and the other near Corumba in southwestern Brazil near its borders with Bolivia and Paraguay.

DOMESTIC PRODUCTION

Ore and Concentrate.—No manganese ore, concentrate, or nodules containing 35% or more manganese or ferruginous manganese ores or concentrates containing from 10% to 35% manganese were produced or shipped in the United States. The only mineral production of material containing 5% or more manganese was that mined in Cherokee County, SC, by brick manufacturers or contractors for use in coloring brick. This material consisted of manganiferous schist, clay, or other earthy material associated with the manganiferous member of the Battleground Schist of the Kings Mountain area. The manganese content ranged from 5% to 15% and averaged less than 10%.

Table 3.—Manganiferous ore shipped[1] in the United States, by type and State

(Short tons unless otherwise specified)

Type and State	1984		1985	
	Gross weight	Manganese content	Gross weight	Manganese content
Ferruginous manganese ore (10% to 35% Mn, natural):				
Minnesota	68,019	8,754	--	--
Manganiferous iron ore (5% to 10% Mn, natural):				
South Carolina[2]	20,404	1,799	19,882	1,882
Total	88,423	10,553	19,882	1,882
Value	$860,226	XX	W	XX

W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Shipments are used as the measure of manganiferous ore production for compiling U.S. mineral production value.
[2]Miscellaneous ore.

Ferroalloys and Metal.—Production continued to be generally slack. Operations were curtailed late in the summer at the Marietta, OH, plant of Elkem Metals by a labor dispute that lasted nearly 1 month. The Kingwood, WV, facility of Chemetals Inc. was disabled by a flood on November 4 and was out of production for the rest of the year.

Ownership structure was changed for both manganese ferroalloys producers. Elkem Metals became a wholly owned subsidiary of Elkem A/S of Norway in the first half of the year. Elkem acquired the 10% share in Elkem Metals held by the Jebsen Group of Norway in March, and then in May acquired the remaining outstanding 23% share in Elkem Metals held by a group of four Norwegian companies. Details of organizational changes within the Belgian parent of Chemetals are given under "Belgium" in the "World Review" section of this chapter.

SKW Alloys Inc. announced it will continue to market manganese ferroalloys in the United States but will produce only a limited amount of silicomanganese. SKW Alloys had been producing ferromanganese and silicomanganese at Calvert City, KY, until production workers there began a strike in September 1983 that lasted throughout 1985. The company said that after the strike ended it would produce silicomanganese again, but only until manganese ore on hand or committed for was consumed.

Production quantities tabulated for manganese ferroalloys are net production for shipment outside the producing ferroalloy facility, and do not include that portion of gross production recycled to the furnaces, used as an intermediate in producing medium- or low-carbon ferromanganese, or lost in the plant.

Table 4.—Domestic producers of manganese products in 1985

Company	Plant location	Products[1] FeMn	SiMn	Mn	MnO_2	Type of process
Chemetals Inc:						
Chemicals Div	Baltimore, MD	--	--	--	X	Chemical.
Metals Div	Kingwood, WV	X	--	--	--	Fused-salt electrolytic.
Elkem Metals Co	Marietta, OH	X	X	X	--	Electric furnace and electrolytic.
Foote Mineral Co	New Johnsonville, TN.	--	--	--	X	Electrolytic.
Kerr-McGee Chemical Corp	Hamilton, MS	--	--	X	--	Do.
Do	Henderson, NV	--	--	--	X	Do.
RAYOVAC Corp: ESB Materials Co.	Covington, TN	--	--	--	X	Do.
Union Carbide Corp	Marietta, OH	--	--	--	X	Do.

[1]FeMn, ferromanganese; SiMn, silicomanganese; Mn, electrolytic manganese metal; MnO_2, synthetic manganese dioxide.

Table 5.—Ferromanganese and silicomanganese produced and shipped in the United States and manganese ore consumed in their manufacture

(Thousand short tons, gross weight, unless otherwise specified)

Year	Ferromanganese: Production: Gross weight	Ferromanganese: Production: Manganese content (average percent)	Ferromanganese: Shipments	Silicomanganese: Production	Silicomanganese: Shipments	Manganese ore consumed[1]: Total quantity	Manganese ore consumed[1]: Per ton of ferromanganese and silicomanganese made
1981	193	80	188	173	173	743	2.0
1982	119	82	98	69	83	412	2.2
1983	86	81	109	W	63	283	W
1984	W	82	W	W	W	W	W
1985	W	81	W	W	W	W	W

W Withheld to avoid disclosing company proprietary data.
[1]Containing 35% or more manganese (natural); includes ore used in producing manganese metal.

CONSUMPTION, USES, AND STOCKS

Ironmaking and Steelmaking.—The average rate at which manganese was consumed as manganese ore in making pig iron or equivalent hot metal decreased to 0.9 pound per ton of raw steel. This rate was calculated from an estimated consumption of 90,000 tons of manganese ore containing more than 35% manganese, all of foreign origin, in iron blast furnaces and production of 88.3 million tons of raw steel ingots, continuous- or pressure-cast blooms, billets, slabs, etc. Data were not available for the quantity of domestic manganiferous iron ore containing 5% to 10% manganese also consumed in iron blast furnaces. The quantity of manganese ore containing 35% or more manganese used directly in steelmaking was reportedly negligible.

Unit manganese consumption in steelmaking as ferroalloys and metal decreased slightly to approximately the 1983 level. For reported consumption in the production of 89.1 million tons of raw steel and steel castings in 1985, the pounds of manganese consumed per ton of raw steel was 7.7 as ferromanganese, 1.5 as silicomanganese, and 0.1 as metal, for a total of 9.3. In 1984, the corresponding unit consumption in production of 93.5 million tons of raw steel and steel castings totaled 9.5, of which ferromanganese accounted for 7.9; silicomanganese, 1.4; and metal, 0.2.

Table 6.—U.S. consumption and industry stocks of manganese ore,[1] by use

(Short tons)

Use	Consumption 1984	Consumption 1985	Stocks, Dec. 31 1984	Stocks, Dec. 31 1985
Manganese alloys and metal	W	W	257,698	262,664
Pig iron and steel	116,953	e90,000	96,679	e78,940
Dry cells, chemicals, miscellaneous[2]	W	W	227,890	247,008
Total	r615,311	e545,000	582,267	e588,612

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Containing 35% or more manganese (natural).
[2]Natural ore, including that consumed in making synthetic manganese dioxide.

Table 7.—U.S. consumption, by end use, and industry stocks of manganese ferroalloys and metal in 1985

(Short tons, gross weight)

End use	Ferromanganese: High carbon	Ferromanganese: Medium and low carbon	Ferromanganese: Total	Silicomanganese	Manganese metal
Steel:					
Carbon	290,105	67,725	357,830	76,343	2,903
Stainless and heat-resisting	12,483	(1)	12,483	3,228	1,543
Full alloy	26,000	8,379	34,379	13,653	908
High-strength, low-alloy	26,765	7,441	34,206	5,642	626
Electric	(1)	(1)	(1)	(1)	(1)
Tool	275	(1)	275	(1)	101
Unspecified	156	536	692	660	61
Total steel	355,784	84,081	439,865	99,526	6,142
Cast irons	15,345	973	16,318	2,583	W
Superalloys	130	W	130	W	196
Alloys (excluding alloy steels and superalloys)	946	W	946	W	[2]17,630
Miscellaneous and unspecified	7,989	294	8,283	2,669	537
Total consumption	380,194	85,348	465,542	104,778	24,505
Total manganese content[3]	297,000	68,000	365,000	69,000	24,500
Stocks, Dec. 31	82,829	17,035	99,864	14,207	5,271

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified" where applicable.
[1]Withheld to avoid disclosing company proprietary data; included with "Steel: Unspecified."
[2]Partly based on data of the Aluminum Association Inc.; not directly comparable with data prior to 1984.
[3]Estimated based on typical percent manganese content (rounded).

Battery and Miscellaneous Industries.—Duracell Inc., RAYOVAC Corp., and Union Carbide Corp. all announced significant performance improvements in their alkaline batteries that use synthetic manganese dioxide. Such batteries captured a larger share of both civilian and military battery markets from carbon-zinc dry cells. Synthetic dioxide also was blended with natural ore in carbon-zinc cells and used in specialized chemical applications. Foote Mineral Co. became the fifth domestic producer of synthetic dioxide by starting commercial production of electrolytic manganese dioxide (EMD) at its plant in New Johnsonville, TN, in November. Output at the design capacity rate of 10,200 tons per year was achieved in December. This culminated a $16.9 million program in which part of a plant that had produced electrolytic manganese metal from 1968 to 1983 was converted into a computerized EMD facility equipped with titanium anodes.

Union Carbide sold the welding and cutting systems business of its Linde Div. to L-Tec Co., a new limited partnership affiliated with Integrated Resources Inc. of New York City. Property at Niagara Falls, NY, where manganese-containing welding fluxes are manufactured was included in the sale.

In June, a year-old strike by production workers ended at Carus Chemical Co., LaSalle, IL, a producer of potassium permanganate.

N. K. Industries Inc., a new company in Phenix City, AL, began grinding manganese ore for applications in the brick industry.

PRICES

Manganese Ore.—Prices depend primarily on manganese content but are also influenced by several other factors. These include other chemical constituents, physical character, quantity, delivery terms, ocean freight rates, insurance, inclusion or exclusion of duties if applicable, buyers' needs, and availability of ores having the specifications desired. Trade journal quotations reflect the editors' evaluation of the market.

The price of metallurgical ore increased by only a nominal amount. Negotiations between consumers in Japan and in Western Europe were again drawn out and extended late into the summer. Japanese consumers ended up agreeing to prices averaging less than 1% higher overall for a contract volume about the same as that of 1984. The price averaged over the year for delivery to West European ports was barely 1% greater than that of 1984. The average price, c.i.f. U.S. ports, for metallurgical ore containing 48% manganese was $1.43 per long ton unit, compared with $1.42 in 1984; per metric ton unit, these prices were $1.41 and $1.40, respectively. These prices convert to 6.4 and 6.3 cents per pound of manganese in ore, respectively.

Manganese Ferroalloys.—A published list price for domestically produced high-carbon ferromanganese with a minimum manganese content of 78% was not available. The price of comparable imported high-carbon ferromanganese averaged less than 1% lower than that of 1984. For most of 1985, the quoted price was the same as that at yearend 1984, $325 to $335 per long ton of alloy, f.o.b. Pittsburgh or Chicago warehouse, although a peak of $335 to $345 had been reached early in February. A final price of $320 to $330 applied as of late October. The price of imported silicomanganese containing 2% carbon generally declined throughout 1985 to average 10% less than that of 1984. For this material, the price per pound of alloy, f.o.b. warehouse, started 1985 at 18 to 20 cents and ended the year at 15.5 to 16.5 cents. For the same grade of domestically produced silicomanganese, the only price published was 23.5 cents per pound of alloy, f.o.b. producer, a price unchanged from that set in July 1984.

Manganese Metal.—Electrolytic metal from domestic suppliers was quoted throughout 1985 at 80 cents per pound for bulk shipments, f.o.b. shipping point. This price had been reached late in November 1984.

FOREIGN TRADE

Reported ore exports were presumed to be mostly metallurgical ore obtained from excess Government stocks except for about 13,000 tons of reexports shipped to Canada. About 4,000 tons of ore shipped to Mexico plus about two-thirds of that shipped to destinations other than Mexico and Canada apparently was imported manganese dioxide ore possibly ground, blended, or otherwise classified in the United States. Reported reexports of ore, all apparently metallurgical grade, totaled 20,587 tons, destinations of which included 15,568 tons to Mexico and 4,962 tons to Canada. Exports of ferromanganese and silicomanganese remained insignificant compared with imports of these ferroalloys. Exports of manganese metal increased about one-fourth over those of 1984.

Gabon and Brazil were the leading sources of ore imports, each with about one-third of the total. No receipts were reported from the Republic of South Africa for the first time since 1938. Average grade of imported ore remained nearly the same at 48.8%. The quantity of manganese imported as ore and dioxide was approximately 50% of that imported as ferroalloys and metal. Imports of manganiferous ore consisted of only 15 tons from Mexico having an average manganese content of 30%.

Imports of ferromanganese decreased about one-tenth overall from those of 1984, and the average manganese content of all ferromanganese imports declined from 78.6% to 78.2%. Record high imports of silicomanganese were about one-fifth greater than in 1983-84, with those from the Republic of South Africa triple the 1984 quantity from that country. Imports of unwrought manganese metal receded from the 1984 record high to about the 1978-81 import level.

Reported imports for consumption of spiegeleisen were 270 tons, composed of 188 tons from the Federal Republic of Germany having relatively high unit value and 82 tons from Canada.

Imports of manganese dioxide increased 5% over those of 1984 to another record high, although the value of dioxide imports decreased slightly as overall average unit value declined. All but 83 tons were apparently synthetic dioxide for battery or chemical applications. Imports of other manganese chemicals included 165 tons of manganese sulfate, consisting of 114 tons from Belgium-Luxembourg, 29 tons from Japan, 19 tons from the Federal Republic of Germany, and 4 tons from the United Kingdom. Those from Japan and the Federal Republic of Germany had relatively high unit value. Imports for consumption of potassium permanganate increased to 1,499 tons, of which the principal sources were Spain, 1,091 tons; China, 207 tons; and the German Democratic Republic, 191 tons.

Tariffs.—Under section 201(b) of the Trade Act of 1974, the International Trade Commission determined on April 8 that increased imports of potassium permanganate were not a substantial cause or threat of serious injury to the domestic potassium permanganate industry. Carus Chemical, the petitioner and sole domestic producer of potassium permanganate, was thereby precluded from possible import relief under section 203 of the Trade Act of 1974.

Table 8.—U.S. exports of manganese ore, ferroalloys, and metal, by country

(Gross weight)

Country	1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ore and concentrates containing 5% or more manganese:				
Canada	54,859	$4,225	23,977	$1,530
France	109,664	6,300	--	--
Italy	38,181	2,212	--	--
Mexico	25,987	1,705	30,020	2,379
Other	8,915	1,201	2,043	377
Total	237,606	15,643	56,040	4,286
Ferromanganese:				
Canada	5,498	3,745	6,165	4,158
Mexico	277	241	288	241
Trinidad and Tobago	879	355	--	--
Other	110	55	474	363
Total	6,764	[1]4,397	6,927	4,762
Silicomanganese:				
Canada	123	97	2,149	904
Dominican Republic	466	243	10	9
Mexico	3,749	1,537	27	41
Trinidad and Tobago	962	345	881	373
Other	[r]34	[r]15	22	32
Total	[1]5,333	2,237	3,089	1,359
Metal including alloys and waste and scrap:				
Belgium-Luxembourg	1,015	1,460	932	1,304
Canada	280	462	429	766
Germany, Federal Republic of	40	65	400	563
Japan	1,533	2,035	1,873	2,322
Netherlands	384	493	888	1,215
Sweden	182	256	8	18
Other	[r]648	[r]1,145	632	1,054
Total	4,082	[1]5,915	5,162	7,242

[r]Revised.
[1]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census, adjusted by the Bureau of Mines.

Table 9.—U.S. imports for consumption of manganese ore, ferroalloys, metal, and dioxide, by country

Country	1984 Gross weight (short tons)	1984 Manganese content (short tons)	1984 Value (thousands)	1985 Gross weight (short tons)	1985 Manganese content (short tons)	1985 Value (thousands)
ORE AND CONCENTRATES						
35% or more manganese:						
Australia	39,689	21,005	$2,670	82,948	43,104	$4,490
Brazil	88,333	44,259	3,135	122,726	59,816	5,423
Gabon	132,985	66,135	6,898	129,360	64,093	8,240
Mexico	40,831	[1]16,298	2,122	51,708	[1]21,761	4,379
Morocco	77	[1]39	21	118	[1]65	29
South Africa, Republic of	36,179	17,286	1,178	--	--	--
Total[2]	338,094	165,023	16,024	386,859	188,840	22,561
Of which, more than 35% but less than 47% manganese: Mexico	38,028	14,897	1,975	43,698	16,842	2,422
FERROMANGANESE						
All grades:						
Australia	5,937	4,637	1,406	11,133	8,729	2,908
Belgium-Luxembourg	843	758	787	--	--	--
Brazil	9,425	7,266	2,477	11,538	8,854	2,814
Canada	2,052	1,408	352	36,562	28,275	9,270
France	123,031	96,445	33,271	117,708	91,905	33,196
Germany, Federal Republic of	24,308	19,794	11,650	10,158	8,157	3,842
Japan	2,756	2,225	1,385	212	192	213
Mexico	39,124	30,876	12,715	38,071	30,401	12,548
Norway	39,844	31,920	12,092	2,894	2,512	2,616
Portugal	17,444	13,475	3,237	5,842	4,483	1,258
South Africa, Republic of	133,708	104,497	34,599	127,591	99,121	34,013
Spain	6,320	4,972	2,587	2,243	1,892	974
Yugoslavia	4,519	3,427	1,120	2,921	2,225	738
Total[2]	409,310	321,699	117,678	366,874	286,744	104,389
Of which, 1% or less carbon:						
Belgium-Luxembourg	843	757	787	--	--	--
Canada	17	12	2	40	27	5
France	892	790	1,012	2,389	2,113	2,239
Japan	--	--	--	212	192	213
Norway	3,268	2,872	2,753	2,895	2,512	2,616
Spain	--	--	--	40	34	26
Total[2]	5,020	4,431	4,554	5,575	4,877	5,098
More than 1% to 4% or less carbon:						
Brazil	606	497	297	--	--	--
Canada	17	12	2	171	124	32
France	4,368	3,655	2,139	--	--	--
Germany, Federal Republic of	24,308	19,794	11,650	5,204	4,269	2,310
Japan	2,756	2,225	1,385	--	--	--
Mexico	15,830	12,727	7,540	20,592	16,652	8,667
South Africa, Republic of	649	527	313	2,214	1,787	966
Spain	4,976	3,980	2,347	2,203	1,858	948
Total[2]	53,509	43,419	25,674	30,383	24,689	12,923
SILICOMANGANESE						
Australia	14,181	9,344	4,096	14,762	9,774	4,420
Brazil	46,591	30,565	14,190	20,315	13,471	6,204
Canada	933	632	302	2,249	1,388	315
France	413	270	253	--	--	--
Italy	--	--	--	551	340	352
Mexico	15,447	10,311	5,002	9,656	6,358	2,855
Norway	11,854	7,680	5,137	13,635	8,948	5,075
Portugal	827	498	141	2,425	1,642	770
Romania	9,094	6,066	3,011	--	--	--
South Africa, Republic of	23,425	15,694	7,138	71,736	48,133	21,365
Spain	1,265	820	765	1,475	958	916
Sweden	--	--	--	1	1	1
Thailand[3]	--	--	--	1,320	858	600
United Kingdom	--	--	--	41	23	5
Yugoslavia	14,465	9,459	4,711	27,356	17,827	8,545
Total[2]	138,494	91,339	44,746	165,523	109,719	51,423

See footnotes at end of table.

Table 9.—U.S. imports for consumption of manganese ore, ferroalloys, metal, and dioxide, by country —Continued

Country	1984 Gross weight (short tons)	1984 Manganese content (short tons)	1984 Value (thousands)	1985 Gross weight (short tons)	1985 Manganese content (short tons)	1985 Value (thousands)
METAL						
Unwrought:						
South Africa, Republic of	13,295	XX	$12,951	8,402	XX	$8,890
Other	19	XX	27	164	XX	162
Total	13,314	XX	12,978	8,566	XX	9,052
Waste and scrap: Japan	--	XX	--	4	XX	2
DIOXIDE						
Belgium-Luxembourg	453	XX	381	439	XX	401
Brazil	788	XX	908	505	XX	612
Greece	2,600	XX	3,112	2,386	XX	2,625
Ireland	218	XX	302	933	XX	1,190
Japan	19,884	XX	25,165	19,429	XX	23,805
South Africa, Republic of	74	XX	77	1,888	XX	1,490
Other	r480	XX	r431	90	XX	31
Total[2]	24,498	XX	30,378	25,671	XX	30,154

rRevised. XX Not applicable.
[1]Includes Bureau of Mines conversion of part of reported data (from apparent MnO_2 content to Mn content).
[2]Data may not add to totals shown because of independent rounding.
[3]Country of transshipment rather than original source.

Source: Bureau of the Census, adjusted by the Bureau of Mines.

Table 10.—U.S. import duties on manganese materials

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Ore and concentrate	601.27	Free	Free	1 cent per pound Mn.
Ferromanganese:				
Low-carbon	606.26	2.4% ad valorem[1]	2.3% ad valorem	22% ad valorem.
Medium-carbon	606.28	1.4% ad valorem[1]	1.4% ad valorem	6.5% ad valorem.
High-carbon	606.30	1.5% ad valorem[2]	1.5% ad valorem	10.5% ad valorem.
Silicomanganese	606.44	4.4% ad valorem[1]	3.9% ad valorem	23% ad valorem.
Metal	632.30	14% ad valorem	14% ad valorem[3]	20% ad valorem.

[1]Free from certain countries under Generalized System of Preferences, not including Brazil for silicomanganese.
[2]As of Sept. 1, 1985, free for products of Israel.
[3]5.6% ad valorem for products of Israel.

WORLD REVIEW

Australia.—Manganese ore production increased 9% to the highest level since 1980, according to preliminary data of the Australian Bureau of Mineral Resources. Shipments by Groote Eylandt Mining Co. Pty. Ltd. declined, however, to about 1,540,000 tons for exports and to about 350,000 tons for domestic shipments, for a total of about 1,900,000 tons. This was more than 8% below the 1984 total.[6]

Belgium.—Production facilities for manganese chemicals and ferroalloys were included when Société Générale de Belgique SA consolidated its main chemical subsidiaries into Gechem in the final months of the year. In the restructuring, Société Européenne des Dérivés du Manganèse SA (Sedema) was absorbed from Société Carbochimique SA (Carbochim) into Société d'Applications de la Chimie de l'Electricité et des Métaux SA (Sadacem). Principal ownership of Sadacem was divided between Carbochim, 65%, and Gechem, 26%. Gechem owned 99% of Carbochim. A Gechem business sector was formed that included the Sadacem chemical plant at Tertre and Chemetals in the United States, both of which had been owned by Sedema, and the manganese ferroalloy plant of Belgische Vennootschap voor Mangaanproduktie SA (Belgomang) at Langerbrugge. Ownership of Belgomang was shared equally between Sadacem and a state-owned company.

Earlier in the year, the chemical plant at Tertre had raised its production capacities for manganese sulfate solution and manganese sulfate monohydrate ($MnSO_4 \cdot H_2O$) powder to 79,400 and 16,500 tons per year, respectively, both expressed as $MnSO_4 \cdot H_2O$ equivalent.

Brazil.—Overall shipments of manganese ore from the Serra do Navio, Amapá Territory, operations of Indústria e Comércio de Minérios S.A. rose slightly to 1,013,000 tons, all via Porto de Santana on the Amazon River. Exports increased to 815,000 tons. Destinations were Europe, 520,000 tons; North America, 162,000 tons; Asia, 87,000 tons; and South America, 45,000 tons. Shipments in coastal vessels to Brazilian consumers declined to 198,000 tons.[7]

Inauguration of the railroad from the Carajás mineral province to ocean shipping facilities at São Luis at the end of February marked another advance in development of the Igarapé Azul deposit. Ore production from this deposit by Cia. Vale do Rio Doce rose to about 228,000 tons, of which 211,000 tons was metallurgical grade and 17,000 tons was battery grade. Metallurgical ore exports were 60,000 tons, beginning with a shipment of 11,000 tons to the United Kingdom in July. This ore was medium grade and typically analyzed about 45% manganese and unusually high alumina, about 10%.

Upgrading of Carajás ore into manganese ferroalloys was the objective of plants announced by two Brazilian ferroalloy producers, Cia. Paulista de Ferro-Ligas and Prometal Produtos Metalúrgicos S.A. Each company planned for a plant rated at a ferromanganese-silicomanganese output of about 40,000 tons per year, to be located in the region and to begin producing in the 1986-88 period. Technical feasibility of producing both standard ferromanganese and silicomanganese beginning with feed material from the Azul deposit and using charcoal as a reductant was demonstrated in pilot plant experiments.[8]

Production of manganese ferroalloys increased to another record high total of about 350,000 tons, according to preliminary data.

Production of manganese materials other than ferroalloys from Carajás ore was preindicated by formation of Metalman S.A. within the Metalur Group. Initial objective of Metalman was to construct a plant capable of producing 5,000 tons per year of electrolytic manganese metal in the Rosário region of Maranhão State. Production was scheduled to begin by mid-1987, with the possibility of expanding within a few years to a capacity of 20,000 tons per year of metal, 12,000 tons per year of electrolytic manganese dioxide, and 1,000 tons per year of potassium permanganate, all largely for export.

Canada.—In the first half of the year, Elkem Metals Canada Inc. came under full ownership by Elkem of Norway upon Elkem's acquisition of the 10% share formerly held by the Jebsen Group, also of Norway. The assets of Elkem Metals Canada included a manganese ferroalloy plant at Beauharnois in the Province of Quebec.

European Economic Community.—The problem of surplus capacity for high-carbon ferromanganese was still not resolved. At midyear, the Commission of the European Community issued "General Objectives Steel 1990," a working document that projected declines in manganese consumption in ironmaking and steelmaking. Use of manganese ore in iron blast furnaces was foreseen to end in the near future. Rate of use of high-carbon ferromanganese in steelmaking was forecast to decrease, a trend expected to adversely affect Community producers of this ferroalloy.

France.—Blast furnace production of high-carbon ferromanganese plus a small amount of spiegeleisen was virtually unchanged at 366,000 tons, according to preliminary data.

Société du Ferromanganèse de Paris-Outreau (SFPO) continued with plasma-assist in commercial blast furnace production of high-carbon ferromanganese. The practice was begun in the latter part of 1984 by attaching a plasma torch to each of three of the nine tuyeres on one of the blast furnaces at SFPO's Boulogne plant. The torches were operated at a power level of up to 1.5 megawatts to superheat the blast. Because of seasonal fluctuation in electric power prices, SFPO tended to emphasize plasma usage during the warmer months when revenue from sales of the plant's surplus electricity was the least.[9]

Early in the year, Société Française d'Électrométallurgie (Sofrem), a subsidiary of Pechiney and a manufacturer of "Gimel metal" and refined ferromanganese, was renamed Pechiney Électrométallurgie.

Gabon.—Production of manganese ore at the Moanda Mine of Compagnie Minière de l'Ogooué S.A. (Comilog) increased about 10% to surpass slightly that in the former record high year of 1979. Shipments by Comilog also advanced to about 2,450,000 tons.

Ghana.—Exports of manganese ore produced at the Nsuta Mine of Ghana National Manganese Corp. rose somewhat to 291,000 tons. Shipments through the Port of Takoradi were reported as having gone to eight European countries, Japan, and the United States.[10] Shipments in 1985 were approximately double those in the recent low-point year of 1982, having increased every year since.

Greece.—Production of battery ore from the Plavista Mine was to be expanded severalfold by C. Christoforidis Mining S.A., its new owner, from a 1985 production level of about 10,000 tons. Grade of the battery ore concentrate was about 72% manganese dioxide. Plans were also made to produce a manganese carbonate ore containing about 32% manganese.[11] The mine is situated on the eastern Khalkidhiki Peninsula near Neochorio.

Japan.—Ore production dropped by nearly two-thirds following closure in late 1984 of two mines in Hokkaido Prefecture. These were the Ooe and Inakunaishi Mines of Hokushin Mining Co. Ltd. that had been producing carbonate ore. Chugai Mining Co. Ltd., operator of the Jokoku Mine, thus became the largest domestic ore producer.

Production of manganese ferroalloys decreased about 8%, dropping to 487,000 tons for ferromanganese and to 239,000 tons for silicomanganese. Exports of both materials remained comparatively small, approximately 29,000 tons for ferromanganese and 190 tons for silicomanganese. Imports declined again for ferromanganese, to about 6,500 tons, whereas those of silicomanganese rose to about 134,000 tons. At midyear, Mizushima Gokintetsu began production of high-carbon ferromanganese in a shaft furnace sited within a steelmaking complex of parent company Kawasaki Steel Corp. Demand for manganese ferroalloys continued to decrease owing to steelmakers' hot metal pretreatment practices, especially at Nippon Steel Corp.[12]

The trend of successive increases to new record high totals continued for synthetic manganese dioxide, with production up slightly to 54,000 tons and exports up by one-fifth to 48,400 tons. Both Chuo Denki Kogyo Co., a manganese ferroalloy producer, and Toho Zinc Co. Ltd. announced plans to move into production of chemical manganese dioxide and possibly other manganese chemicals. Production of electrolytic manganese metal rose to 5,100 tons.

Norway.—Elkem increased to 100% its ownership of both Elkem Metals Canada and Elkem Metals in the United States, thereby completing the takeover begun in 1983 of the bulk ferroalloy business in North America formerly held by Union Carbide.

South Africa, Republic of.—Ore production was relatively steady through the year, well below capacity at a level attained as of mid-1984. Compared with 1984, production overall and production of metallurgical ore increased about one-fifth, whereas production of chemical ore decreased about one-fifth. Production of the various categories of ore was as follows:

	Quantity (thousand short tons)
METALLURGICAL ORE	
30% to 40% Mn	1,589
Over 40% to 45% Mn	923
Over 45% to 48% Mn	235
Over 48% Mn	1,047
Total	[1]3,795
CHEMICAL ORE	
35% MnO_2 and less	42
Over 35% to 65% MnO_2	131
Over 65% to 75% MnO_2	1
Total	174

[1]Data do not add to total shown because of independent rounding.

At its midyear annual meeting, South African Manganese Amcor Ltd. shortened its name to SAMANCOR Ltd. Earlier in the year, SAMANCOR had combined separate divisions for manganese ore and manganese ferroalloys into a single unit. SAMANCOR produced manganese ore from its Hotazel, Mamatwan, and Wessels Mines.

The Associated Manganese Mines of South Africa Ltd. shipped about 1,240,000 tons of manganese ore, a 6% decrease from shipments of about 1,320,000 tons in 1984.[13]

Table 11.—Manganese ore: World production, by country[1]

(Thousand short tons unless otherwise specified)

Country[2]	Range percent Mn[e 3]	Gross weight					Metal content				
		1981	1982	1983	1984[p]	1985[e]	1981	1982	1983	1984[p]	1985[e]
Australia[4]	37-53	1,555	1,238	1,510	2,016	[5]2,192	754	594	754	953	1,070
Brazil[6]	38-50	[7]2,251	[7 8]2,580	[7]2,306	[7 8]2,969	2,976	900	1,032	922	1,187	1,190
Bulgaria	29	50	50	50	50	50	15	15	14	14	14
China[e 9]	30	1,760	1,760	1,760	1,760	1,760	530	530	530	530	530
Gabon[6 10]	50-53	1,640	1,667	2,047	2,336	[5]2,592	757	769	945	1,078	1,196
Ghana[6]	30-50	246	176	191	296	338	98	71	76	118	135
Hungary[6 11]	30-33	78	91	65	74	72	23	27	20	22	22
India[6 10 12]	10-54	1,682	[r]1,642	1,455	1,192	[5]1,257	618	603	535	438	462
Japan	24-27	96	86	83	68	[5]23	23	22	22	18	[5]6
Mexico	27-50	[e]637	[e]561	[e]386	[r e]525	511	229	202	147	199	194
Morocco[6]	50-53	121	106	81	63	[5]48	64	56	43	33	26
Romania[6]	30	63	61	86	73	73	19	18	26	22	22
South Africa, Republic of[6 10]	30-48+	5,555	5,750	3,181	3,361	[5]3,969	2,123	2,220	1,225	1,341	1,587
Thailand[6]	46-50	12	9	7	10	9	6	4	4	5	4
Turkey[6]	27-46	16	8	4	47	55	6	3	1	17	19
U.S.S.R	29-30	10,090	10,830	10,890	11,100	10,900	3,043	3,260	3,280	3,300	3,200
Yugoslavia	25-45	34	[r]30	35	[e]30	28	12	11	12	[e]11	10
Other[e 13]	XX	[r]80	56	54	[r]60	69	[r]32	22	20	[r]23	25
Total[14]	XX	[r]25,967	[r]26,701	24,190	26,027	26,922	[r]9,254	[r]9,460	8,575	9,310	9,713

[e]Estimated. [p]Preliminary. [r]Revised. XX Not applicable.
[1]Table includes data available through June 10, 1986.
[2]In addition to the countries listed, Colombia, Cuba, and Namibia may have produced manganese ore and/or manganiferous ore, but available information is inadequate to make reliable estimates of output levels. Low-grade ore not included in this table has been reported as follows, in thousand short tons, gross weight: Argentina (19% to 30% Mn), 1981—3, 1982—4, 1983—8, 1984—9, and 1985—8, and Czechoslovakia (about 17% Mn), an estimated 1 in each year.
[3]May be for average content of each year's production rather than for content of typical products.
[4]Metallurgical ore.
[5]Reported figure.
[6]Gross weight reported; metal content estimated. Estimated metal content figures have been revised as necessary.
[7]Figures are the sum of (1) sales of direct-shipping manganese ore and (2) production of beneficiated ore, both as reported in Anuário Mineral Brasiliero.
[8]Only about two-thirds of this quantity was marketed.
[9]Includes manganiferous ore.
[10]Calculated metal content includes allowance for assumed moisture content.
[11]Concentrate.
[12]Much of India's production grades below 35% Mn; average content was reported as 37.5% Mn in 1981-82.
[13]Category represents the combined totals of Bolivia (exports), Chile, Greece, Indonesia, Italy (from wastes), the Republic of Korea, Pakistan, the Philippines, Sudan, and Zaire.
[14]Data may not add to totals shown because of independent rounding.

Effective August 1, the world's two largest producers of electrolytic manganese metal, Electrolytic Metal Corp. (Pty.) Ltd. (Emcor) and Delta Manganese (Pty.) Ltd. (Deltamang), were merged into a single firm, Manganese Metal Co. (Pty.) Ltd. (MMC). MMC's metal capacity of about 48,000 tons per year, all in Transvaal Province, consisted of the former Emcor plant at Krugersdorp and the former Deltamang plant at Nelspruit, the newer and larger of the two with a capacity about 160% that of the Krugersdorp plant.[14] At the time of the merger, Emcor was controlled by General Mining Union Corp. Ltd., and Deltamang was controlled by Delta S.A. (Pty.) Ltd. Division of ownership of MMC was Emcor, 51%, and Delta S.A., 49%. Delta EMD (Pty.) Ltd., formerly a subsidiary of Deltamang and the country's only producer of electrolytic manganese dioxide, was not merged into MMC but remained a subsidiary of Delta S.A.

U.S.S.R.—Mine production declined slightly, and the percentage decline was apparently somewhat greater for the Chiatura Basin in Georgia than for the Nikopol' Basin in the Ukraine. Various methods of beneficiating high-clay, low-grade ores of the Nikopol' and Chiatura Basins containing about 20% manganese were being developed. High-gradient magnetic separation (HGMS) was being tested for Chiatura ores. Application of chemical benefication to Nikopol' ores showed that high-grade concentrates low in phosphorus could be produced by a dithionate process.[15] In 1984, the overall average grade of concentrates had fallen to a little under 30%.

Kazakhstan's contribution to Soviet manganese mine production remained insignificant but was being increased. In 1984, the open pit Ushkatyn-1 Mine in central Kazakhstan was brought into operation, adding its capacity of nearly 1 million tons of crude ore per year to output from the Dzhezdy manganese mine and the Karazhal iron-manganese deposit.

The quantity of ore exported in 1984, 1,192,000 tons, was virtually the same as that in 1983. Principal destinations, accounting for over 90% of the total, were, in tons, Poland, 605,000; Czechoslovakia, 331,000; Bulgaria, 82,000; and the German Democratic Republic, 75,000.

United Kingdom.—Sale of about one-fourth of a Government stockpile of strategic materials in the second half of the year included about 26,000 tons of high-carbon ferromanganese, 29,000 tons of manganese ore fines, and 1,400 tons of battery ore.

TECHNOLOGY

In a report on deposits of strategic and critical minerals in Nevada, the Bureau of Mines listed data on five deposits that have a potential for commercial production of manganese: Boulder City, Fannie Ryan, Gibellini, Three Kids, and Virgin River. Except for Gibellini, all of these deposits are in the southeast corner of Nevada east of Las Vegas. Three Kids is a past producer; the other deposits are inactive and have been explored only.[16]

The Bureau summarized its research on analysis and characterization of ocean manganese nodules and potential rejects from nodule processing. This research, funded by the National Oceanic and Atmospheric Administration, gave a positive indication that commercial recovery of cobalt, copper, manganese, and nickel from manganese nodules would be environmentally acceptable.[17] Tailings and slags characterized by the Bureau were generated by processing nodules in the laboratory according to five proposed first-generation processes. Pacific manganese nodules from the Clarion-Clipperton fracture zone served as feed material for these tests.[18]

Hypothetical mining of nodules from this portion of the northeast equatorial Pacific Ocean and subsequent metal recovery were subjected to cost sensitivity analysis by the Bureau. It was concluded that, for the foreseeable future, significant financial incentives would be required to make nodule mining and processing economically attractive.[19]

Tables of thermodynamic data on elemental manganese and various manganese borides, carbides, carbonates, chlorides, fluorides, nitrides, oxides, phosphides, selenides, silicates, silicides, sulfides, and tellurides were included in a Bureau compilation of thermodynamic data.[20]

HGMS was investigated as a method for utilizing the manganese resource of the Cuyuna iron ore range in central Minnesota. Tests were conducted on samples of the major types of manganiferous ore found in the north range district of the Cuyuna Range. Fine grinding, such as to 85% minus

500 mesh, enhanced liberation of manganese minerals. Hematite ore responded best to HGMS, yielding a product with 21% manganese and 32% iron at a manganese recovery of about 80% from an ore feed with 13% manganese and 29% iron.[21]

Expansion of India's manganese resource base by pan sintering ore fines was evaluated. This method of agglomeration was considered for fines of high-grade manganese ore and beneficiated low-grade manganese ore. Laboratory-scale through semicommercial-scale tests were conducted, as well as smelting trials in a commercial ferromanganese furnace. These tests indicated pan sintering was suitable for the limited quantities of manganese fines produced during processing of a variety of Indian ores.[22]

Modification of a conventional composition of Hadfield steel resulted in an as-cast steel that was successfully field tested in France for use in rail frogs, and led to similar applications elsewhere in Europe and Africa. A manganese-molybdenum steel was derived from the Hadfield steel composition with about 13% manganese by lowering carbon content from 1.2% to about 0.8% and adding 1.0% to 1.8% molybdenum. The modified composition eliminated the need for heat treatment that is required during both installation and repair of conventional steel frogs.[23]

The possibility that the residual limits for manganese in aluminum casting alloys could be raised in the future was discussed in light of the growing significance of recycling manganese-bearing used beverage cans. Further investigation is needed, but a review of the effects of manganese in aluminum alloys for casting was encouraging. In a number of instances, addition of manganese has been found to improve alloy properties.[24]

Discovery that rapid solidification of aluminum-manganese alloys can produce atomic arrangements that are neither crystalline nor glassy has attracted considerable scientific interest. The first such nonperiodic or "quasicrystal" structure found has icosahedral symmetry.[25] Further work has revealed existence of a decagonal phase that is structurally intermediate between icosahedral and fully crystalline symmetries.[26] These unusual structures have been produced in aluminum-manganese compositions having 10 to 22 atomic percent manganese.

A review of nonmetallurgical manganese ore production and markets for such ore and manganese compounds pointed out the increasing number of sources of battery ore. A conserative outlook for the synthetic manganese dioxide industry was advocated.[27]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Unless otherwise stated, the unit of weight in this chapter is the short ton of 2,000 pounds.

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Mercury

By Linda C. Carrico[1]

Domestic mercury mine production, reported by four mines in Nevada, decreased for the fifth consecutive year. Secondary production increased 5%, reflecting the resumption of secondary mercury sales by the General Services Administration (GSA). Imports for consumption decreased 25% from the high level of 1984, with Spain continuing to be the dominant supplier. Reported consumption was virtually the same as that of 1984, with the battery industry accounting for more than 50% of total demand. A buildup of industry stocks, especially during the first half of the year, contributed to the decrease in the domestic dealers' price during that period. As the domestic supply of mercury remained ample during 1985, the average dealers' price declined for the fourth consecutive year. Owing to a worldwide oversupply, the London price plunged below the $300 per flask level in early January and never regained that level.

Domestic Data Coverage.—Domestic data for mercury are developed by the Bureau of Mines from three separate, voluntary surveys of U.S. operations. Typical of these surveys is "Mercury," a survey of mercury consumption. Of the 362 firms to which this survey report was sent, 93% responded, representing an estimated 99.6% of the reported U.S. consumption shown in tables 1 and 4. Consumption for the 26 nonrespondents was estimated using prior years' consumption levels.

Table 1.—Salient mercury statistics

	1981	1982	1983	1984	1985
United States:					
Producing mines	3	3	3	3	4
Mine production ______ flasks	27,904	25,760	25,070	19,048	16,530
Value ______ thousands	$11,549	W	W	W	W
Secondary production:					
Industrial ______ flasks	4,244	4,473	13,751	r5,673	5,358
Government[1] ______ do	7,000	--	--	--	585
Industry stocks, yearend[2] ______ do	27,339	28,827	31,018	r27,255	27,985
Shipments from the National Defense Stockpile[3] do	--	7,076	6,000	4,092	4,534
Imports for consumption ______ do	12,408	8,916	12,786	25,327	18,890
Exports ______ do	NA	NA	NA	NA	NA
Consumption ______ do	59,244	48,943	49,138	r54,669	53,483
Price: New York, average per flask	$413.89	$370.93	$322.44	$314.38	$310.96
Employment, mine and mill, average	48	45	45	41	35
World:					
Mine production ______ flasks	r210,885	r197,901	180,800	p195,286	e196,250
Price: London, average per flask	$417.52	$376.96	$313.33	$306.40	$288.56

eEstimated. pPreliminary. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Secondary mercury released from U.S. Department of Energy stocks.
[2]Stocks at mines, consumers, and dealers.
[3]Primary mercury.

Legislation and Government Programs.—Public Law 98-525 of 1984 authorized GSA to dispose of 5,000 flasks[2] of excess mercury and 500,000 pounds of excess mercuric oxide from the National Defense Stockpile (NDS) during fiscal year 1985.

GSA auctioned mercury on an "as-is" basis from the NDS on the third Tuesday of each month, offering 1,500 flasks per month. GSA sold 4,499 flasks and shipped

4,534 flasks during the year, leaving 159,189 flasks in excess to the stockpile goal. In June, GSA sold its last authorized (Public Law 98-525) quantity of mercury from the NDS for fiscal year 1985. The stockpile goal remained at 10,500 flasks.

GSA continued to auction 50,000 pounds of mercuric oxide on the first Wednesday of each month from the NDS on an "as-is" basis. The monthly auctions took place through September, when GSA terminated the mercuric oxide disposal program by selling the remaining excess quantity in the stockpile. GSA sold 350,875 pounds of mercuric oxide and shipped 390,822 pounds, with 80 pounds remaining to be shipped at yearend. From the inception of the mercuric oxide disposal program in 1981 through 1985, the following quantities were sold, in pounds: 1981—none; 1982—1,000; 1983—none; 1984—359,100; and 1985—350,875. The total quantity sold was 710,975 pounds.

On October 15, after a lapse of 3 years, GSA resumed monthly auctions of surplus secondary mercury managed by the U.S. Department of Energy (DOE) in Oak Ridge, TN. On the third Tuesday of each month, GSA offered a maximum of 1,500 flasks on an "as-is" basis. GSA sold and shipped 585 flasks, leaving 34,720 flasks available for disposal.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. Mercury was included in tier I of the proposal with no goal listed, pending Government review. The Department of Defense Authorization Act, 1986 (Public Law 99-145),[3] signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The Environmental Protection Agency (EPA) issued final regulations under the Clean Water Act for certain nonferrous metals manufacturing operations that limit the discharge of pollutants into navigable waters and into publicly owned treatment works by existing and new operations. This regulation provides effluent limitations based on best practicable and best available technology, new source performance standards based on best demonstrated technology, and pretreatment standards for existing and new indirect discharges. The maximum effluent limitations for primary and secondary mercury manufacturing facilities, based on a daily and monthly average, varied according to the type of operation and effluent source.[4] This regulation became effective November 4, 1985.

Under section 304 of the Clean Water Act, EPA announced the availability of final ambient water quality criteria documents for nine pollutants, of which mercury was included. These criteria reflect the latest scientific knowledge on the identifiable effects of pollutants on public health and welfare and aquatic life.[5]

EPA continued its review of the national emission standards, under section 112 of the Clean Air Act, for mercury-cell chlor-alkali plants, sludge incineration and drying plants, and mercury ore processing plants.

On September 30, Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), expired. Attempts to reauthorize the Superfund prompted legislative action, and at yearend, several bills were under consideration by Congress.

DOMESTIC PRODUCTION

Since 1982, Nevada has been the only mercury producing State. Total reported mine production in 1985, including byproduct mercury, was 16,530 flasks, with producers operating at 47% of capacity. Production decreased as a result of increased imports over the past 2 years and sales of excess mercury and mercuric oxide from the NDS.

Four mines were in operation during the year: the McDermitt, the Carlin, the Pinson, and the Borealis. The McDermitt Mine, operated by Placer U.S. Inc., remained the principal domestic mercury producer. The Carlin Mine, operated by Carlin Gold Mining Co., the Pinson Mine, operated by Pinson Mining Co., and the Borealis project, operated by Tenneco Minerals Co., produced mercury as a byproduct from their gold mining operations.

Placer continued exploration work at its McDermitt Mine and at other prospects in the Western States. At yearend, the McDermitt Mine had about 6 years of proven reserves, based on an annual production rate of 15,000 flasks.

Waste stripping at FMC Corp.'s Paradise Peak open pit mine near Gabbs, NV, was under way in late 1985. Construction of the mill and leach facility was about 85% completed by yearend, with startup scheduled for June 1986. FMC's geologists predicted that the mine could yield between 800 and 2,600 flasks of mercury per year as a byproduct from gold mining.

Table 2.—Mercury ore treated and mercury produced in the United States[1]

Year	Ore treated (short tons)	Mercury produced	
		Flasks	Pounds per ton of ore
1981	262,380	27,888	8.1
1982	300,978	25,704	6.5
1983	335,389	25,033	5.7
1984	216,212	19,014	6.7
1985	182,385	16,337	6.8

[1]Excludes mercury produced from old surface ores, dumps, and placers, and as a byproduct.

Table 3.—Production of secondary mercury in the United States

(Flasks)

Year	Industrial production	GSA releases	Total
1981	4,244	7,000	11,244
1982	4,473	--	4,473
1983	13,751	--	13,751
1984[r]	5,673	--	5,673
1985	5,358	585	5,943

[r]Revised.

The following five companies redistilled purchased primary and/or processed purchased scrap mercury: Adrow Chemical Co., Wanaque, NJ; Bethlehem Apparatus Co. Inc., Hellertown, PA; D. F. Goldsmith Chemical and Metal Corp., Evanston, IL; Mercury Refining Co. Inc., Albany, NY; and Troy Chemical Corp., Newark, NJ. Total secondary production from industry and government materials was equivalent to 11% of the reported mercury consumption. Major sources of secondary mercury were amalgams, sludges, obsolete industrial and control instruments, metal retrieved from chlorine and caustic soda plants, and mercuric oxide from the NDS.

CONSUMPTION AND USES

Consumption of mercury was reported by about 275 plants, of which more than one-half were east of the Mississippi River. Primary mercury accounted for 68% of the total reported consumption, followed by redistilled mercury,[6] 22%, and secondary mercury, 10%.

Domestic mercury consumption was virtually the same as that of 1984, with the battery industry continuing to be the dominant consumer, followed by industries producing chlorine and caustic soda, paints, wiring devices and switches, and measuring and control instruments.

Mercury consumed by the chlorine and caustic soda manufacturing industry declined because of the permanent closing of three mercury-cell chlor-alkali plants and the temporary closure of one plant. The following mercury-cell chlor-alkali plants closed during 1985: LCP Chemicals and Plastics Inc., Linden, NJ; Olin Corp., McIntosh, AL; and Monsanto Co., Sauget, IL. Throughout 1985, Occidental Chemical Corp.'s Niagara Falls, NY, plant remained temporarily closed. At yearend, 20 mercury-cell chlor-alkali plants were in operation.

Cosan Chemical Corp. of Carlstadt, NJ, became a wholly owned subsidiary of CasChem Group Inc. Reportedly, Cosan is the largest domestic producer of aryl mercury chemicals and the only domestic producer of 100% phenyl mercuric acetate.[7] These products are used as a mildewcide and a preservative in coatings and building products.

Thor Chemicals Inc. in Norwalk, CT, established a warehouse facility for the storage and handling of several different mercury compounds produced at its plants in Natal, Republic of South Africa, and Margate, United Kingdom. The compounds include battery-grade mercurous and mercuric chlorides, urethane and polymerization catalysts, and phenyl mercuric compounds. Thor announced plans to sell and distribute these compounds to consumers in the United States.

Table 4.—Mercury consumed in the United States, by use

(Flasks)

SIC code	Use	1981	1982	1983	1984	1985
28	Chemical and allied products:					
2812	Chlorine and caustic soda manufacture	7,323	6,243	8,054	7,347	6,700
2816	Pigments	W	W	W	W	W
2819	Catalysts, miscellaneous	815	499	484	359	497
2821	Catalysts for plastics	W	W	W	W	W
2819	Laboratory uses	328	281	280	r269	446
2851	Paints	7,049	6,794	6,047	4,651	4,892
2879	Agricultural chemicals	79	36	--	--	--
--	Other chemicals and allied products	W	W	W	W	W
36	Electrical and electronic uses:					
3641	Electric lighting	1,043	826	1,273	1,487	1,726
3643	Wiring devices and switches	2,641	2,004	2,316	r2,730	2,843
3692	Batteries	29,441	24,880	23,350	29,700	29,782
--	Other electrical and electronic uses	W	W	W	W	W
38	Instruments and related products:					
382	Measuring and control instruments	5,671	3,064	2,465	r2,856	2,654
3843	Dental equipment and supplies	1,613	1,019	1,597	1,432	1,960
--	Other instruments and related products	253	194	W	W	W
--	Other	242	984	1,356	1,404	267
	Total	59,244	48,943	49,138	r54,669	53,483

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

STOCKS

The NDS, as of December 31, 1985, contained 169,689 flasks of mercury and 80 pounds of mercuric oxide. DOE held 34,720 flasks of secondary mercury in Oak Ridge, TN. Reported stocks of mercury held by mine producers, consumers, and brokers increased during the first half of the year, and thereafter, slowly declined and ended the year at 27,985 flasks.

Table 5.—Stocks of mercury in the United States, December 31

(Flasks)

Year	Producer (mine)	Consumer and dealer	Total
1981	11,783	15,556	27,339
1982	13,598	15,229	28,827
1983	18,323	12,695	31,018
1984r	19,964	7,291	27,255
1985	19,398	8,587	27,985

rRevised.

PRICES

According to Metals Week, the New York dealers' price for mercury was $320 to $325 per flask at the beginning of the year. Thereafter, the price fell until June 7 when it increased to $303 to $310 per flask. On July 18, the price reached a yearly high of $323 to $328 per flask and remained at that level for 15 consecutive weeks owing primarily to a static domestic mercury market. The price then decreased steadily and by yearend reached a yearly low of $273 to $280 per flask.

The London price of mercury (minimum 99.99% pure), quoted by Metal Bulletin (London), reached a high of $300 to $309 per flask for the first 8 days of the year, and thereafter, fell and never regained the $300 level. The price reached a yearly low of $250 to $260 per flask at yearend.

Table 6.—Average prices of mercury at New York and London

(Per flask)

Period	New York	London
1981	$413.89	$417.52
1982	370.93	376.96
1983	322.44	313.33
1984	314.38	306.40
1985:		
January	317.52	301.66
February	314.00	300.12
March	309.95	296.56
April	299.59	292.88
May	293.59	289.33
June	310.00	291.75
July	321.46	292.83
August	323.00	291.17
September	323.00	288.63
October	323.00	282.22
November	313.37	275.72
December	283.00	259.89
1985 average	310.96	288.56

Sources: Metals Week (New York) and Metal Bulletin (London).

FOREIGN TRADE

Imports for consumption of mercury and mercury-bearing waste and scrap, which included imports for immediate consumption plus material withdrawn from bonded warehouses, decreased 25% from the high level in 1984. Spain continued for the third consecutive year to be the leading supplier. The average unit value of imports was $282.53 per flask, compared with $287.20 per flask in 1984.

The U.S. rate of duty on imported mercury and mercury-bearing waste and scrap, TSUS 632.34, as of January 1, 1985, from countries with most-favored-nation status was 6.2 cents per pound.[8] A duty of 25 cents per pound applied to other countries.

Table 7.—U.S. imports for consumption of mercury and mercury-bearing waste and scrap, by country

Country	1983		1984		1985	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Algeria	1,795	$560	8,201	$2,441	1,938	$580
Canada	4	19	14	33	5	26
China	--	--	350	112	2,382	662
Denmark	--	--	14	8	--	--
Dominican Republic	100	23	--	--	--	--
Finland	--	--	120	54	--	--
France	--	--	--	--	1	7
Germany, Federal Republic of	13	20	--	--	500	148
Italy	500	122	800	196	--	--
Japan	511	179	500	120	2,502	630
Malaysia	--	--	--	--	380	81
Mexico	1,590	426	21	9	214	38
Netherlands	1,501	359	1,556	392	--	--
Spain	3,408	1,063	11,749	3,344	7,955	2,322
Turkey	1,333	385	2,002	564	3,012	842
United Kingdom	2,031	657	(1)	1	(1)	1
Total	12,786	3,813	25,327	7,274	[2]18,890	5,337

[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World mine production was 54% of available capacity.

The Bureau of Mines investigated the availability of mercury from 22 deposits in market economy countries.[9] Of the deposits investigated, 15 had demonstrated resources of approximately 25 million metric tons of ore containing 5.3 million flasks of mercury and accounted for 85% of the demonstrated resources for market economy countries. It was concluded that in order to meet anticipated future demand, additional mercury production will be required to supplement those properties currently producing, at higher production costs.

World mercury reserves were estimated by the Bureau of Mines at 4 million flasks, of which 85% is in market economy countries. Spain had the largest share of world reserves, 65%.[10]

Table 8.—Mercury: World mine production, by country[1]

(Flasks)

Country	1981	1982	1983	1984[p]	1985[e]
Algeria	25,000	11,000	[e]10,000	23,000	25,000
China[e]	20,000	20,000	20,000	20,000	20,000
Czechoslovakia	4,438	4,380	4,177	4,409	4,400
Dominican Republic	77	49	[e]40	[e]30	20
Finland	1,949	[r]2,068	1,857	2,292	2,300
Germany, Federal Republic of	2,205	1,537	2,005	(2)	--
Italy	7,427	4,612	--	--	--
Mexico	6,962	8,558	6,411	11,140	10,000
Spain	46,008	48,808	41,075	44,093	45,000
Turkey	[r]5,915	[r]7,129	4,665	5,274	6,000
U.S.S.R.[e]	63,000	64,000	64,000	64,000	65,000
United States	27,904	25,760	25,070	19,048	[3]16,530
Yugoslavia	--	--	[e]1,500	[e]2,000	2,000
Total	[r]210,885	[r]197,901	180,800	195,286	196,250

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 22, 1986.
[2]Revised to zero.
[3]Reported figure.

China.—Exploration work on the western end of Gongguan-Huilong mercury deposit was reportedly completed with work under way on the eastern end. Ore reserves at the deposit at Dianyang in Shaanxi Province was ranked the second largest in China.[11]

The Songhua River in Northeastern China reportedly has been plagued with mercury emissions from chemical and metallurgical plants. The Government forced an immediate closure of all factories and prohibited all fishing in the area. It was estimated that 150 metric tons of toxic mercury could be present in the banks and body of the river. The Chinese Government in cooperation with Swedish experts was investigating the extent of mercury contamination to the environment.

Japan.—In October 1985, the Japanese Ministry of International Trade and Industry (MITI) announced that eight Japanese mercury-cell chlor-alkali producers have until June 30, 1986, to convert to the ion-exchange membrane-cell process in order to comply with its 1983 order. Analysts predicted that the mercury-cell process in Japan will disappear completely by mid-1986.[12]

Several Japanese manufacturers of dry-cell batteries formed the Alkaline Dry Cell Technology Research Association in September 1984 to study ways to reduce the amount of mercury used in dry-cell batteries without reducing their efficiency. The average mercury content in an alkaline-manganese dry-cell battery was 0.33 gram in 1983 and 0.24 gram in 1984. Research and development work was under way during 1985 on a mercury-free alkaline-manganese battery cell. It was reported that a "new material" could appear in the near future to produce the mercury-free battery cell.[13]

Mexico.—Four mercury-cell chlor-alkali plants were in operation compared with five in 1984. The producers and locations of the active mercury-cell plants in 1985 were as follows: Guanos y Fertilizantes de México S.A., Salamanca; Pennwalt S.A. de C.V., Santa Clara; Celulosa y Derivados S.A. de C.V., Monterrey; and Industria Química del

Istmo S.A., Pajaritos. The Guanos y Fertilizantes de México's San Cristobal plant did not operate in 1985.[14]

Spain.—Three mines in the Almadén region, operated by Minas de Almadén y Arrayanes S.A. (MAYASA), a mining company owned by the Spanish Government, remained the only producers of mercury in Spain. The Almadén Mine, the oldest and richest mercury deposit in the world, is expected to be mined out by the end of the decade. The El Entredicho open pit mine, about 11 miles from Almadén, went into full production in 1982 and since has produced 70% to 80% of the company's output. Reserves, reportedly some of the richest in the world, could last about 25 years at the present production rate. Development work continued at the Las Cuevas Mine, about 5 miles from Almadén. During 1985, small amounts of low-grade waste material were processed. MAYASA estimated the life of this underground mine to be about 20 years and planned to mine it by the vertical crater retreat method.

TECHNOLOGY

A mercuric iodide crystal was grown in a microgravity environment aboard *Spacelab 3's* shuttle flight in the spring of 1985.[15] The purpose was to grow a near-perfect single crystal of mercuric iodide and to improve the understanding of crystal growth by a vapor process. Mercuric iodide crystals have practical use as sensitive X-ray and gamma-ray detectors and could be useful in portable detector devices for monitoring nuclear powerplants, prospecting for natural resources, biomedical applications in diagnosis and therapy, and in astronomical instruments. In addition to their high-performance electronic properties, these crystals operate well at room temperature. Similar equipment was used on earth to grow an identical crystal under the same environmental conditions other than in microgravity. A comparison of the space- and earth-grown crystals was being made to determine if the microgravity environment was a crucial factor in the growth of a near-perfect single crystal.

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[1]Mineral specialist, Division of Nonferrous Metals.

[2]Flask, as used throughout this chapter, refers to the 76-pound flask.

[3]U.S. Congress. Department of Defense Authorization Act, 1986. Public Law 99-145, Nov. 8, 1985, 99 Stat. 775.

[4]Federal Register. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 50, No. 183, Sept. 20, 1985, pp. 38276-38402.

[5]———. Water Quality Criteria; Availability of Documents. V. 50, No. 145, July 29, 1985, pp. 30784-30796.

[6]Redistilled mercury is primary mercury further processed or refined to a higher grade.

[7]American Paint and Coatings Journal. CasChem Group Acquires Cosan Chemical Corp. V. 70, No. 16, Oct. 14, 1985, p. 34.

[8]Federal Register. Proclamation of Trade Agreement with Japan and Spain Providing Compensatory Concession. V. 48, No. 247, Dec. 22, 1983, pp. 56553-56559.

[9]Mishra, C. P., D. R. Wilburn, D. G. Hartos, C. D. Sheng-Fogg, and R. C. Bowyer. Mercury Availability—Market Economy Countries. A Minerals Availability Appraisal. BuMines IC 9038, 1985, 18 pp.

[10]Carrico, L. C. Mercury. Ch. in Mineral Facts and Problems, 1985 Edition. BuMines B 675, 1985, p. 500.

[11]Yingbi, D. An Outline of Shaanxi's Mineral Product Resources. Beijing Zhongguo Dizhi (China Geology). No. 8, Aug. 13, 1985, pp. 21-22.

[12]Japan Chemical Week. Caustic Soda Process Conversion Progressing. V. 26, No. 1340, Dec. 5, 1985, p. 1.

[13]———. Joint Research Assn. Endeavoring for Reduction of Hg Residue in Dry Cell. V. 26, No. 1318, July 4, 1985, p. 7.

[14]The Chlorine Institute Inc. North American Chlor-Alkali Industry Plants and Production Data Book. Pam. 10, Jan. 1986, 20 pp.

[15]Research and Development. Researchers Assess Crystals Grown in Microgravity. V. 27, No. 7, July 1985, pp. 54-55.

Mica

By Lawrence L. Davis[1]

In 1985, a total of 138,000 short tons of scrap and flake mica was reported produced in the United States, a 14% decrease from 1984 production.

Nearly all sheet mica supply continued to be imported. Consumption of muscovite mica block decreased by 18% to 51,100 pounds. Consumption of mica splittings remained the same at 2.4 million pounds. The value of sheet mica exports increased 4% to $5.3 million. Imports for consumption of sheet mica increased 14% to 2.7 million pounds.

Domestic Data Coverage.—Domestic production and consumption data for mica are developed by the Bureau of Mines by means of three separate, voluntary surveys and one mandatory survey. Of the 63 canvassed operations to which 1 or more of the 4 survey forms were submitted, 56 operations, or 89%, responded. Responses to the scrap and flake mica production form and the ground mica production form were 100%, representing 100% of the totals shown in table 1. Of the eight canvassed operations to which the mica block and film consumption form was sent, seven operations, or 88%, responded, representing 95% of the consumption shown in table 1. Of the 12 canvassed operations to which the mica splittings consumption form was sent, 9 operations, or 75%, responded, representing 90% of the splittings consumption shown in table 1. Consumption for the nonrespondents was estimated using prior year production data.

Table 1.—Salient mica statistics

	1981	1982	1983	1984	1985
United States:					
Production (sold or used by producers):					
Scrap and flake mica ---- thousand short tons	133	106	140	161	138
Value ---- thousands	$8,212	$6,398	$6,479	$7,139	$6,330
Ground mica ---- thousand short tons	117	96	130	146	136
Value ---- thousands	$17,440	$16,106	$18,702	$21,334	$21,256
Consumption:					
Block, muscovite ---- thousand pounds	155	86	74	62	51
Value ---- thousands	$1,448	$1,325	$961	$842	$751
Film ---- thousand pounds	W	W	W	W	W
Value ---- thousands	W	W	W	W	W
Splittings ---- thousand pounds	4,386	2,639	2,120	2,366	2,361
Value ---- thousands	$3,064	$2,032	$1,394	$1,679	$1,610
Exports ---- thousand short tons	12	12	11	9	10
Imports ---- do	13	10	8	13	11
World: Production ---- thousand pounds	[r]530,038	[r]476,550	535,231	[p]608,700	[e]537,792

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. The proposed goals for mica in tier I are 246,400 pounds for muscovite block, 18,700 pounds for muscovite film, 14,391,100 pounds for muscovite splittings, 85,000 pounds for phlogopite block, and 482,600 pounds for phlogopite splittings. Tier II would contain a supplemental reserve of material already possessed by the Government. The proposed goal for tier II is 200,000 pounds of muscovite block. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The Government inventory of stockpile-grade natural sheet mica was reduced by 3% to 22.4 million pounds by yearend. The General Services Administration sold 800 pounds of muscovite film, 753,000 pounds of muscovite splittings, and 50 pounds of phlogopite splittings.

Table 2.—Stockpile goals and Government inventories for mica, December 31, 1985

(Thousand pounds)

Material	Goal	Inventory: Stockpile grade	Inventory: Non-stock-pile grade	Available for disposal	1985 sales
Block:					
Muscovite, Stained and better	6,200	5,006	207	--	--
Phlogopite	210	17	114	--	--
Film: Muscovite, 1st and 2d qualities	90	1,178	1	1,032	1
Splittings:					
Muscovite	12,630	14,652	--	(1)	753
Phlogopite	930	1,519	--	--	(1)

[1]Less than 1/2 unit.

DOMESTIC PRODUCTION

Scrap and Flake Mica.—U.S. production of scrap (flake) mica[2] was 138,000 tons valued at $6.3 million. North Carolina remained the major producing State with 58% of the total. The remainder was produced in Connecticut, Georgia, New Mexico, Pennsylvania, South Carolina, South Dakota, and Texas. Most of the scrap (flake) mica was recovered from mica schist, high-quality sericite schist, and as a byproduct of kaolin, feldspar, and lithium beneficiation. The five leading producers were, in order of output, Lithium Corp. of America Inc., Gastonia, NC; The Feldspar Corp., Spruce Pine, NC; Mineral Industrial Commodities of America Inc. (M.I.C.A.), Santa Fe, NM; Kings Mountain Mica Co. Inc., Kings Mountain, NC; and Mineral Mining Corp., Kershaw, SC. These five companies produced 61% of the national total.

Ground Mica.—Production (sold or used) of ground mica, from scrap and flake mica, decreased 7% to 136,000 tons, valued at $21.3 million. Dry-ground mica, 91% of the total, decreased 8%. The decrease was attributed to decreased demand for mica used in well-drilling muds because of sharply reduced drilling for oil and gas. Wet-ground mica production remained the same. Thirteen companies operated sixteen grinding plants; of these, 12 produced dry-ground and 4 produced wet-ground mica. Leading ground mica producers were, in order of output, U.S.G. Corp., Chicago, IL; Harris Mining Co., Spruce Pine, NC; Pacer Corp., Custer, SD; M.I.C.A, Santa Fe, NM; and Kings Mountain Mica, Kings Mountain, NC. These five companies produced 73% of the national total. Alamo Mining Corp., Van Horn, TX, ceased operations during the year.

Table 3.—Scrap and flake mica[1] sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
1981	133	8,212
1982	106	6,398
1983	140	6,479
1984	161	7,139
1985:		
North Carolina	80	3,726
Other States[2]	58	2,604
Total	138	6,330

[1]Includes finely divided mica recovered from mica schist and high-quality sericite schist, and mica that is a byproduct of feldspar, kaolin, and lithium beneficiation.

[2]Includes Connecticut, Georgia, New Mexico, Pennsylvania, South Carolina, South Dakota, and Texas.

Production of low-quality sericite, primarily for use in brick manufacturing was 41,000 tons valued at $158,000. Approximately 41,000 tons of ground sericite valued at $280,000 was sold or used. Low-quality sericite is excluded from tabulated data contained in this report.

Table 4.—Ground mica sold or used by producers in the United States, by method of grinding[1]

(Thousand short tons and thousand dollars)

Year	Dry-ground		Wet-ground		Total[2]	
	Quantity	Value	Quantity	Value	Quantity	Value
1981	107	13,439	11	4,001	117	17,440
1982	85	11,604	11	4,502	96	16,106
1983	118	13,907	12	4,795	130	18,702
1984	133	16,269	13	5,065	146	21,334
1985	123	15,993	13	5,263	136	21,256

[1]Domestic and some imported scrap. Low-quality sericite is not included.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Sheet Mica.—Consumption of muscovite block (ruby and nonruby) totaled 51,100 pounds, a decrease of 18% from that of 1984. Of the total muscovite block fabricated, 81% went into electronic uses; of this, the majority was used in vacuum tubes. Most of the decrease in consumption was in Stained quality, although it remained in greatest demand, accounting for 77% of consumption. Consumption of grade No. 6 increased while consumption of other sizes decreased.

Eight companies continued to consume muscovite block and film in eight plants in seven States; two in North Carolina and one each in Massachusetts, New Jersey, New York, Ohio, Pennsylvania, and Virginia. The New York, Pennsylvania, and Virginia companies consumed 75% of the total.

Phlogopite block fabrication decreased compared with that of 1984. The block was consumed by five companies in five States.

Consumption of mica splittings remained at 2.4 million pounds. Muscovite splittings from India accounted for 99% of the consumption. The remainder was phlogopite splittings from Madagascar. The splittings were fabricated into various built-up mica products by 11 companies operating 11 plants in 9 States.

Built-up Mica.—The primary use of this mica-base product, made by mechanical or hand settings of overlapping splittings and alternate layers of binders and splittings, was as electrical insulation material. Total production, sold or used, of built-up mica decreased 4% from that of 1984. Segment plates and molding plates were the major end products, accounting for 31% and 28% of the total, respectively. Other end products included flexible plates, heater plates, and tapes.

Reconstituted Mica (Mica Paper).—Five companies consumed 4.9 million pounds of scrap mica to produce 3.3 million pounds of mica paper. The principal source of this scrap mica was India. Primary end uses for mica paper were the same as those for built-up mica. Manufacturing companies were Corona Films Inc., West Townsend, MA; General Electric Co., Schenectady, NY; Kirkwood Acim Corp., Hempstead, NY; WearEver-ProctorSilex, Mt. Airy, NC; and US Samica Corp., Rutland, VT.

Ground Mica.—The major end uses were joint cement, 50%; paint, 15%; and well-drilling muds, 12%. Other end uses included plastics, roofing, and rubber.

Table 5.—Fabrication of muscovite block mica in the United States in 1985, by quality and end product use

(Pounds)

Quality	Electronic uses	Nonelectronic uses	Total[1]
Good Stained or better	1,100	3,500	4,600
Stained	W	W	39,500
Lower than stained[2]	W	W	7,000
Total	41,700	9,500	51,100

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data may not add to totals shown because of independent rounding.
[2]Includes punch mica.

Table 6.—Fabrication of muscovite block mica in the United States in 1985, by quality

(Pounds)

Quality	No. 4 and larger	No. 5 and smaller[1]	Total[2]
Good Stained or better	3,700	1,000	4,600
Stained	6,200	33,300	39,500
Lower than Stained	1,400	5,600	7,000
Total	11,300	39,900	51,100

[1]Includes all smaller than No. 6 and punch mica.
[2]Data may not add to totals shown because of independent rounding.

Table 7.—Consumption and stocks of mica splittings in the United States, by source

(Thousand pounds and thousand dollars)

	India		Madagascar		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1981	4,268	2,601	117	463	4,386	3,064
1982	2,576	1,775	63	257	2,639	2,032
1983	2,079	1,257	41	137	2,120	1,394
1984	2,323	1,537	42	141	2,366	1,679
1985	2,327	1,485	34	125	2,361	1,610
Stocks on Dec. 31:						
1981	2,621	NA	101	NA	2,722	NA
1982	1,922	NA	42	NA	1,964	NA
1983	1,187	NA	148	NA	1,335	NA
1984	877	NA	77	NA	954	NA
1985	1,085	NA	41	NA	1,126	NA

NA Not available.
[1]Data may not add to totals shown because of independent rounding.

Table 8.—Built-up mica[1] sold or used in the United States, by product

(Thousand pounds and thousand dollars)

Product	1984		1985	
	Quantity	Value	Quantity	Value
Flexible (cold)	237	1,072	193	810
Heater plate	103	397	69	182
Molding plate	655	1,912	654	2,397
Segment plate	773	2,651	723	2,974
Tape	234	1,612	266	1,675
Other	404	2,155	399	1,796
Total	2,406	9,799	2,304	[2]9,835

[1]Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2]Data do not add to total shown because of independent rounding.

Table 9.—Ground mica sold or used by producers in the United States, by end use

(Thousand short tons and thousand dollars)

End use	1984		1985	
	Quantity	Value	Quantity	Value
Joint cement	68	10,193	68	10,372
Paint	19	3,195	20	3,451
Plastics	2	427	2	498
Roofing	W	W	W	W
Well-drilling mud	23	2,416	16	1,730
Other[1]	r34	r5,102	29	5,205
Total[2]	146	21,334	136	21,256

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]Includes mica used for agricultural products, molded electrical insulation, rubber, welding rods, textile and decorative coatings, and uses indicated by symbol W.

[2]Data may not add to totals shown because of independent rounding.

STOCKS

Reported yearend consumer stocks of sheet mica increased 8% to 1.3 million pounds; of this, mica splittings represented 86% and mica block represented 14%.

PRICES

Average reported values of consumed muscovite sheet mica changed as follows: Block increased 8% to $14.68 per pound; film decreased 30% to $3.79 per pound; and splittings decreased 3% to $0.64 per pound. The average value of phlogopite block increased 104% to $6.90 per pound while the value of phlogopite splittings increased 10% to $3.68 per pound.

The average value of crude scrap (flake) mica, including high-quality sericite, was $46.02 per ton. The average value per ton for North Carolina scrap (flake) mica, predominantly a flotation product, was $46.48.

Table 10.—Average reported price for dry- and wet-ground mica sold or used by U.S. producers in 1985

(Dollars per short ton)

Kind	Price
Wet-ground	407
Dry-ground	130
End uses:	
Joint cement	152
Paint	174
Plastics	218
Roofing	W
Well-drilling mud	106
Other[1]	182

W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]Includes mica used for agricultural products, molded electrical insulation, rubber, welding rods, textile and decorative coatings, miscellaneous, and use indicated by symbol W.

FOREIGN TRADE

The United States was a net exporter of ground mica in 1985, exporting 14.5 million pounds valued at $2.0 million while importing 12.1 million pounds valued at $2.2 million. Ground mica was exported to 32 countries. The leading countries of destination were Canada, 28%; Mexico, 27%; Venezuela, 10%; and Spain, 7%. Canada supplied 96% of the ground mica imports.

Imports of unmanufactured block, film,

and splittings increased 14% to 1.7 million pounds. It was the first increase since 1980. India remained the primary source, accounting for 98% of the imports.

The total value of exported cut, stamped, and built-up mica was $5.1 million, an increase of 13%. Canada continued to be the leading country of destination, accounting for 31%. Mexico received 25%; Italy, 11%; the United Kingdom, 6%; and the remainder went to 36 countries. The total value of imports of these materials increased 11% to $3.2 million. Of this, 58% by weight and 35% by value was imported from Belgium; 13% by weight and 21% by value came from Japan; and 12% by weight and 31% by value came from India.

The combined value of all mica exports was $7.6 million, an increase of 7%. The total imported mica value was $7.2 million, a 6% increase.

Table 11.—U.S. exports of mica and manufactures of mica in 1985, by country

(Thousand pounds and thousand dollars)

Country	Scrap and flake mica				Sheet mica		
	Ground or pulverized		Waste and scrap[1]		Unmanufactured block, film, splittings		Manufactured, cut or stamped, built-up
	Quantity	Value	Quantity	Value	Quantity	Value	Value
Argentina	194	43	--	--	--	--	14
Australia	66	7	--	--	--	--	212
Bahamas	--	--	--	--	--	--	36
Belgium	240	23	--	--	--	--	2
Brazil	--	--	--	--	--	--	295
Canada	4,024	429	892	121	--	--	1,569
Colombia	260	46	12	2	--	--	40
France	380	36	--	--	--	--	9
Germany, Federal Republic of	126	28	80	11	2	11	57
India	--	--	--	--	--	--	106
Italy	302	41	160	19	32	74	580
Japan	734	143	212	35	6	17	34
Korea, Republic of	484	136	--	--	--	--	9
Mexico	3,856	496	1,562	220	--	--	1,288
Netherlands	666	127	--	--	32	40	--
Spain	1,020	139	--	--	--	--	287
Sweden	--	--	--	--	--	--	61
Taiwan	302	30	--	--	10	17	7
United Kingdom	90	10	--	--	--	--	319
Venezuela	1,422	160	--	--	--	--	11
Other[2]	294	68	--	--	--	--	167
Total	14,460	1,962	2,918	408	82	159	5,103

[1]Some shipments of ground mica are included in this category.
[2]Includes Barbados, the Cayman Islands, Chile, the Dominican Republic, Ecuador, El Salvador, the French Pacific Islands, Guatemala, Honduras, Hong Kong, Indonesia, Ireland, Israel, Jamaica, Kenya, Malaysia, Mozambique, the Netherlands Antilles, New Zealand, Pakistan, Peru, Philippines, Portugal, Saudi Arabia, Singapore, the Republic of South Africa, Switzerland, Trinidad and Tobago, and Turkey.

Source: Bureau of the Census.

Table 12.—U.S. imports for consumption of scrap and flake mica, by country

(Thousand pounds and thousand dollars)

Country	Waste and scrap		Ground or pulverized	
	Quantity	Value	Quantity	Value
1983	3,787	316	10,304	1,873
1984	10,384	985	12,814	2,266
1985:				
Canada	88	3	11,666	2,077
France	40	11	--	--
Germany, Federal Republic of	--	--	4	5
India	7,767	689	340	20
Japan	--	--	87	100
Madagascar	65	15	--	--
Total	7,960	718	12,097	2,202

Source: Bureau of the Census.

Table 13.—U.S. imports for consumption of unmanufactured sheet mica, by country

(Thousand pounds and thousand dollars)

Country	Block		Splittings		Not cut or stamped, not over 0.006 inch in thickness[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1983	44	169	1,577	608	278	209
1984	68	151	1,368	458	44	35
1985:						
Belgium	--	--	1	17	--	--
Brazil	7	28	--	--	--	--
Canada	--	--	--	--	5	11
France	9	42	(2)	2	--	--
Germany, Federal Republic of	--	--	3	3	--	--
Gibraltar	--	--	1	9	--	--
India	35	19	1,618	926	--	--
Japan	1	7	--	--	--	--
United Kingdom	2	16	--	--	--	--
Total[3]	55	112	1,624	957	5	11

[1]Including film.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 14.—U.S. imports for consumption of manufactured sheet mica, by country

(Thousand pounds and thousand dollars)

Country	Cut or stamped: Not over 0.006 inch in thickness		Cut or stamped: Over 0.006 inch in thickness		Plates and built-up		Articles not especially provided for	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1983	48	633	186	731	460	927	41	292
1984	114	517	152	610	467	1,007	123	702
1985:								
Belgium	--	--	--	--	568	1,094	(1)	3
France	--	--	--	--	47	84	29	79
Germany, Federal Republic of	--	--	--	--	--	--	7	7
India	43	330	52	271	3	14	19	356
Japan	16	172	64	251	43	219	8	26
Netherlands	--	--	(1)	7	64	111	(1)	1
United Kingdom	--	--	(1)	1	2	5	4	38
Other[2]	1	8	4	30	2	13	3	33
Total[3]	60	510	120	560	729	1,540	69	544

[1]Less than 1/2 unit.
[2]Includes Canada, China, Haiti, Hong Kong, Italy, Singapore, Spain, Switzerland, and Taiwan.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 15.—Summation of U.S. mica trade data

(Thousand pounds and thousand dollars)

	Scrap and flake mica				Sheet mica			
	Ground or pulverized		Waste and scrap[1]		Unmanufactured block, film, splittings		Manufactured, cut or stamped, built-up	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:								
1981	13,954	2,085	7,588	1,085	298	267	NA	7,001
1982	16,746	2,144	5,254	742	294	296	NA	5,499
1983	16,430	2,112	3,986	545	70	109	NA	4,001
1984	11,500	1,506	3,806	532	348	549	NA	4,519
1985	14,460	1,962	2,918	408	82	159	NA	5,103
Imports for consumption:								
1981	13,369	1,390	8,075	915	3,484	1,854	688	3,377
1982	10,824	1,724	5,030	427	3,173	1,449	724	2,936
1983	10,304	1,873	3,787	316	1,899	986	735	2,583
1984	12,814	2,266	10,384	985	1,480	644	856	2,836
1985	12,097	2,202	7,960	718	1,683	1,080	978	3,154

NA Not available.
[1]Some shipments of ground mica are included in this category.

Source: Bureau of the Census.

WORLD REVIEW

World production of mica decreased 12% to 538 million pounds, primarily because of decreased production of scrap and flake mica in the United States. India continued to lead the world in the production of sheet mica. The United States remained the leader in the production of scrap (flake) mica.

Canada.—The world's largest known phlogopite deposit and Canada's only commercial mica operation was purchased from Martin Marietta Corp. by Lacana Mining Corp. for about $6.5 million.[3] The purchase includes the deposit and operating mine at Lac Letondal in Suzor Township, Quebec, and a dry processing plant in Boucherville, near Montreal. Lacana is planning to double production over the next 18 to 24 months. Lacana also acquired an option on a muscovite mica deposit from Koizumi Group Canada Ltd. and plans to do some exploration work. The deposit is near Kaladar, Ontario.[4]

Finland.—Kemira Oy began operation of its new 22,000-ton-per-year mica processing plant in September. The plant, at Siilinjarvi, uses phlogopite separated by flotation at a nearby apatite plant. Various grades were produced ranging from coarse flakes for use in drilling muds to fine flakes suitable for use in paints, paper, and plastics. The company announced plans to begin operation of a pearlescent pigment plant at its Vuorikemia works in Pori in 1986. The plant will coat mica flakes with titanium dioxide using domestic phlogopite from the Siilinjarvi plant and imported muscovite. Products will be marketed for use in cosmetics, paints, printing inks, and plastics.[5]

India.—The Mica Trading Corp. of India Ltd. (MITCO) raised its floor prices for mica powder and flakes by 25%, effective March 1, 1985.[6] MITCO also began a concentrated effort to increase exports of mica to Japan, the Republic of Korea, and Singapore, in a continuing attempt to diversify its export market. All three countries are major importers of mica for use in electronics and electrical products manufacture and are believed to be promising targets for increased Indian export sales.[7]

Spain.—Cía. Minera Santa Comba S.A., one of Spain's principal flake mica producers, ceased mica production in 1983.[8] The bulk of the company's production had been exported to the United Kingdom for micronizing.

United Kingdom.—Wood Treatment Ltd. doubled its dry grinding plant capacity to about 11,000 tons per year in response to increased demand. Most of the plant feed was crude mica imported from China. A small amount of mica from Brazil was also ground.[9]

[1]Physical scientist, Division of Industrial Minerals.
[2]Production of high-quality sericite is included in the totals; however, figures for low-quality sericite, used principally for brick manufacturing, are not included.
[3]Mining Journal (London). V. 305, No. 7842, Dec. 6, 1985, p. 433.
[4]Jorgensen, B. Firm Pins Hopes on Mica Being Unseen but Ubiquitous. The Globe and Mail (Toronto), Jan. 10, 1986, p. B13.
[5]Griffith, J. Kemira Mica—Utilizing Resources. Ind. Miner. (London), No. 219, Dec. 1985, pp. 77-83.
[6]Industrial Minerals (London). No. 213, June 1985, p. 10.
[7]———. No. 214, July 1985, p. 11.
[8]———. No. 217, Oct. 1985, p. 59.
[9]———. No. 215, Aug. 1985, p. 15.

Table 16.—Mica: World production, by country[1]

(Thousand pounds)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina:					
Sheet	97	53	62	26	34
Waste, scrap, etc	1,012	481	628	613	620
Brazil	1,735	1,936	7,926	7,939	7,800
Canada[e]	24,000	22,000	23,000	23,000	25,000
France	19,972	17,527	20,472	23,929	22,000
India:					
Exports:					
Block	2,610	[e]2,400	[e]2,400	[e]2,400	2,200
Film and disk	768	[e]440	[r] [e]440	[r] [e]440	440
Splittings	7,303	[e]8,800	[e]7,000	[e]7,000	7,000
Scrap	14,274	[e]17,600	[e]15,500	[e]15,500	15,500
Powder	25,674	[e]11,000	[e]9,000	[e]9,000	9,000
Manufactured	925	[e]660	[e]1,100	[e]1,100	1,100
Domestic consumption, all forms[e]	6,600	6,600	6,600	6,600	7,700
Total	58,154	[e]47,500	[r] [e]42,040	[r] [e]42,040	42,940
Korea, Republic of (all grades)	[e]22,000	44,875	31,751	53,872	33,000
Madagascar (phlogopite)	844	2,866	1,585	1,587	1,500
Mexico (all grades)	4,579	1,124	3,439	3,695	3,500
Morocco	3,979	1,129	[e]1,100	2,646	2,600
Mozambique	660	326	681	[e]660	660
Namibia	--	--	220	198	--
Peru[e]	1,265	1,200	1,200	1,200	1,200
South Africa, Republic of:					
Sheet	--	--	--	--	[3]179
Scrap	5,280	3,871	5,891	9,872	[3]4,747
Spain	7,769	7,557	2,866	2,183	2,200
Sri Lanka (scrap)	401	642	377	[e]440	440
Sudan	4,409	364	22	22	22
Tanzania (sheet)	11	11	([4])	([4])	([4])
Taiwan	187	97	686	670	250
U.S.S.R. (all grades)[e]	104,000	106,000	108,000	108,000	110,000
United States:					
Sheet	NA	NA	NA	NA	NA
Scrap and flake[5]	266,000	212,000	280,000	322,000	[3]275,100
Yugoslavia	584	3,093	2,086	[r] [e]2,100	2,200
Zimbabwe	3,100	1,898	1,199	2,008	1,800
Grand total	[r]530,038	[r]476,550	535,231	608,700	537,792

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 13, 1986.
[2]In addition to the countries listed, China, Norway, Pakistan, Romania, and Sweden are known to produce mica, but available information is inadequate to make reliable estimates of output levels.
[3]Reported figure.
[4]Less than 1/2 unit.
[5]Excludes U.S. production of low-quality sericite.

Molybdenum

By John W. Blossom[1]

Domestic and foreign molybdenum markets remained imbalanced in 1985. Worldwide mine production exceeded demand, but domestic producer and consumer stocks were kept at a minimum. U.S. mine output of molybdenum increased 4.6% compared with that of 1984 and represented 50% of the world production. Reported end-use consumption of molybdenum in raw materials and apparent domestic demand increased compared with that of 1984. Exports of molybdenum from the United States remained level during 1985. Domestic producer stocks of molybdenum decreased by 5%, but confronted with stock inventories equivalent to about 1 year's consumption, domestic producers' prices were weak. World market prices were below those of most U.S. producer price listings for most of the year.

Domestic Data Coverage.—Domestic production data for molybdenum are developed by the Bureau of Mines by means of three separate, voluntary surveys. These surveys are the "Molybdenum Ore and Concentrate," "Molybdenum Concentrate and Molybdenum Products," and "Molybdenum Concentrates." Out of 13 operations to which surveys were sent, all responded, representing 100% of the total production shown in table 1.

Table 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Concentrate:					
Production	139,900	84,381	33,593	103,664	108,409
Shipments	118,916	76,135	48,805	102,405	111,936
Value	$945,540	$504,089	$166,612	$326,780	$347,812
Reported consumption	80,725	49,444	27,014	54,843	W
Imports for consumption	1,988	3,115	1,673	28	112
Stocks, Dec. 31: Mine and plant	35,043	38,510	11,637	12,450	9,322
Primary products:					
Production	105,824	65,381	37,533	79,689	87,436
Shipments	64,368	47,884	50,562	r65,527	73,861
Reported consumption	50,189	27,665	27,225	34,792	33,451
Stocks, Dec. 31: Producers	44,961	49,402	28,352	22,155	21,014
World: Mine production	r240,003	r209,336	140,585	p214,506	e215,139

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.

DOMESTIC PRODUCTION

Domestic mine production of molybdenum increased to a total of 108 million pounds of contained molybdenum, compared with 104 million pounds in 1984. The country's four largest producers were AMAX Inc., Cyprus Minerals Co. (formerly Cyprus Mines Corp.), Duval Corp., and Molycorp Inc., which together produced 87% of the year's total production. Domestic producers attempted to correct oversupply conditions by reducing production.

Table 2.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Molybdic oxides[1] 1984	Molybdic oxides[1] 1985	Metal powder 1984	Metal powder 1985	Ammonium molybdate 1984	Ammonium molybdate 1985
Received from other producers	4,889	9,989	--	--	1,527	W
Gross production during year	62,131	69,978	5,863	5,416	3,332	W
Used to make other products listed here	21,946	21,228	1,561	1,682	2,215	1,999
Net production	40,186	48,750	4,302	3,734	1,116	W
Shipments	50,253	58,984	4,178	3,968	W	W
Producer stocks, Dec. 31	17,295	16,281	594	W	684	W
	Sodium molybdate		**Other[2]**		**Total**	
Received from other producers	W	W	63	1,734	6,479	11,723
Gross production during year	W	W	8,363	12,042	79,689	87,436
Used to make other products listed here	W	W	614	626	26,336	25,535
Net production	W	W	7,749	9,417	53,353	61,901
Shipments	W	W	11,096	10,909	65,527	73,861
Producer stocks, Dec. 31	W	W	3,582	4,733	22,155	21,014

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes technical and purified molybdic oxide and briquets.
[2]Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, molybdic acid, molybdenum metal, pellets, molybdenum pentachloride, molybdenum hexacarbonyl, and data indicated by symbol W.

CONSUMPTION AND USES

The quantity of molybdenum in concentrate roasted domestically to produce technical-grade molybdic oxide increased above that of 1984. The remainder of the mine production of concentrate was either exported for conversion, purified to lubrication-grade molybdenum disulfide, or added to the stocks at mines and plants. The oxide, or roasted concentrate, is the chief form of molybdenum utilized by industry, particularly steel, cast iron, and superalloy producers. However, some of the material is also converted to other molybdenum products, such as ferromolybdenum, high-purity oxide, ammonium and sodium molybdate, and metal powder.

Apparent consumption (defined as U.S. primary plus secondary production plus imports minus exports plus adjustments for Government and industry stock changes) remained about the same, at 42 million pounds of molybdenum. The total reported end-use consumption of molybdenum in raw materials decreased about 4% from that of 1984. Molybdenum consumed in oxide form (technical-grade, purified, and briquets) accounted for about 60% of total reported consumption; in ferromolybdenum, 14%; and in other forms, 26%.

Molybdenum reported as consumed in the production of steel accounted for 57% of total consumption. Approximately 28% of consumption was attributed to other metallurgical uses, such as cast irons, superalloys, and as a refractory metal. Catalyst, lubricant, pigment, and other nonmetallurgical applications composed the final 15% of total consumption. Nearly all end-use areas remained about the same in molybdenum consumption when compared with those of 1984. Notable exceptions were high-strength, low-alloy steel (+46%), tool steel (-41%), cast iron (-36%), and full alloy steel (-12%).

Table 3.—U.S. reported consumption of molybdenum, by end use

(Thousand pounds of contained molybdenum)

End use	Molybdic oxides	Ferromolybdenum[1]	Ammonium and sodium molybdate	Other molybdenum materials[2]	Total
1984					
Steel:					
Carbon	787	101	--	2	890
Stainless and heat resisting	4,414	562	--	154	5,130
Full alloy	8,914	835	--	29	9,778
High-strength, low-alloy	1,094	531	--	25	1,650
Tool	2,165	569	--	27	2,761
Cast irons	407	1,208	--	24	1,639
Superalloys	1,230	156	--	1,604	2,990
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	172	--	19	191
Other alloys[3]	282	141	--	175	598
Mill products made from metal powder	--	--	--	4,507	4,507
Chemicals and ceramics:					
Pigments	W	--	302	--	302
Catalysts	2,601	W	W	187	2,788
Other	4	--	--	835	839
Miscellaneous and unspecified	327	87	260	55	729
Total	22,225	4,362	562	7,643	34,792
1985					
Steel:					
Carbon	704	138	--	--	842
Stainless and heat resisting	4,946	627	--	167	5,740
Full alloy	7,773	798	--	28	8,599
High-strength, low-alloy	1,342	1,075	--	W	2,417
Tool	1,204	418	--	W	1,622
Cast irons	W	1,049	--	W	1,049
Superalloys	1,368	W	--	1,788	3,156
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	168	--	W	168
Other alloys[3]	200	129	W	135	464
Mill products made from metal powder	--	--	--	4,621	4,621
Chemicals and ceramics:					
Pigments	W	--	W	--	W
Catalysts	1,977	--	W	299	2,276
Other	4	4	--	732	740
Miscellaneous and unspecified	697	144	766	150	1,757
Total	20,215	4,550	766	7,920	33,451

W Withheld to avoid disclosing company proprietary data.
[1]Includes calcium molybdate.
[2]Includes purified molybdenum disulfide, molybdenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal, pellets, and other molybdenum materials.
[3]Includes magnetic and nonferrous alloys.

STOCKS

Total industry stocks, which include those of producers and consumers, decreased by almost 10% to 35 million pounds of contained molybdenum. Inventories of molybdenum in concentrate at mine locations decreased from 12.4 to 9.3 million pounds. Producers' stocks of molybdenum in consumer products, such as oxide, ferromolybdenum, molybdate, metal powders, and other types, decreased from 22 million pounds at the beginning of the year to 21 million pounds by yearend. Compared with monthly molybdenum shipments, yearend producers' stocks of these materials totaled almost a 3.5-month supply. Domestic consumers held inventories of about 4 million pounds throughout most of the year, representing approximately a 1.5-month supply compared with average monthly reported consumption.

Table 4.—Industry stocks of molybdenum materials, December 31

(Thousand pounds of contained molybdenum)

Material	1981	1982	1983	1984	1985
Concentrate: Mine and plant	35,043	38,510	11,637	12,450	9,322
Producers:					
Molybdic oxides[1]	38,999	41,855	22,991	17,295	16,281
Metal powder	507	443	503	594	W
Ammonium molybdate	1,075	1,072	1,038	684	W
Sodium molybdate	27	48	79	W	W
Other[2]	4,353	5,984	3,741	3,582	4,733
Total	44,961	49,402	28,352	22,155	21,014
Consumers:					
Molybdic oxides[1]	3,217	2,103	1,467	1,552	2,020
Ferromolybdenum[3]	914	616	570	721	597
Ammonium and sodium molybdate	167	76	70	80	47
Other[4]	1,467	1,386	1,567	1,540	1,778
Total	5,765	4,181	3,674	3,893	[5]4,441
Grand total	85,769	92,093	43,663	38,498	34,777

W Withheld to avoid disclosing company proprietary data.

[1]Includes technical and purified molybdic oxide and briquets.

[2]Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, molybdic acid, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

[3]Includes calcium molybdate.

[4]Includes purified molybdenum disulfide, molybdenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal, pellets, and other molybdenum materials.

[5]Data do not add to total shown because of independent rounding.

PRICES

The price of molybdic oxide (per pound of contained molybdenum) increased from \$2.88 in January to \$4.43 in March, then declined to the year's low of \$2.60 at the end of December. The average price of oxide was \$3.33 or \$0.23 less than the average price in 1984.

Table 5.—Domestic price listings for molybdenum

(Per pound)

	1984	1985
Producer quotes:		
Concentrate	\$3.36	\$3.18
Ferromolybdenum-export	4.32	3.91
Oxide	3.56	3.33

FOREIGN TRADE

Exports.—Exports of molybdenum in concentrate and oxide remained nearly level at about 64 million pounds for 1985. Molybdenum concentrate exports were about 59% of domestic mine production. Approximately 96% of reported concentrate and oxides was shipped to Belgium-Luxembourg, the Federal Republic of Germany, Japan, the Netherlands, and the United Kingdom. The calculated molybdenum content of all exports remained constant at 76 million pounds. Total value of exports decreased from \$318 million in 1984 to \$316 million in 1985.

Imports.—Approximately 5 million pounds of molybdenum in various forms was imported into the United States, a decrease of about 3 million pounds from that in 1984. This quantity represented 12% of apparent consumption. Total value of all forms of molybdenum imported decreased 32% from \$38 million in 1984 to \$26 million in 1985. In terms of both value and quantity, the major forms imported were as ore and concentrate and as materials in chief value molybdenum. The principal originating countries for these imports were Canada and Chile.

Table 6.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

	1984	1985
Molybdenite concentrate	41,687	38,646
Molybdic oxide	24,553	36,268
All other primary products	1,424	1,385

Table 7.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by country

(Thousand pounds of contained molybdenum and thousand dollars)

	1983		1984		1985	
	Quantity	Value	Quantity	Value	Quantity	Value
Austria	2,179	8,105	--	--	31	50
Belgium-Luxembourg	4,354	20,171	5,146	22,629	5,743	30,114
Brazil	55	246	82	258	153	627
Canada	475	1,377	281	632	780	1,979
Chile	1,394	1,988	208	679	102	377
France	274	593	--	--	--	--
Germany, Federal Republic of	6,148	20,918	6,576	14,936	3,379	7,758
Japan	4,531	17,706	6,896	25,979	7,031	26,202
Mexico	13	52	(1)	1	71	135
Netherlands	20,700	95,598	34,914	150,558	40,076	160,250
Sweden	1,475	3,032	789	1,674	949	2,896
United Kingdom	5,208	14,336	7,863	23,057	4,991	15,463
Other	262	1,000	611	2,367	552	1,840
Total[2]	47,068	185,122	63,366	242,770	63,859	247,690

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 8.—U.S. exports of molybdenum products, by country

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1984		1985	
	Quantity	Value	Quantity	Value
Ferromolybdenum:[1]				
Australia	118	240	14	73
Canada	37	133	86	285
Japan	--	--	72	149
Malaysia	1	4	--	--
Mexico	66	169	34	93
Philippines	(2)	1	--	--
South Africa, Republic of	16	50	--	--
Other	411	970	1,055	2,098
Total[3]	650	1,567	1,262	2,698
Metal and alloys in crude form and scrap:				
Belgium	8	84	--	--
Canada	57	242	15	114
France	8	80	1	13
Germany, Federal Republic of	83	96	145	438
India	--	--	2	19
Japan	30	198	170	700
Mexico	--	--	67	174
Netherlands	61	98	21	206
Spain	1	8	--	--
United Kingdom	53	357	30	265
Other	5	45	122	436
Total[3]	306	1,209	574	2,365
Wire:				
Argentina	2	52	8	78
Australia	1	9	--	--
Bahamas	78	120	--	--

See footnotes at end of table.

Table 8.—U.S. exports of molybdenum products, by country —Continued

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1984 Quantity	1984 Value	1985 Quantity	1985 Value
Wire —Continued				
Belgium-Luxembourg	9	138	85	190
Brazil	18	309	21	366
Canada	22	514	29	573
France	6	95	2	38
Germany, Federal Republic of	92	859	119	1,470
India	3	47	1	34
Italy	26	374	36	449
Japan	97	1,327	71	1,395
Mexico	15	548	11	340
Netherlands	21	526	(2)	8
Singapore	1	13	1	8
South Africa, Republic of	(2)	3	(2)	1
Spain	27	326	51	203
Sweden	11	196	15	201
United Kingdom	7	100	33	277
Other	39	400	62	499
Total[3]	474	5,954	546	6,130
Powder:				
Australia	(2)	2	--	--
Belgium-Luxembourg	--	--	(2)	2
Canada	4	33	10	103
France	25	362	11	111
Germany, Federal Republic of	16	73	45	147
Italy	2	33	(2)	6
Japan	23	191	45	335
Mexico	37	174	5	60
Netherlands	(2)	3	126	477
Sweden	6	39	--	--
Taiwan	148	1,668	116	886
United Kingdom	11	65	5	47
Other	189	630	5	124
Total[3]	461	3,272	369	2,298
Semifabricated forms, n.e.c.:				
Australia	3	74	2	54
Belgium-Luxembourg	1	25	7	153
Brazil	31	752	15	430
Canada	33	655	13	347
France	13	367	16	681
Germany, Federal Republic of	36	667	79	1,215
Japan	41	1,074	55	351
Mexico	2	44	8	141
Netherlands	29	873	34	933
Philippines	1	7	(2)	4
Singapore	(2)	12	(2)	7
South Africa, Republic of	1	16	1	81
United Kingdom	57	1,411	90	2,085
Other	9	390	89	1,909
Total[3]	257	6,368	408	8,390
Molybdenum compounds:				
Argentina	(2)	6	(2)	3
Australia	175	452	274	676
Belgium-Luxembourg	4,688	8,346	2,755	4,797
Brazil	5	26	6	30
Canada	513	1,937	137	494
Germany, Federal Republic of	1,296	2,481	3,113	5,421
Japan	5,127	14,908	4,018	10,063
Mexico	7	23	7	76
Netherlands	6,746	13,097	6,956	12,946
Sweden	953	1,816	1,600	2,970
Switzerland	7	25	--	--
United Kingdom	2,644	5,133	3,000	5,547
Other	4,440	8,204	1,903	3,087
Total[3]	26,602	56,453	23,769	46,109

[1]Ferromolybdenum contains about 60% to 65% molybdenum.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of molybdenum

(Thousand pounds and thousand dollars)

Item	TSUS No.	1984 Gross weight	1984 Contained molybdenum	1984 Value	1985 Gross weight	1985 Contained molybdenum	1985 Value
Ore and concentrate	601.33	46	28	183	182	112	566
Material in chief value molybdenum	603.40	8,800	5,266	19,441	4,173	2,239	7,329
Ferromolybdenum	606.31	2,086	1,545	4,438	1,424	945	3,721
Waste and scrap	628.70	NA	437	2,565	NA	517	2,830
Unwrought	628.72	NA	142	2,170	NA	145	2,370
Wrought	628.74	132	NA	3,023	94	NA	2,301
Ammonium molybdate	417.28	95	54	287	386	223	1,028
Molybdenum compounds	419.60	883	599	2,547	872	578	2,563
Sodium molybdate	421.10	183	108	319	365	205	721
Mixtures of inorganic compounds, chief value molybdenum	423.88	250	42	731	38	7	88
Molybdenum orange	473.18	2,026	NA	2,367	2,154	NA	2,278
Total[1]		14,501	8,221	38,071	9,686	4,969	25,794

NA Not available.
[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 10.—U.S. import duties on molybdenum

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Molybdenum ore and concentrate	601.33	9.8 cents per pound	9 cents per pound	35 cents per pound.
Material in chief value molybdenum	603.40	7 cents per pound plus 2.2% ad valorem.	6 cents per pound plus 1.9% ad valorem.	50 cents per pound plus 15% ad valorem.
Ferromolybdenum	606.31	5.2% ad valorem	4.5% ad valorem	31.5% ad valorem.
Molybdenum:				
Waste and scrap	628.70	7.1% ad valorem	6% ad valorem	50% ad valorem.
Unwrought	628.72	7.2 cents per pound plus 2.2% ad valorem.	6.3 cents per pound plus 1.9% ad valorem.	50 cents per pound plus 15% ad valorem.
Wrought	628.74	8.1% ad valorem	6.6% ad valorem	60% ad valorem.
Molybdenum chemicals:				
Ammonium molybdate	417.28	4.8% ad valorem	4.3% ad valorem	29% ad valorem.
Calcium molybdate	418.26	do	4.7% ad valorem	24.5% ad valorem.
Molybdenum compounds	419.60	3.4% ad valorem	3.2% ad valorem	20.5% ad valorem.
Potassium molybdate	420.22	3.2% ad valorem	3% ad valorem	23% ad valorem.
Sodium molybdate	421.10	4.1% ad valorem	3.7% ad valorem	25.5% ad valorem.
Mixtures of inorganic compounds, chief value molybdenum	423.88	3% ad valorem	2.8% ad valorem	18% ad valorem.
Molybdenum orange	473.18	4% ad valorem	3.7% ad valorem	25% ad valorem.

WORLD REVIEW

World mine production of molybdenum was 215 million pounds, about the same production as that of 1984. Canada, Chile, the U.S.S.R., and the United States accounted for more than 89% of the molybdenum produced worldwide. Although comprehensive statistics on world consumption were not available, market evidence clearly indicated that supply exceeded demand. World molybdenum consumption remained level, and stocks continued to decrease but exceeded more than 1 year's demand.

Canada.—Molybdenum production (shipments) in Canada decreased by about 32% in 1985 from that in 1984.

Brenda Mines Ltd. restarted production on September 15 following an agreement reached with the Commission of Critical Industries of British Columbia.

Lornex Mining Corp. Ltd.'s copper-molybdenum mine returned to profitability after 1 year of operating at a loss. Output of molybdenum at the Highland Valley Mine increased 14% during 1985.

Chile.—Molybdenum production from Corporación Nacional del Cobre de Chile (CODELCO-Chile) increased 9% compared with that of 1984. Much of CODELCO-Chile's production came from the Chuquicamata Mine, the largest copper mine in the world.

[1]Physical scientist, Division of Ferrous Metals.

Table 11.—Molybdenum: World mine production, by country[1]

(Thousand pounds of contained molybdenum)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Bulgaria[e]	330	[r]375	[r]420	[r]420	420
Canada (shipments)	[r]28,329	[r]30,779	22,474	25,479	16,730
Chile	33,863	44,198	33,651	37,172	[3]40,543
China[e]	4,400	4,400	4,400	4,400	4,400
Japan[e]	163	214	214	[r]324	215
Korea, Republic of	1,023	796	313	348	660
Mexico	994	11,442	12,932	8,938	8,150
Mongolia[e]	1,460	1,830	2,120	2,200	2,200
Niger	249	93	[e]88	[e]73	73
Peru	5,485	6,378	5,794	6,788	[3]8,439
Philippines	207	150	86	--	--
U.S.S.R.[e]	23,600	24,300	[r]24,500	24,700	24,900
United States	139,900	84,381	33,593	103,664	[3]108,409
Total	[r]240,003	[r]209,336	140,585	214,506	215,139

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 17, 1986.

[2]In addition to the countries listed, North Korea, Romania, Turkey, and Yugoslavia are believed to produce molybdenum, but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.

[3]Reported figure.

Nickel

By Peter G. Chamberlain[1]

Calculated apparent nickel demand in the United States was about the same as that of 1984. However, reported consumption of nickel in stainless and heat-resistant steels, alloy steels, copper-nickel alloys, and other nickel-based alloys decreased. Superalloys and miscellaneous uses provided the only major gains in consumption. In addition to being an important constituent of stainless steel, nickel formed a critical component of essential alloys in electronics, aerospace, and other applications. Consequently, nickel production, consumption, and trade impacted these major industrial sectors.

Worldwide, the nickel production in 1985 continued to rebound from its 1982 low. World demand did not keep pace, however,

Table 1.—Salient nickel statistics

(Short tons of contained nickel unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Mine production:					
Nickel ore (gross weight)	1,794,000	432,488	--	1,674,600	868,100
Shipments	12,099	3,203	--	14,540	6,127
Plant production:					
Smelter, from domestic ores (includes byproduct nickel)	10,305	3,456	W	9,604	5,214
Refinery, from imported matte	38,500	41,500	33,400	35,329	31,168
Secondary recovery, from purchased scrap:[e]					
From ferrous scrap	34,459	30,034	30,076	[r]35,760	[p]41,151
From nonferrous scrap	17,617	12,934	19,776	[r]19,407	16,032
Exports:					
Primary (unwrought)	19,674	37,356	23,359	[r]31,638	21,745
Total (gross weight)	46,836	57,029	43,913	[r]58,525	51,429
Imports for consumption:					
Primary	209,008	129,787	152,333	176,715	157,690
Primary (gross weight)	306,747	177,493	215,361	249,929	220,349
Total (gross weight)	315,837	186,913	225,537	264,778	236,001
Consumption:					
Reported:					
Primary	144,851	103,981	127,845	136,861	119,907
Secondary (purchased scrap)[e]	43,768	35,690	42,034	49,649	[p]43,903
Apparent:					
Primary	153,994	138,032	[r]154,148	[r]155,395	161,973
Secondary (purchased scrap)[e]	52,076	42,968	49,852	[r]55,167	[p]57,183
Stocks, yearend:					
Producer	100,000	62,000	38,500	37,300	13,300
Consumer:					
Primary	22,508	18,853	20,448	20,934	19,106
Secondary[e]	11,326	10,004	10,304	6,520	[p]6,320
Employment, yearend:					
Mine	160	160	160	130	130
Smelter	230	230	230	170	170
Refinery	NA	420	420	420	--
Price (cathode):[1]					
Producer (North American), per pound	$3.43	$3.20	XX	XX	XX
New York dealer, per pound	$2.65	$2.24	$2.20	$2.22	$2.26
World: Mine production	[r]800,032	[r]681,715	735,359	[p]832,592	[e]856,749

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Weighted average calculated by Metals Week.

sustaining a serious oversupply. World mine capacity continued to exceed production by 25%.

Concerns over short-term nickel supplies pushed the nickel price upwards during the first half of the year. However, the excess supply situation that developed in the second half of the year drove the price down to its lowest level since early 1983.

The major event affecting the domestic nickel producers was the closure of AMAX Nickel Inc.'s Port Nickel refinery in Braithwaite, LA. The refinery was the country's only primary nickel-cobalt refinery. The M.A. Hanna Co., formerly Hanna Mining Co., temporarily closed its integrated nickel mine and smelter at midyear to install a wet screening unit at the mine and a slurry transportation system to haul the ore to the smelter.

Domestic Data Coverage.—Domestic primary production data for nickel are obtained by the Bureau of Mines from a survey of the single integrated nickel mine-smelter and from another survey of the two copper refineries that produced byproduct nickel. Domestic consumption data for nickel are developed by the Bureau from a voluntary survey of U.S. operations. Of the 375 operations to which a survey request was sent, 340 responded, representing 74% of the apparent primary nickel consumption shown in table 4. Apparent consumption of primary nickel was estimated using U.S. primary production plus imports minus exports plus adjustments for Government and industry stock changes.

Legislation and Government Programs.—The General Services Administration (GSA) received 5,014 short tons of vacuum-melting-grade nickel for the National Defense Stockpile. The material, purchased in late 1984, brought the yearend inventory to 37,223 tons, well below the goal of 200,000 tons.

On July 8, the President approved recommendations by the National Security Council (NSC) for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, nickel would be categorized in tier II, and the goal would be 5,000 tons. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The U.S. Department of the Treasury, Bureau of the Mint, solicited bids on March 8, 1985, for copper-nickel coin blanks instead of the raw metal usually purchased. The purpose was to cut fabrication costs and shift expenses from normal operating funds to the special Mint coinage fund. Concerns raised by domestic mills and members of Congress that foreign bidders would have a built-in cost advantage convinced the Mint, however, not to award any contracts under the solicitation. Arrowhead Metals Ltd., Toronto, Canada—the lowest bidder—unsuccessfully challenged the decision to drop the solicitation in Federal courts. Meanwhile, the Mint purchased 1,700 tons of nickel under three tenders for processing into coins according to the past practices. Most was purchased from trading companies with U.S. offices; AMAX Nickel provided 263 tons as one of its last sales before ceasing primary nickel production.

U.S. Geological Survey (USGS) continued exploring and evaluating the Exclusive Economic Zone for seafloor mineral resources, particularly cobalt-nickel-manganese crusts. The U.S. Department of the Interior's Minerals Management Service (MMS) established a new office, the Office of Strategic and International Minerals, to formulate policies for exploring and developing minerals from the Outer Continental Shelf. An interagency working group consisting of the USGS, National Oceanic and Atmospheric Administration, and MMS completed draft regulations on such activities. MMS financed detailed geologic and hydrothermal studies of the Gorda Ridge crust deposit off the Oregon coast. The Gorda Ridge Technical Task Force, consisting of State and Federal representatives, formulated recommendations to the Secretary of the Interior regarding future leasing.

Possible seafloor mineral development moved closer to reality near Hawaii as the Hawaiian Task Force reviewed mine development scenarios, developed leasing plans, and began overseeing an Environmental Impact Statement (EIS). MMS sponsored an additional data-gathering cruise over the Cross Seamounts site, one of the most promising crust deposits near Hawaii.

Congress failed to enact legislation reauthorizing the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund) prior to its expiration on September 30. Moreover, no Superfund legislation passed by yearend. Money from the Superfund is critical to maintaining the Environmental Protection Agency's hazardous waste cleanup program.

The President signed legislation, Senate bill 883, into law in July. The law extended the Export Administration Act, which restricts exports of many nickel and cobalt strategic alloys. Although the act's Commodity Control List remained unchanged, export licensing regulations were loosened for trade with countries that are members of the Free World Coordinating Committee of Western Trading Partners. The extension also restricted the President's ability to block existing export contracts for political purposes.

DOMESTIC PRODUCTION

Hanna closed its mine and ferronickel smelter at Riddle, OR, on June 15 for construction of a wet screening system at the mine. The system is expected to concentrate the ore by a factor of two with attendant savings in haulage and roasting costs. A new ore transportation system was also installed during the $13 million capital improvement program. Prior to undertaking the modifications, Hanna received a 5-year extension to the reduced-power-rate agreement with the Bonneville Power Administration. The company also negotiated a 5-year labor contract with the union before committing funds to improvements. Although the mine reopened in October, most activity was devoted to fine-tuning the new systems. Hanna had not refired its smelter furnaces by yearend. Consequently, U.S. mine and smelter production in 1985 was one-half that of 1984.

AMAX Nickel closed its Port Nickel refinery in Braithwaite, LA, on November 30. This action left the Nation with no primary nickel or cobalt refining capacity. During events culminating in the closure, AMAX Nickel released Bamangwato Concessions Ltd. (BCL) of Botswana from its contract to supply AMAX Nickel with nickel matte for the refinery. AMAX Nickel also contracted to resell the matte that it purchased from Agnew Mining Co. Pty. Ltd., Australia, to Sherritt Gordon Mines Ltd., Canada, and Outokumpu Oy, Finland. The refinery had received about 60% of its matte feedstock from BCL and 40% from Agnew. The closure dropped domestic refinery production 12% from that of 1984.

The U.S. Forest Service informed California Nickel Corp., the U.S. exploration and mining subsidiary of Ni-Cal Development Ltd., that additional information was needed for the EIS on a proposed nickel bulk sampling operation at Gasquet Mountain. The administrative order rescinded the Forest Service District's tentative approval of California Nickel's operating plan. The company conducted additional studies on tailing characteristics to fulfill the additional requirements pursuant to the order.

Ni-Cal Technology Ltd., another subsidiary of Ni-Cal Development, received permission from the Del Norte County Planning Commission in California to construct a research laboratory and an 85-ton-per-day demonstration plant near Smith River, CA. Ni-Cal Technology intended to test its acid leaching process, developed for the Gasquet Mountain deposit, at the facility preparatory to world marketing efforts. Environmental groups brought court action against the commission, however, to block the approval. When the court judgment imposed additional environmental data-gathering requirements on the company as a prerequisite for approval, Ni-Cal Technology dropped the pilot plant from further consideration.

Davy McKee Corp. completed its preliminary assessment of the Pine Flat nickel laterite deposit in northern California for Interstrat Resources Inc. The favorable assessment spawned a full engineering and cost study, initiated in November, on the feasibility of producing nickel, chromium, cobalt, and magnesium from the site. A sulfuric acid leaching system was contemplated.

In contrast to the minor domestic production of primary nickel, the production of domestic secondary nickel in the form of scrap recovery was a major source of nickel for many consumers. Since the Bureau of Mines documents only the recovery of nickel in scrap that is consumed, recovery and consumption figures are essentially the same. Recovery of nickel in scrap increased, reflecting the availability of low-cost stainless steel scrap, the major scrap form. The nickel recovered from scrap stainless steel was calculated from the gross weight of the scrap and an estimated nickel content of 6%, which is the weighted-average content in all stainless steels produced since 1962.

Table 2.—Nickel recovered from purchased scrap in the United States, by kind of scrap and form of recovery[e]

(Short tons of contained nickel)

	1984[r]	1985
KIND OF SCRAP		
Aluminum-base	2,449	121
Copper-base	3,500	2,503
Ferrous-base	35,760	[p]41,151
Nickel-base	13,458	13,408
Total	55,167	[p]57,183
FORM OF RECOVERY		
Aluminum-base alloys	2,547	118
Chemical compounds	391	--
Copper-base alloys	7,938	10,635
Ferrous alloys	36,855	[p]41,283
Metal	--	--
Nickel-base alloys	7,436	5,147
Total	55,167	[p]57,183

[e]Estimated. [p]Preliminary. [r]Revised.

CONSUMPTION

Reported domestic primary nickel consumption decreased considerably from that of 1984. Consumption shrank in stainless and heat-resistant steels, alloy steels, copper-nickel alloys, and other nickel-based alloys. Nickel consumption gained appreciably only in superalloys and miscellaneous uses; in electroplating, it remained essentially unchanged. Despite the drop in reported consumption, the apparent primary consumption changed only slightly from that of 1984. The market was lethargic despite gains in such economic indicators as the gross national product, consumer purchases of durable goods, and construction spending. Clearly, factors in addition to the general economic health controlled nickel demand. The resultant diminishing "intensity of use" pervaded essentially all major nickel consuming industries.[2] Other materials, particularly plastics, continued to be preferred over nickel in finished products used in nonstressful environments. A ubiquitous trend toward lightness and economy fostered these substitutions. Imports of nickel alloys and fabricated products containing such alloys also decreased domestic consumption of primary nickel.

Commercially pure unwrought nickel (Class I) in the form of electrolytic cathodes, pellets, briquets, or powder again dominated the forms of primary nickel consumed. These forms comprised most of the nickel consumed in all products except in stainless and heat-resistant steels wherein they were a major but not dominant nickel source. Cathodes and pellets comprised 73% of the pure unwrought nickel. The Class II materials—ferronickel, nickel oxide, oxide sinter, and utility-grade nickel—were primarily used in producing stainless and heat-resistant steels.

Consumption of nickel in scrap was a major form of consumption in stainless steel production. Since the value of stainless steel scrap was generally less than the value of the sum of its primary components (nickel, chromium, and iron), steelmakers charged furnaces with as much scrap as was available. The nickel consumed as outside scrap (old and new scrap received by the consumer from outside sources, generally through purchases) contributed an estimated 40% of the total nickel consumed in producing stainless steel, about the same as that of 1984. Consumption statistics include only this outside scrap to avoid double counting.

The use of scrap nickel in producing nonferrous alloys remained constant at about one-fourth of the nickel consumed in those alloys. About one-half of nickel in cast iron originated as outside scrap. For chemicals, essentially none of the nickel was secondary. For steel alloys, excluding stainless and heat-resistant steels, less than 10% of the nickel consumed was consumed in the form of outside scrap.

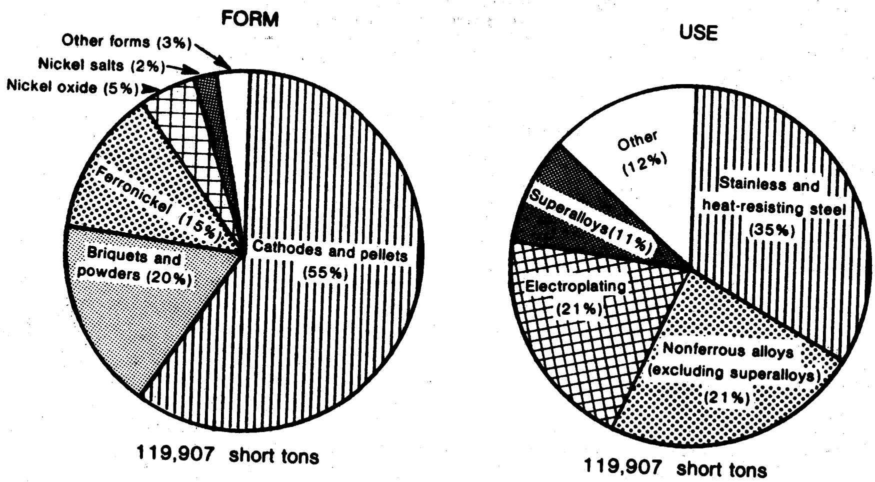

Figure 1.—U.S. nickel consumption in 1985, by form and use.

Table 3.—U.S. consumption of nickel,[1] by form

(Short tons of contained nickel)

Form	1981	1982	1983	1984	1985
Primary:					
Ferronickel	26,290	15,426	15,595	18,419	17,993
Metal	101,847	79,032	96,981	104,958	90,379
Oxide powder and oxide sinter	9,412	4,196	9,670	7,087	6,297
Salts[2]	4,197	3,874	4,402	2,962	2,770
Other	3,105	1,453	1,197	3,435	2,468
Total primary	144,851	103,981	127,845	136,861	119,907
Secondary (scrap)[3]	43,768	35,690	42,034	49,649	[p]43,903
Grand total	188,619	139,671	169,879	186,510	163,810

[p]Preliminary.
[1]Reported.
[2]Metallic nickel salts consumed by plating industry are estimated.
[3]Based on gross weight of purchased scrap consumed and estimated average nickel content.

Table 4.—U.S. consumption of nickel in 1985, by use

(Short tons of contained nickel)

Use	Commercially pure nickel	Ferronickel	Nickel oxide	Nickel salts	Other primary forms	Total primary	Secondary[e] (scrap)	Grand total
Cast irons	729	356	98	W	337	1,520	1,588	3,108
Chemicals and chemical uses	1,580	--	223	104	147	2,054	--	2,054
Electric, magnet, expansion alloys	733	--	--	--	1	734	70	804
Electroplating (sales to platers)[1]	22,354	W	W	2,496	18	24,868	--	24,868
Nickel-copper and copper-nickel alloys	3,895	--	9	--	329	4,233	10,635	14,868
Other nickel and nickel alloys	19,454	388	255	27	66	20,190	5,082	25,272
Steel:								
Stainless and heat-resistant	20,811	15,847	5,185	--	78	41,921	p26,055	67,976
Alloys (excludes stainless)	6,458	1,235	269	--	1,351	9,313	p290	9,603
Superalloys	13,361	W	W	W	105	13,466	148	13,614
Other[2]	1,004	167	258	143	36	1,608	35	1,643
Total reported by companies canvassed	90,379	17,993	6,297	2,770	2,468	119,907	43,903	163,810
Total all companies, apparent primary	XX	XX	XX	XX	XX	[3]161,973	p57,183	219,156

[e]Estimated. [p]Preliminary. W Withheld to avoid disclosing company proprietary data; included with "Other."
XX Not applicable.
[1]Based on monthly estimates.
[2]Includes batteries, ceramics, and other alloys containing nickel.
[3]U.S. production plus imports minus exports minus stock increases.

STOCKS

The combined stocks of primary nickel maintained in the United States by U.S. producers, foreign producers with U.S. sales offices, and metal trading companies with U.S. sales offices decreased sharply during the year. At yearend, these stocks represented slightly over 1 month's domestic consumption. Much of the drop was attributed to the closure of AMAX Nickel's refinery and the attendant liquidation of its inventory.

Nickel stocks on the London Metal Exchange (LME) remained fairly constant after their big decrease in 1984. The yearend inventory was about 7,100 tons compared with 8,100 tons at yearend 1984.

Consumer stocks declined steadily throughout the year. In December, a buying surge by a few companies, however, swelled the yearend inventory to nearly the same amount as at yearend 1984. Although consumer stocks averaged about 1 month's domestic consumption, the yearend level reached about 6 weeks' consumption. Stocks of nickel in ferrous scrap held by iron and steel producers were about the same at yearend as they were at yearend 1984.

GSA received 5,014 tons of vacuum-melting-grade nickel, purchased in 1984, for the National Defense Stockpile. This raised the total nickel stocks to 37,223 tons, considerably less than the 200,000-ton goal.

Table 5.—Nickel in consumer stocks in the United States, by form

(Short tons of contained nickel)

Form	1981	1982	1983	1984	1985
Primary:					
Ferronickel	2,257	1,122	893	692	1,930
Metal	18,355	16,743	17,359	17,479	13,754
Oxide and oxide sinter	1,039	488	1,677	2,259	3,059
Salts	508	226	268	229	184
Other	349	274	251	275	179
Total primary	22,508	18,853	20,448	20,934	19,106
Secondary (scrap)	11,326	10,004	10,304	6,520	p6,320
Grand total	33,834	28,857	30,752	r27,454	25,426

[p]Preliminary. [r]Revised.

PRICES

The world nickel price was more volatile than it was in 1983 and 1984. Fueled by concerns over the short-range supply of nickel, the price climbed steadily during most of the first half of the year. By May, the average monthly price exceeded $2.50 per pound in the LME compared with $2.24 per pound in January. In June, however, supply concerns dissipated when the U.S.S.R. and Nonoc Mining and Industrial Corp., Philippines, renewed nickel shipments to the LME. In September, heavy shipments of ferronickel into European markets drove the nickel price lower, demonstrating the existence of a considerable oversupply of the material. The collapse of the International Tin Council's buffer stock acquisition program in October further lowered the price amid concerns over the future trading of all base metals. The LME price eventually hit a 3-year low of $1.77 per pound before recovering at yearend. The weighted-average LME price for 1985 was $2.258 per pound for prompt delivery.[3]

In the United States, the New York dealer selling price for electrolytic cathode nickel best indicated prices paid by domestic consumers. At a weighted-annual average of $2.26 per pound, it closely paralleled the LME price. An overabundance of ferronickel kept its price lower than the cathode and briquet price despite the contained iron credits. Although the producer list prices remained about $3.20 per pound, major producers discounted nickel prices to levels that yielded 10 to 15 cents per pound more than the LME price. One producer, for instance, realized an average of $2.39 per pound for its nickel over the year.

FOREIGN TRADE

Since the U.S. net import reliance for nickel was 72%, nickel imports dominated trade statistics. Nickel originating from Canada comprised the major import tonnage, especially considering that most of the nickel imported from Norway was mined and smelted in Canada before being shipped to Kristiansand, Norway, for refining. Imports from Australia and Botswana remained important because nickel matte purchased from sources in those countries supplied AMAX Nickel's Port Nickel refinery in Louisiana until it closed in November.

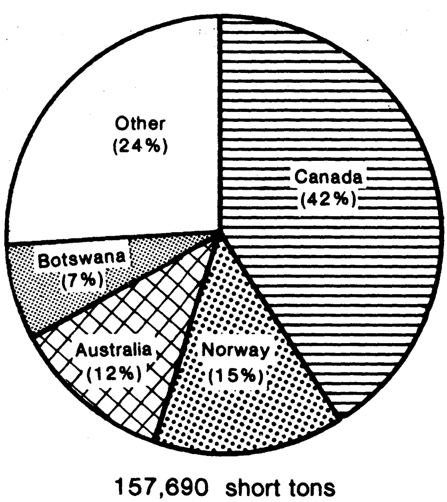

Figure 2.—Major sources of U.S. primary nickel imports in 1985.

An international advisory panel to the General Agreement on Tariffs and Trade (GATT) recommended that voluntary restraint agreements should be brought into conformance with GATT rules. The panel, which included a U.S. representative, concluded that trade agreements such as that of steel between the United States and the European Economic Community, as well as the U.S. import restraints negotiated with Japanese automakers, violate the free trade principles agreed upon by GATT signatory nations. The recommendations reportedly may lead to a revamping of GATT.

Table 6.—U.S. exports of nickel and nickel alloy products, by class

(Gross weight unless otherwise specified)

Class	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Primary:						
Cathodes, pellets, briquets (unwrought)	22,165	$99,097	25,997	$118,453	17,761	$86,596
Electroplating anodes	177	1,235	140	965	132	965
Ferronickel	NA	NA	7,880	NA	5,355	NA
Powder and flakes	1,017	6,973	1,790	12,062	1,106	8,942
Total	23,359	107,305	r35,807	131,480	24,354	96,503
Nickel content[1]	23,359	XX	31,638	XX	21,745	XX
Wrought:						
Bars, rods, angles, shapes, sections	1,582	18,747	3,342	34,808	4,253	45,060
Plates, sheets, strip	1,430	18,351	1,968	21,316	2,645	28,726
Tubes, pipes, blanks, fittings, hollow bar	348	7,447	428	7,929	303	6,356
Wire	1,039	8,831	1,119	11,166	954	9,147
Nickel-compound catalysts	3,165	13,940	2,718	15,156	3,523	22,811
Nickel waste and scrap	12,990	17,106	13,143	23,566	15,397	26,705
Grand total	43,913	191,727	r58,525	245,421	51,429	235,308

rRevised. NA Not available. XX Not applicable.
[1]Based on estimated nickel content and gross weight of primary nickel products.

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of nickel products, by class

(Gross weight unless otherwise specified)

Class	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Primary:						
Smelter products:						
Ferronickel	45,134	$65,264	43,048	$68,429	36,528	$60,253
Matte and/or salts (includes slurry)	62,454	83,613	82,509	116,956	68,210	101,101
Refined nickel:						
Cathodes, pellets, briquets (unwrought)	90,839	418,943	103,017	461,371	97,779	446,009
Flakes	96	427	759	3,306	242	1,151
Oxide and oxide sinter	4,209	19,083	5,526	22,413	5,079	20,722
Powder	12,629	65,320	15,070	75,430	12,511	66,566
Total	215,361	652,650	249,929	747,905	220,349	695,802
Nickel content[1]	152,333	XX	176,715	XX	157,690	XX
Wrought:						
Bars, plates, sheets, anodes	1,235	11,531	2,000	18,036	3,177	32,276
Pipes, tubes, fittings	575	54,774	1,171	11,034	3,744	33,984
Rods and wire	2,241	17,935	5,419	28,544	2,990	22,103
Shapes, sections, angles	54	313	60	506	189	1,297
Nickel waste and scrap	6,071	17,691	6,199	20,542	5,552	16,430
Grand total	225,537	754,894	264,778	826,567	236,001	801,892

XX Not applicable.
[1]Based on estimated nickel content and gross weight of primary nickel products.

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption of nickel products, by country

(Short tons of contained nickel)

Country	Cathodes, pellets, briquets (unwrought)		Powder and flakes		Oxide and oxide sinter		Ferronickel		Matte and salts[e] (includes slurry)	
	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
Australia	7,680	8,428	3,545	2,306	--	--	--	--	13,487	7,803
Botswana	75	--	--	--	--	--	--	--	21,324	11,244
Canada	55,689	52,130	10,644	8,433	4,255	3,770	--	242	1,961	6,104
Dominican Republic	--	7	--	--	--	--	8,291	7,754	--	--
Finland	4,072	4,771	--	--	--	--	--	--	122	47
France	2,035	2,042	1	5	--	--	--	--	89	242
Germany, Federal Republic of	536	56	166	223	--	--	5	299	257	175
Japan	29	--	--	--	--	--	877	--	--	28
Netherlands	567	155	--	--	--	--	--	--	9	12
New Caledonia	--	--	--	--	--	54	3,045	3,744	--	--
Norway	18,947	24,166	--	--	--	--	--	--	--	--
Philippines	3,923	635	818	664	--	--	--	--	26	--
South Africa, Republic of	3,964	2,298	479	659	--	--	10	20	4	4,182
Sweden	566	30	4	17	--	--	--	--	41	35
U.S.S.R	60	--	--	--	--	--	--	--	--	--
United Kingdom	878	417	170	231	--	--	15	--	3	2
Zimbabwe	3,147	2,150	--	--	--	--	--	--	--	--
Other	849	494	2	215	--	87	3,604	683	444	631
Total	103,017	97,779	15,829	12,753	4,255	3,911	15,847	12,742	37,767	30,505

[e]Estimated.

Source: Bureau of the Census.

WORLD REVIEW

Excess production capacity and oversupply dominated the world nickel industry. Although early in the year consumer concerns over possible shortfalls drove the price up, the physical shortages failed to materialize. Settlement of separatist strife in New Caledonia and requalification of Nonoc nickel briquets to satisfy LME contracts eliminated these potential shortages. The U.S.S.R. resumed shipments of nickel into the LME, and ferronickel producers flooded European markets. Furthermore, Falconbridge Nikkelverk A/S, Norway, and Sherritt Gordon, Canada, announced refinery expansions. Western Platinum Ltd. (Wesplat), Republic of South Africa, began building a refinery in the Republic of South Africa. In Zimbabwe, Rio Tinto (Zimbabwe) Ltd. (RTZ) reopened its refinery to further swell effective nickel capacity. These expansions more than offset the strikes and periodic technical difficulties experienced during the year by several major producers. Instead of the anticipated shortages, world plant production actually rose slightly above the 1984 figure. By yearend, prices plummeted to their lowest point since 1983.

A major revamping of nickel traffic patterns emerged from closure of AMAX Nickel's refinery. BCL matte, previously shipped to the refinery, instead was shipped to the Falconbridge Nikkelverk refinery in Norway and the RTZ refinery in Zimbabwe. Matte from the Agnew Mine in Australia was resold by AMAX Nickel to Sherritt Gordon and Outokumpu.

Representatives of countries seeking to form an International Nickel Discussion Group (INDG) gathered in Geneva, Switzerland, during the first week in November for another in a series of formative meetings. The United States sent an observer. Representatives attended from all of the nickel producing countries, except China, and from the major consuming countries. Scope and objectives of the proposed INDG were completed; most rules were established. Two issues remained outstanding: (1) whether or not to share a secretariat with the International Lead and Zinc Study Group and (2) the formula for financing the organization. Regarding the first issue, one proposal was for an autonomous three- or four-person secretariat. The probable financing plan featured a two-part budget. One portion would be shared equally by all participating countries; the second would be prorated, based upon the member's share of the world nickel trade.

The Nickel Development Institute, founded in 1984, began operating in 1985 as a nonprofit organization dedicated to providing applications information on nickel, conducting nickel market research, and developing new markets for nickel. Headquartered in Toronto, Canada, the institute was supported by 14 major nickel producing companies. It began publishing the quarterly publication "Nickel" in September to disseminate information to industrial sectors.

Albania.—The year 1985 marked the end of Albania's seventh 5-year plan, which included an emphasis on boosting mine output. Nickeliferous iron ore annual production increased 91% over the annual amount produced in 1981, the first year of the plan. Discussions reportedly were held with Yugoslavia pursuant to possible exports of the ore to the Kosovo smelter.

Construction continued on a nickel-cobalt cathode refinery being built at Elbasan by the West German company Salzgitter AG using technology supplied by Inco Ltd.

Argentina.—At Las Aguilas near San Luis, a detailed exploration program sponsored by the Dirección General de Fabricaciones Militares identified 2.75 million tons of sulfide ore grading 1.3% to 2% nickel with considerable copper and cobalt content. Feasibility studies have not established commercial viability of production. Considering the weak nickel market and lack of mining infrastructure in the region, mine development is unlikely in the near future.

Australia.—A major rock fall in the Agnew Mine in Western Australia during January drastically altered the mining plan and reportedly cut production by at least 20% for several months. After AMAX Nickel decided to close its refinery in Louisiana, the matte from the Agnew Mine was sold to the Sherritt Gordon refinery in Canada and Outokumpu's refinery in Finland. Western Mining Corp. Ltd. (WMC) continued toll smelting the ore into matte at its Kambalda plant.

Nickel production in Australia received a boost with the return of the Greenvale Mine and Yabulu refinery to essentially full-scale production. Owned by Metals Exploration Ltd. and Freeport Queensland Ltd., the refinery operated at 70% of capacity in 1985.

WMC suffered several strikes. During March, lifter operators struck for 16 days in the Kambalda District. Underground miners at Kambalda struck for 11 days in July, after which mill workers went on strike for 2 days. Smelter and refinery output were not greatly affected, and production for the Australian fiscal year, which ended July 1985, remained close to that of fiscal year 1984.

Metals Exploration reopened the Nepean Mine, which had been mothballed since 1983. Ore from the mine was shipped to WMC for smelting into nickel matte. Approximately 275,000 tons of ore grading 2.7% nickel constitute enough mine reserves for 2 years of operation.

Mine production kept Australia in third place among world producers of nickel.

Bolivia.—The Eastern Bolivia Mineral Exploration Project, jointly conducted by the Bolivian and British geological services, revealed a significant laterite nickel deposit in eastern Bolivia. The Rincon del Tigre deposit reportedly contains 3.3 million tons of material grading 3% to 11% nickel.

Botswana.—AMAX Nickel released BCL from the contract to supply AMAX Nickel with matte from the Selebi and Phikwe Mines in Botswana. BCL began to fulfill the contract signed earlier in 1985 to supply matte to Falconbridge Nikkelverk's refinery in Norway and RTZ's Eiffel Flats refinery in Zimbabwe. Small amounts of matte reportedly were also shipped to Bindura Nickel Corp. Ltd.'s smelter in Zimbabwe and to Matthey Rustenburg Refiners (Pty.) Ltd.'s refinery in the Republic of South Africa.

Canada.—Early in the year, the Canadian Government announced that it will provide financial assistance to Canadian smelters in order to ensure that smelters are able to achieve the Government's goal of reducing by 50% sulfur dioxide (SO_2) emissions by 1994. Inco agreed to comply with the limits, feeling that they could be reached by retrofitting existing equipment. At yearend, however, Ontario imposed tough new SO_2 emission standards on nickel smelters operated by Inco and Falconbridge Ltd. in the Sudbury District. Inco must reduce its emissions from present limits of 755,000 to 292,000 tons per year by 1994. Falconbridge must lower its emissions from 170,000 to 110,000 tons per year.

Canada was second behind the U.S.S.R. in nickel mine production.

Inco, the largest nickel producer among market economy countries, posted its first annual profit since 1980. The profit occurred primarily through stringent cost-cutting efforts and modest nickel price hikes in the first half of 1985.

To reduce its work force, Inco offered several early retirement incentives. In an additional streamlining move, Inco halted electrolytic nickel refining at its Port Colborne refinery in favor of producing utility-grade nickel from its high-purity pellets.

The company thus concentrated its cathode nickel production at the Manitoba operations. Utility-grade nickel was deemed more economical to make from the pellets than from the formerly used nickel oxide because byproduct cobalt was recovered during pellet production.

Inco employees at the Sudbury and Port Colborne operations voted to accept a labor contract agreed upon by the company and the employees' union. The 3-year contract links base-pay raises and cost-of-living adjustments to the price of nickel. Falconbridge Ltd. and its labor union also agreed to a new 3-year labor contract for the Sudbury District mines. Sherritt Gordon reached accord with the union at its nickel refinery in Alberta.

Falconbridge announced a major 3-year expansion program for its Craig Mine near Sudbury. The development work is necessary to boost production after the premature closure of the Falconbridge No. 5 shaft in 1984.

Sherritt Gordon reported significantly increased nickel production and sales. As a consequence of obtaining nickel matte formerly sent to AMAX Nickel's refinery, the company expanded its Fort Saskatchewan refinery capacity from 22,000 to 25,000 tons per year.

Hudson Bay Mining and Smelting Co. Ltd. delineated a copper-nickel deposit beneath Namew Lake near Flin Flon, Manitoba. Containing approximately 1.3 million tons of ore, the deposit averages approximately 2.8% nickel with 0.7% copper. Proximity to other mining districts in Manitoba favors eventual development of the deposit despite currently depressed nickel markets.

China.—At the Tokyo, Japan, trade fair, the China National Nonferrous Metals Industry Corp. announced plans to double the present capacity of its Jinchuan nickel mine in the Gansu Province by 1990. Present capacity is 22,000 tons per year of cathode nickel. China signed an agreement with a Swedish consortium, including Boliden AB, to provide technology for the expansion. A conversion to undercut-and-fill mining highlights the desired technology. The expansion could convert China from a nickel importer to an exporter.

The Bechtel Group Inc., San Francisco, CA, and Galactic Resources Ltd., Canada, joined the large list of companies from market economy countries that signed cooperative agreements for mineral development in China. Galactic established a joint venture for developing a massive polymetallic sulfide deposit in the Xinjiang Uygur Autonomous Region in western China. The Bechtel letter of intent involved engineering and construction for mine development.

Colombia.—Shortly after rebuilding a ferronickel smelter furnace over a 2-month span, Cerro Matoso S.A. closed its smelter following another furnace failure in August. The Colombian producer did not produce ferronickel again until October. Although earlier in the year the smelter had been operating close to its effective capacity of 25,000 tons per year of nickel in ferronickel, the 5-month shutdown significantly curtailed its 1985 ferronickel production. The company was able to reschedule its debt with international banks in order to defer a portion of that debt until 1987.

Cuba.—Although Cuba's new Punta Gorda nickel refinery was scheduled to open late in 1984, it apparently was not inaugurated until November 1985 and did not achieve commercial production during 1985. Although Cuba expects plant capacity to eventually reach 33,000 tons per year, the immediate production goal ranges from 5,500 to 8,300 tons per year.

Meanwhile, construction proceeded on the Las Camariocas plant. An agreement between Cuba and Hungary infused more funds into the project.

Dominican Republic.—Falconbridge Dominicana C. por A. shipped more nickel in ferronickel than it did in each of the previous 11 years. On December 20, the ferronickel smelter began a 5-week shutdown to facilitate planned furnace maintenance and to reduce ferronickel inventories. The 1985 production was achieved with one furnace operating out of three available for duty.

Finland.—Outokumpu, the large state-controlled mining and metals group, continued developing the Enonkoski Mine in eastern Finland. At Laukunkangas near Savonlinna, the mine began production at year-end. The underground mine was expected to provide 440,000 tons of ore per year from sublevel stoping operations. The company's Harjavalta smelter experienced technical difficulties with its flash furnace for several weeks, necessitating production from a more expensive electric furnace.

France.—Société Métallurgique le Nickel (SLN) was restructured into Eramet-SLN, retroactive from January 1, 1985. Shareholders remained unchanged. The company's New Caledonia operations were placed in a separate, 100%-owned subsidiary, LeNickel-SLN. Eramet-SLN purchased all nickel produced by LeNickel-SLN except the ore sold to Japanese smelters.

The French mint decided to replace its present 10-franc coin with one of pure nickel. The plans called for producing 600 million coins with 4,300 tons of nickel over the next 5 years. Eramet-SLN was expected to supply most of the nickel.

Greece.—Larco S.A.'s ferronickel smelter at Larymna near Boeotia experienced a 2-week strike early in 1985. In February, shortly after the strike was settled, one of its furnaces exploded when slag leaked into a pool of water. The smelter resumed production in March at about 80% of capacity, up from the 50% to 60% utilization in 1984.

India.—Progress was made on plans for development of a ferronickel complex. The Industrial Promotion and Investment Corp. of Orissa procured a letter of intent from involved Government agencies to develop a 15,000-ton-per-year plant near Cuttack. The plant would be built adjacent to the corporation's Jaipur Road ferrochromium plant. Land, electric power, and transportation are readily available. Since early development of domestic deposits is unlikely, imported ore is the most likely source of material.

Indonesia.—P.T. International Nickel Indonesia lost an estimated production of 500 to 750 tons of nickel in matte when one furnace in its smelter overheated. The resultant damages shut the furnace down for repairs several weeks during May and June. Despite the damage to the smelter, nickel matte exports from Indonesia jumped 30% above those of 1984.

Ni-Cal Technology signed a letter of intent with P.T. Aneka Tambang (Antam), the Government-owned nickel mining operation, to establish a joint nickel-cobalt processing venture. The proposed plant would be built at Antam's Gebe Island laterite deposit. The plant's acid leaching technology would be adopted from technology developed by Ni-Cal Technology for the Gasquet Mountain deposit in the United States. Antam considered the technology as a possible method of producing pure forms of nickel to increase profitability.

Japan.—Ferronickel production increased significantly in 1985 compared with that in 1984, offsetting declines in pure metal production. Demand for primary nickel dropped, as evidenced, for example, by sharply lower consumption of nickel in the Ni-42 alloy used in integrated circuitry. Primary nickel stocks remained high throughout the year. The high inventories accrued in part owing to a supply contract with the Soviet export agency Raznoimport, preventing stock levels from responding to the shrinking demand. Resumption of nickel shipments from Nonoc also contributed to the heavy flow of nickel into the country.

Citing financial losses by its ferroalloys industry, Japan approved a plan submitted by its Ministry of International Trade and Industry to provide financial assistance to those producers under the Structural Reform Law. The plan called for a 12% reduction in smelting capacity by the four leading ferronickel producers in exchange for substantially reduced fixed property taxes. The law also provided tax credits for upgrading facilities. Since production in 1984 averaged about 57% of capacity, the closures will not result in a production cut.

Meanwhile, Japan encouraged increased nickel imports by accelerating by 2 years the planned tariff reduction for nickel metal, nickel oxide, and ferronickel. The tariff on ferronickel, for instance, will decrease to 6.5% from 8.3%, effective April 1, 1986.

New Caledonia.—Mining and smelting facilities owned by SLN in New Caledonia were restructured to comprise a new corporate subsidiary, LeNickel-SLN, effective January 1, 1985.

Political violence associated with the Kanak separatist movement adversely impacted the nickel mining operations. Raids during January shut down the major nickel mines, damaging equipment at the Camp des Sapin Mine near Thio and the Meaba Mine at Kouaoua. By March, however, SLN had reopened its Le Plateau Mine, closed since the outbreak of violence late in 1984. SLN also reported that the Meaba Mine was operating at 100% of capacity. A flareup of separatist activity in August closed the mines again for 1 week, but without additional damage to the facilities. Owing to high stockpiles of nickel ore, augmented by ore purchased from the several small independent miners on the island, SLN's Doniambo smelter near Nouméa maintained production throughout the crisis. Ferronickel production in 1985 eventually far exceeded that of 1984.

Norway.—Falconbridge Nikkelverk successfully negotiated a contract to receive the bulk of BCL's nickel matte production until the end of the century. The negotiations prompted the company to initiate a 3-year, $43 million expansion program at the Kristiansand refinery. Refinery capacity was expected to increase by 33% to 60,000 tons upon completion. Even before the expansion was initiated, the refinery supplied a significant portion of the primary nickel purchased by U.S. consumers. Its primary feed source remained company mines in the Sudbury District of Canada.

Philippines.—Production of briquet nickel resumed after Nonoc repaired damage inflicted to its refinery during the 1984 typhoon. Production rates gradually picked up during 1985. Marc Rich & Co. A.G. supplanted Philipp Bros. Inc. as sole Nonoc sales agent outside of Japan. This shift spawned several unsuccessful court challenges by Philipp Bros., hampering nickel movements. Nonoc eventually registered its briquet on the LME, facilitating sales of the product.

Ni-Cal Technology reportedly entered into an agreement with the Surigao Nickel Development and Industrial Corp. to develop and process the Catilian nickel laterite deposits. The deposits are approximately 100 miles from the nickel refinery at Surigao. Under the agreement, Surigao Nickel would mine and process the ore using Ni-Cal Technology's acid leaching process. The letter of intent parallels one signed in 1984 by Ni-Cal Technology and Nonoc.

South Africa, Republic of.—Wesplat neared completion of a new base metal refinery at the Marikana platinum mine near Rustenburg in Transvaal. The new refinery was to produce byproduct nickel sulfate at a rate of 2,200 tons of contained nickel per year using Sherritt Gordon technology employing a sulfuric acid leach. Meanwhile, concentrates from the platinum mine were shipped to Falconbridge Nikkelverk's refinery in Norway for extracting nickel, copper, and cobalt. The residue was then returned to Wesplat for precious metals recovery. Several scattered short labor disputes failed to significantly disrupt mine production at company mines.

U.S.S.R.—In late 1984, the U.S.S.R. changed its nickel sales policy to push for direct, long-term sales contracts with consumers rather than relying on sales to trading companies. The terms of the contracts fell from favor among consumers, however, as the nickel price and demand slipped. Negotiations initiated in 1985 for 1986 nickel purchases consequently marked a return to sales through traders.

Nickel mine production estimated for the U.S.S.R. increased slightly, allowing it to regain the production lead from Canada.

Table 9.—Nickel: World mine production, by country[1]

(Short tons of nickel content)

Country	1981	1982	1983	1984[p]	1985[e]
Albania (content of ore)[e]	6,200	6,400	6,400	6,600	6,600
Australia (content ofconcentrate)	81,963	96,510	84,465	83,653	[2]93,700
Botswana (content of matte)	18,200	19,573	20,079	[e]19,300	20,000
Brazil (content of ore)	[r]7,239	[r]15,929	17,153	23,887	26,000
Burma (content of speiss)[e]	[2]22	22	22	22	22
Canada[3]	176,642	[r]97,644	141,220	192,017	167,000
China[e]	12,000	13,200	14,300	15,400	22,000
Colombia (content of ferroalloys)	--	[r]1,455	14,400	18,810	13,000
Cuba (content of oxide, sinter, sulfide)	42,489	39,790	41,487	35,087	35,700
Dominican Republic	20,601	[r]5,926	21,552	26,371	29,000
Finland (content of concentrate)	7,566	[r]6,980	5,858	7,638	7,200
German Democratic Republic[e]	3,000	2,800	2,400	[r]2,200	1,800
Greece (recoverable content of ore)[e 4]	[2]17,200	5,500	18,500	18,400	19,000
Indonesia (content of ore)[4]	53,848	50,578	54,430	52,474	54,000
Morocco (content of nickel ore and cobalt ore)	144	140	--	--	--
New Caledonia (recoverable content of ore)	86,079	66,250	50,885	[r e]63,000	80,400
Norway (content of concentrate)	[r]551	[r]551	500	600	600
Philippines	32,239	[r]21,643	15,322	14,993	30,300
Poland (content of ore)[e]	2,300	2,300	2,300	2,300	2,200
South Africa, Republic of[e]	[2]29,100	24,250	22,600	27,600	27,600
U.S.S.R. (content of ore)[e]	174,000	182,000	187,000	192,000	198,000
United States (content of ore shipped)	12,099	3,203	--	14,540	[2]6,127
Yugoslavia (content of ore)[e]	[r]2,200	4,400	3,300	4,400	5,500
Zimbabwe (content of concentrate)	14,350	14,671	11,186	11,300	11,000
Total	[r]800,032	[r]681,715	735,359	832,592	856,749

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Insofar as possible, this table represents recoverable mine production of nickel; where data relate to some more highly processed form, the figure given has been used in lieu of unreported actual mine output to provide some indication of the magnitude of mine output and is so noted parenthetically following the country name, or by footnote. Table includes data available through May 13, 1986.

[2]Reported figure.

[3]Refined nickel and nickel content of oxides and salts produced, plus recoverable nickel in exported mattes and speiss.

[4]Includes a small amount of cobalt not reported or recovered separately.

Table 10.—Nickel: World plant production, by country[1]

(Short tons of nickel content)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Australia[3]	46,854	50,630	46,077	42,615	[4]44,982
Brazil[5]	2,574	[r]3,826	9,165	10,127	13,200
Canada[6]	120,486	64,635	[e]96,100	[e]114,600	100,300
China[e]	12,100	13,200	14,300	15,400	22,000
Colombia[5]	--	[r]1,455	14,396	18,810	13,000
Cuba[7]	9,355	[r]9,922	10,298	9,311	9,370
Czechoslovakia[e]	[r]1,800	[r]1,700	[r]3,300	[r]5,000	5,000
Dominican Republic[5]	20,601	5,812	23,369	26,698	[4]28,450
Finland	14,672	13,906	16,355	16,846	17,300
France[6]	11,079	8,114	8,047	5,751	5,500
German Democratic Republic[e]	3,100	3,300	3,300	3,300	3,300
Germany, Federal Republic of[e 8]	1,320	1,320	1,320	1,100	1,100
Greece	14,000	[e]5,000	14,174	17,448	17,600
Indonesia[5]	5,184	5,523	5,352	5,320	5,500
Japan	95,679	91,886	76,667	81,789	[4]85,419
New Caledonia[5]	30,853	30,871	23,939	32,141	[4]40,108
Norway	[r]40,735	[r]28,476	31,205	39,185	[4]41,351
Philippines	23,683	[r]12,371	6,721	3,889	[4]18,360
Poland[e]	[r]2,300	[r]2,300	[r]2,300	[r]2,300	2,300
South Africa, Republic of	19,800	15,900	[e]18,740	22,597	22,000
U.S.S.R.[e]	196,200	198,400	204,000	214,000	220,000
United Kingdom	27,999	7,606	25,574	24,582	15,400
United States	48,805	44,956	33,400	44,933	[4]36,382
Yugoslavia[e]	--	1,700	1,700	2,200	3,300
Zimbabwe	[e]13,200	[e]13,200	11,184	11,300	11,000
Total	[r]762,379	[r]636,009	700,983	771,242	782,222

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Refined nickel plus nickel content of ferronickel produced from ore and/or concentrates unless otherwise specified. Table includes data available through May 13, 1986.

[2]In addition to the countries listed, North Korea is believed to have produced metallic nickel and/or ferronickel, but information is inadequate for formulation of reliable estimates of output levels. Several countries produced nickel-containing matte, but output of nickel in such materials have been excluded from this table to avoid double counting. Countries producing matte include the following, with output indicated in short tons of contained nickel: Australia: 1981—36,223; 1982—54,444; 1983—54,900 (revised, estimated); 1984—56,330; and 1985—56,858; Botswana: 1981—20,143; 1982—19,573; 1983—20,080; 1984—20,507 (revised); and 1985—20,500 (estimated); Indonesia: 1981—21,980; 1982—15,156 (revised); 1983—20,159 (revised); 1984—25,149 (revised); and 1985—27,900 (estimated); and New Caledonia: 1981—16,954; 1982—7,875; 1983—5,046 (revised); 1984—6,219 (revised); and 1985—9,233.

[3]Refined nickel plus the nickel content of oxide.

[4]Reported figure.

[5]Nickel content of ferronickel only. (No refined nickel was produced.)

[6]Includes nickel content of refined nickel, nickel oxide, and nickel matte; from 1982, the totals for France are production of nickel cathodes only.

[7]Content of granular nickel oxide and powder only; Cuba also produces nickel oxide sinter and a processed sulfide, but these are not included in order to avoid double counting, as they may be processed to metal elsewhere. Output of sinter was as follows, in short tons: 1981—13,354; 1982—12,952 (revised); 1983—12,723 (revised); 1984—9,804 (revised); and 1985—9,900 (estimated). Output of processed sulfide was as follows, in short tons: 1981—19,779; 1982—16,916 (revised); 1983—18,466 (revised); 1984—15,971 (revised); and 1985—16,400 (estimated).

[8]Includes nickel content of nickel alloys.

United Kingdom.—Inco Europe Ltd., a subsidiary of Inco Ltd., shut down the Clydach refinery for 3 months early in 1985. The shutdown stemmed from the company's desire to reduce stocks to a level consistent with market conditions. Approximately 370 of the refinery's 537 workers were layed off during the shutdown, and the permanent staff was reduced by 69 by yearend. Nickel chloride and sulfate production continued during closure of the nickel pellet and powder facility. The plant resumed production in April at about 50% of its capacity.

Yugoslavia.—Rudnik i Topionica Feronikl brought a second furnace line onstream at its Kosovo ferronickel smelter. The startup raised production to about 30% of the plant's expected capacity. Ferronickel was exported to Austria, the Federal Republic of Germany, and Italy. Discussions reportedly were held with Albanian officials regarding processing of Albanian nickeliferous iron ore at the Kosovo smelter.

The Government solicited buyers for the plant equipment from the Kavadarci smelter. The plant closed in June 1984 after only 2 years of operation.

Zimbabwe.—The Eiffel Flats refinery reopened in August to process matte purchased from BCL. The refinery, operated by Empress Nickel Mining Co. Ltd., a subsidiary of RTZ, produced cathode nickel by yearend at close to its target rate of 400 tons per month.

TECHNOLOGY

Mining and Processing.—Inco Ltd. continued to focus its attention on new technical developments that could improve productivity and safety in its underground mines. For improved ground support, a spray-on, fiberglass-reinforced epoxy resin was developed to reduce time-consuming rock bolt installation. Modifications were made to the continuous loading machine marketed by its subsidiary, Continuous Mining Systems Ltd. (CMS), to enable the loader to discharge onto a conveyor that follows the machine as it moves through the muck. CMS also participated in the development of a conveyor belt that goes around corners.

France continued to pioneer the development of equipment for recovering seafloor nodules. A consortium of French ocean mining companies, in conjunction with the French National Center for Ocean Exploitation, developed two totally autonomous, remotely operated submarine vehicles. The vehicles can be accurately guided to specific spots of the ocean floor at depths to 6,000 meters. One vehicle, the Epaulard, equipped with lights and cameras for reconnaissance, has completed 100 dives. The other, PLA 2, was designed to move along the ocean floor on tracks, scooping up nodules before returning to the mother ship. The battery-operated vehicle is controlled by a microprocessor.

Numerous research programs were devoted to the recovery of nickel from spent petroleum catalysts. AMAX Nickel successfully completed a pilot program on its process at its shuttered Port Nickel refinery. The experiments were conducted under a joint program with Catalyst Recovery Inc. and Shell Chemical Inc. The AMAX Nickel process yielded a nickel-cobalt sulfate that can be sold as is or reprocessed into pure metal.

Nickel Products.—Allied Corp. announced the development of a new nickel alloy, Altraloy, that may replace gold in some electronic circuit applications. Although gold traditionally is used because it resists corrosion and has a low contact resistance, the new alloy reportedly has similar properties at a lower cost.[4]

Wall Colomony, United Kingdom, offered a new nickel-based hard-surfacing alloy as an alternative to cobalt-based ones. This new alloy is claimed to be easy to deposit and self-fluxing, in addition to being wear resistant.

Developments in amorphous powder metals continued to mount. Allied, one of the leaders in such developments, produced a nickel-molybdenum-boron alloy with superior hardness and toughness properties using an extrusion process.

End Uses.—Cummins Engine Co. received the first commercial license to produce a new nickel-aluminide alloy for use in diesel engines and turbochargers. The alloy, containing 85% nickel, is 10% lighter than present superalloys. It contains no chromium or cobalt, which should reduce reliance on these strategic materials. More importantly, the alloy offers advantageous performance characteristics at high temperatures over those of current superalloys and was expected to replace the current ones in many applications.

The United States Steel Corp. became the second major U.S. company to recently introduce a nickel-coated terne sheet into its product line. Formed by electroplating nickel onto cold-rolled steel sheets before they are dipped into the lead-tin alloy terne bath, the sheets are much more corrosion-resistant than nonnickel terne sheets. With numerous applications in the automobile and heat and air-conditioning industries, the new product offered excellent opportunities for significantly increasing nickel sales in the United States.

Potential applications proliferated for nitinol, a nickel-titanium alloy developed by the Naval Ordnance Laboratory in White Oak, MD. The material features the unique ability to retain a "memory" of its original shape and to return to that shape upon reheating. Nitinol engines have attracted much attention because of their potential to run only on minimal heat energy. The material also looks promising for a variety of surgical applications including bone setting, correction of scoliosis, and reinforcement of artery walls. Switches for fire alarm systems, automatically opening windows, and supports for brassieres are other successful applications of nitinol.[5]

Renovation proceeding on the Statue of Liberty features a high-nickel-content stainless steel support structure for the copper external skin. The 23 tons of material (mostly type 316 L), donated by several domestic producers, replaces the original iron support structure that was prone to corrosion.[6]

[1]Physical scientist, Division of Ferrous Metals.

[2]U.S. Department of the Interior, Bureau of Mines staff, and U.S. Department of Commerce, Basic Industries Sector staff. Domestic Consumption Trends, 1972-82, and Forecasts to 1993 for Twelve Major Metals. BuMines OFR 27-86, Jan. 1986, 158 pp.

[3]Metals Week. Metals Week Annual Prices. V. 57, No. 2, Jan. 13, 1986, p. 10.

[4]American Metal Market. New Nickel Alloy Could Replace Electronics Gold. V. 93, No. 185, p. 5.

[5]Morris, S. Games. Omni, v. 8, No. 8, May 1986, pp. 148-149.

[6]Bowers, E. W. The Lady Is Being Saved. Phoenix Q., v. 17, Summer 1985, pp. 2-6.

Nitrogen

By Charles L. Davis[1]

U.S. production of anhydrous ammonia, 82.2% nitrogen, was about the same as that of 1984. The total value of ammonia produced and sold decreased to about $1.8 billion. The value of apparent consumption decreased to about $2 billion. Production and apparent consumption values were based on average annual 1985 f.o.b. gulf coast spot prices, which decreased considerably during the year. Imports of ammonia also decreased. An increase in ammonia exports was attributed to aggressive marketing practices by U.S. ammonia exporters and the appearance of a temporary European market.

Domestic Data Coverage.—Domestic production data for ammonia were developed by the Bureau of the Census, U.S. Department of Commerce, and published monthly in Current Industrial Reports, Inorganic Fertilizer Materials and Related Products, M28B. The Department of Commerce surveyed approximately 62 firms manufacturing inorganic fertilizer chemicals. Production estimates were supplied for reports not received in time for tabulation. These data are shown in table 1.

Table 1.—Salient ammonia statistics

(Thousand short tons of contained nitrogen)

	1981	1982	1983	1984	1985[p]
United States:					
Production[1 2]	15,732	13,029	11,297	13,368	13,238
Exports	506	610	298	438	1,010
Imports for consumption	1,719	1,737	2,169	2,699	2,306
Consumption[2 3]	16,467	14,145	13,719	15,346	14,439
World: Production	[r]84,847	[r]83,630	86,560	[p]93,029	[e]94,302

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Synthetic anhydrous ammonia and coke oven ammonia.
[2]Coke oven ammonia not available for 1985.
[3]Includes producers' stock changes in synthetic anhydrous ammonia and coke oven ammonia.

DOMESTIC PRODUCTION

Monthly production in 1985 remained above that of 1984 through July, then declined each month for the remainder of the year. The greatest production occurred in March, nearly 1.5 million short tons, and the lowest in December, almost 1.2 million tons. Several ammonia plants were closed because of poor markets; two closed because of explosions at the plant. By yearend, a total of about 2 million tons of plant capacity was closed for an indefinite period. Ammonia was produced by 43 companies at 55 plants in 23 States.

Table 2.—Fixed nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1981	1982	1983	1984	1985[p]
Ammonium compounds, coking plants:					
Ammonia liquor[1]	2	5	5	5	NA
Ammonium phosphate[1]	(²)	(²)	(²)	(²)	NA
Ammonium sulfate[1]	75	56	46	54	NA
Anhydrous ammonia, synthetic plants[3]	15,655	12,968	11,246	13,309	13,238
Total	15,732	13,029	11,297	13,368	13,238

[p]Preliminary. NA Not available.
[1]Quarterly Coal Report, U.S. Department of Energy, Jan.-Mar. 1985, published July 1985.
[2]Included with ammonium sulfate to avoid disclosing company proprietary data.
[3]Current Industrial Reports, Bureau of the Census.

Table 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compound	1983	1984	1985[p]
Acrylonitrile	1,073	1,101	1,173
Ammonium nitrate	6,628	7,009	6,907
Ammonium phosphate	12,814	14,468	12,373
Ammonium sulfate[1]	1,964	2,107	2,049
Nitric acid	7,367	8,016	7,808
Urea	5,771	7,138	6,478

[p]Preliminary.
[1]Excludes ammonium sulfate from coking plants.

Sources: Bureau of the Census and International Trade Commission.

Table 4.—Domestic producers of anhydrous ammonia in 1985

(Thousand short tons per year of ammonia)

Company	Location	Capacity
Agrico Chemical Co	Donaldsonville, LA	468
Do	Verdigris, OK	840
Air Products and Chemicals Inc	New Orleans, LA	210
Do	Pace Junction, FL	100
Allied Chemical Corp	Hopewell, VA	340
American Cyanamid Co	Fortier, LA	580
Arcadian Corp	Geismar, LA	340
Do	La Platte, NE	172
Atlas Chemical Industries Inc	Joplin, MO	136
Borden Chemical Co	Geismar, LA	400
Carbonaire Co. Inc	Palmerton, PA	35
Cargill Inc	Columbus, MS	68
C.F. Industries Inc	Donaldsonville, LA	1,740
Chevron Chemical Co	Pascagoula, MS	530
Do	El Segundo, CA	20
Do	Fort Madison, IA	95
Columbia Nitrogen Corp	Augusta, GA	510
Cominco American Incorporated	Borger, TX	400
Diamond Shamrock Chemical Corp	Dumas, TX	160
The Dow Chemical Co	Freeport, TX	115
E. I. duPont de Nemours & Co. Inc	Beaumont, TX	440
Farmland Industries Inc	Fort Dodge, IA	210
Do	Dodge City, KS	210
Do	Enid, OK	840
Do	Lawrence, KS	340
Do	Pollock, LA	420
First Mississippi Corp	Donaldsonville, LA	400
Georgia-Pacific Corp	Plaquemine, LA	196
Goodpasture Inc	Dimmitt, TX	40
W. R. Grace & Co	Woodstock, TN	340
Grace-Oklahoma Nitrogen	Woodward, OK	450
Green Valley Chemical Corp	Creston, IA	35
Hooker Chemical Co	Tacoma, WA	28
International Minerals & Chemical Corp	Sterlington, LA	770
Jupiter Chemical Co	Lake Charles, LA	78
Mississippi Chemical Corp	Yazoo City, MS	393

Table 4.—Domestic producers of anhydrous ammonia in 1985 —Continued

(Thousand short tons per year of ammonia)

Company	Location	Capacity
Monsanto Co	Luling, LA	650
N-Ren Corp	Pryor, OK	94
Do	East Dubuque, IL	238
Do	Carlsbad, NM	68
Olin Corp	Lake Charles, LA	490
Pennwalt Chemical Co	Portland, OR	8
Phillips Pacific Chemical Co	Kennewick, WA	155
Phillips Petroleum Co	Beatrice, NE	230
PPG Industries Inc	Natrium, WV	50
Reichhold Chemicals Inc	St. Helens, OR	90
J. R. Simplot Co	Pocatello, ID	108
Sohio Chemical Co	Lima, OH	475
Tennessee Valley Authority	Muscle Shoals, AL	74
Terra Chemical International	Port Neal, IA	210
Triad Chemical Co	Donaldsonville, LA	340
Union Chemical Co	Kenai, AK	1,100
Do	Brea, CA	280
U.S.S. Agri-Chemicals Inc	Cherokee, AL	175
Wycon Chemical Co	Cheyenne, WY	109
Total		17,393

Source: Economics and Marketing Research Section, Tennessee Valley Authority. World Fertilizer Capacity, Ammonia. Muscle Shoals, AL, Jan. 7, 1986.

CONSUMPTION AND USES

The small decrease in domestic ammonia consumption in part reflected a decline in the demand for ammonia-based chemicals in the farm market. Imports of anhydrous ammonia decreased 15%, while ammonia exports increased 131%. Approximately 80% of the ammonia consumed was used in fertilizers. Ammonia also was used to produce plastics, fibers, and resins, 10%; explosives, 4%; and numerous other chemicals, 6%.

STOCKS

Producers' stocks of ammonia on hand at the beginning of the year totaled about 1.7 million tons of contained nitrogen. At yearend, stocks totaled about 1.8 million tons of contained nitrogen. At yearend 1984, stocks had tended to increase to meet seasonal demand for spring planting; however, in 1985, stock levels remained static because of uncertain domestic demand and falling prices.

PRICES

Ammonia prices started the year at an annual high of nearly $150 per ton. The price held steady until the middle of May, then began a steady decline until the annual low of about $107 was reached at yearend. The use of other less costly nitrogen fertilizers, lighter applications of ammonia, and ammonia imports contributed to the drop in ammonia prices.

Table 5.—Price quotations for major nitrogen compounds at yearend 1985

(Per short ton)

Compound	Price
Ammonium nitrate: Delivered Corn Belt	$112-$133
Ammonium sulfate: F.o.b. Corn Belt	88- 119
Anhydrous ammonia:	
Delivered Corn Belt	160- 170
F.o.b. gulf coast	107- 110
Diammonium phosphate: F.o.b. central Florida	139- 147
Urea:	
Delivered Corn Belt	110- 137
F.o.b. gulf coast, granulated	98- 101
F.o.b. gulf coast, prilled	82- 95

Source: Green Markets, Fertilizer Market Intelligence Weekly, Dec. 23, 1985.

FOREIGN TRADE

Anhydrous ammonia exports increased 131% from the 438,000 tons of contained nitrogen exported in 1984. The increase was attributed to aggressive marketing in some Western European countries, Taiwan, Tunisia, Turkey, and in countries where plants had experienced production problems. The gross weight of downstream nitrogen compounds exported for industrial and fertilizer uses was about the same as that of 1984. Diammonium phosphate, urea, and anhydrous ammonia led in export tonnage of nitrogen compounds.

Imports of anhydrous ammonia for fertilizer use decreased 15%. Canada was the leading foreign supplier of ammonia to the United States with about 1.1 million tons. The U.S.S.R. supplied about 794,029 tons; Trinidad and Tobago, 531,599 tons; and Mexico, 147,641 tons. Ammonia imports from Canada and Italy increased, whereas imports from Mexico, Trinidad and Tobago, and the U.S.S.R. decreased.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds in 1985

(Thousand short tons and thousand dollars)

Compound	Gross weight	Nitrogen content	Value
EXPORTS			
Fertilizer materials:			
Ammonium nitrate	127	43	13,058
Ammonium sulfate	725	152	48,468
Anhydrous ammonia	1,229	1,010	172,231
Diammonium phosphate	6,758	1,216	1,048,322
Nitrogen solutions	36	12	3,055
Sodium nitrate	24	4	3,914
Urea	1,154	531	148,857
Mixed chemical fertilizers	109	11	20,435
Other ammonium phosphates	575	63	88,176
Other nitrogen fertilizers	56	11	4,340
Industrial chemicals:			
Ammonia, aqua (ammonia content)	2	2	200
Ammonium nitrate	1	(1)	83
Ammonium phosphate	1	(1)	2,105
Ammonium sulfate	2	(1)	143
Total	10,799	3,055	1,553,387
IMPORTS			
Fertilizer materials:			
Ammonium nitrate	561	188	55,355
Ammonium nitrate-limestone mixtures	2	(1)	201
Ammonium sulfate	403	85	33,918
Anhydrous ammonia	2,806	2,306	380,173
Calcium cyanamide or lime nitrogen	2	(1)	616

See footnotes at end of table.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds in 1985 —Continued

(Thousand short tons and thousand dollars)

Compound	Gross weight	Nitrogen content	Value
IMPORTS —Continued			
Fertilizer materials —Continued			
Calcium nitrate	139	21	11,456
Diammonium phosphate	50	9	8,235
Nitrogen solutions	188	60	20,877
Potassium nitrate	46	6	10,568
Potassium nitrate-sodium nitrate mixtures	31	5	4,041
Sodium nitrate	142	23	14,672
Urea	2,165	996	262,480
Mixed chemical fertilizers	139	14	25,028
Other ammonium phosphates	127	14	21,077
Other nitrogen fertilizers	100	20	18,014
Industrial chemicals:			
Ammonium nitrate	98	34	12,693
Ammonium phosphate	950	177	515
Ammonium sulfate	593	126	120
Anhydrous ammonia and chemical-grade aqua	2	2	309
Total	8,544	4,086	880,348

[1]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

A proliferation of new ammonia plant project proposals began in 1985. In addition to the countries discussed in this section, Argentina, Australia, Chile, Finland, Indonesia, Saudi Arabia, Sweden, Trinidad and Tobago, and Turkey either were proposing or were engaged in constructing ammonia projects because of an anticipated increase in world demand by the late 1980's. In 1985, developing countries were becoming self-sufficient in supplying their agricultural fertilizer demands as a result of technology transfer from developed industrial countries. Countries with abundant state-owned, relatively inexpensive natural gas feedstock constructed world capacity ammonia plants whose product, destined for export, captured established markets. Producers from some market economy countries entered into agreements with countries having an ample supply of state-owned natural gas and constructed export-oriented ammonia and urea plants in those countries. State-owned companies operated over 60% of the world ammonia capacity. The economics affecting the overall cost of ammonia worldwide were capital cost of new plants and equipment and costs of management, energy, and transportation. Eastern European countries dominated the world ammonia trade, although the quantity of ammonia for export from Central America was increasing.

Canada.—Ocelot Industries Ltd. of Calgary began construction on its $80 million ammonia complex at Kitimat on the coast of British Columbia. The 200,000-ton-per-year complex was a joint venture with Devco International of Tulsa, OK. Production was scheduled to start in July 1986.[2] Cominco Ltd. and Alberta Energy Co. Ltd. announced the formation of a joint venture to construct a 385,000-ton-per-year ammonia plant in Alberta.[3]

China.—Construction began on an ammonia-urea complex in Yinchuan to produce 550,000 tons per year of urea.[4]

Greece.—A new 130,000-ton-per-year ammonia unit under construction at Kavalla for Phosphoric Fertilizer Industry Ltd. was completed.[5]

India.—Construction on three ammonia-urea plants was progressing approximately on schedule. The plants were to use gas from the new Hazira-Bijaipur-Jagdishpur pipeline. Each project was designed with a 1,350-ton-per-day unit.[6] Construction of a new ammonia-urea plant was begun at Bajwa in the western State of Gujarat. The plant was to have a capacity of 165,000 tons per year of ammonia and 113,000 tons per year of urea.[7]

Iran.—Commissioning began in June of the Shiraz fertilizer complex, which consisted of a 198,000-ton-per-year nitric acid plant, a 220,000-ton-per-year ammonium nitrate plant, a 495,000-ton-per-year urea plant, and a 396,000-ton-per-year ammonia plant. The complex was expected to supply more than $200 million worth of fertilizer per year.[8]

Kuwait.—Petrochemical Industries Corp. commissioned a new 300,000-ton-per-year ammonia plant at Shuaiba.[9]

Poland.—A second 248,000-ton-per-year ammonia plant at the fertilizer complex in Police was constructed and due to start up in 1986.[10]

Somalia.—The ammonia-urea complex at the port of Mogadisho was scheduled for full production early in 1985. The design capacity of the plant was 150 tons per day, and 85% of the output was designated for the export market.[11]

U.S.S.R.—Construction of the 600,000-ton-per-year nitrophosphate complex at Rossoh was ahead of schedule; it was due for completion late in the year. A similar complex had gone on-stream in 1984. The nitrogen fertilizer complex at Mary in Turkmenia was completed in 1985, but commissioning was delayed.[12]

Table 7.—Ammonia: World production, by country[1]

(Thousand short tons of contained nitrogen)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Afghanistan[e]	10	9	9	[r]9	10
Albania[e]	84	84	84	88	88
Algeria	[r]48	[r]181	145	161	165
Argentina	44	64	63	56	55
Australia	352	270	424	414	413
Austria[e]	536	535	546	[r]550	550
Bangladesh	168	201	197	389	400
Belgium	649	561	495	498	375
Brazil	414	555	814	[e]830	830
Bulgaria	[r]1,128	[r]1,138	1,238	1,254	1,543
Burma[e]	65	56	59	[r]63	[3]139
Canada	2,399	2,273	3,183	3,851	3,900
China[e]	13,440	14,010	15,200	15,400	16,500
Colombia	101	108	112	103	105
Cuba	184	108	95	189	220
Czechoslovakia[e]	937	937	937	937	882
Denmark	34	34	13	17	17
Egypt	571	704	998	756	756
Finland	76	71	75	76	77
France[e]	2,500	2,200	2,100	2,200	2,300
German Democratic Republic	1,328	1,290	1,335	1,325	1,334
Germany, Federal Republic of	2,163	1,731	1,877	2,164	1,747
Greece	[r]258	[r]246	[e]248	[r e]248	248
Hungary	902	[r]873	[e]896	897	898
Iceland[e]	8	[r]8	[r]8	[r]8	8
India[4]	[r]3,506	3,824	3,930	4,382	4,520
Indonesia	1,014	1,133	1,268	1,828	1,360
Iran[e]	220	[r]29	[r]32	[r]24	359
Iraq[e]	[4]88	88	88	[r]88	66
Ireland	321	[r]409	324	409	386
Israel	[r]47	[r]54	59	63	63
Italy	1,331	1,153	1,169	[e]1,200	1,300
Japan	2,020	1,821	1,703	1,839	1,820
Korea, North[e]	500	500	500	500	500
Korea, Republic of	823	599	474	512	487
Kuwait	235	202	452	426	459
Libya[e]	165	210	230	230	248
Malaysia	41	31	32	43	40
Mexico	1,979	2,237	2,134	1,954	2,000
Netherlands	2,000	1,824	1,926	2,547	2,500
New Zealand	--	--	48	64	66
Norway	601	574	619	696	[3]576
Pakistan[5]	[r]778	[r]1,033	1,211	1,243	1,270
Peru[e]	107	93	94	94	94
Philippines	36	16	22	18	17
Poland	1,531	[r]1,521	1,571	1,647	1,382
Portugal[e]	[3]147	146	149	154	165
Qatar	404	478	646	696	724
Romania	2,625	2,852	3,006	2,976	2,976
Saudi Arabia	187	229	211	230	229
South Africa, Republic of	608	629	634	639	639
Spain	819	593	678	[e]683	672
Sri Lanka	48	114	69	[e]77	33
Sweden	87	85	53	54	55
Switzerland	36	36	36	33	33
Syria	33	72	125	132	132
Taiwan	448	350	342	296	230

See footnotes at end of table.

Table 7.—Ammonia: World production, by country[1] —Continued

(Thousand short tons of contained nitrogen)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Trinidad and Tobago	r438	r773	1,095	1,190	1,200
Turkey	r313	r281	307	320	320
U.S.S.R	14,220	15,400	16,000	16,500	17,100
United Arab Emirates	--	--	--	303	402
United Kingdom	1,962	1,892	1,896	2,024	2,000
United States[6]	15,732	13,029	11,297	13,368	[3]13,238
Venezuela	457	r485	418	e510	513
Yugoslavia	464	465	452	e440	460
Zambia	20	30	31	31	31
Zimbabwe[e]	57	93	78	83	77
Total	r84,847	r83,630	86,560	93,029	94,302

eEstimated. pPreliminary. rRevised.
[1]Table includes data available through May 13, 1986.
[2]In addition to the countries listed, Vietnam has a nitrogen (N content of ammonia) production capacity of about 60,000 short tons per year; it is not known at what output level the plant is operating.
[3]Reported figure.
[4]Data are for years beginning Apr. 1 of that stated.
[5]Series revised to provide calendar year data, as opposed to fiscal year data provided in previous editions.
[6]Synthetic anhydrous ammonia and coke oven ammonia. Coke oven ammonia not available for 1985.

TECHNOLOGY

British Petroleum Co. Ltd. developed new ammonia process technology around a graphite-based synthesis catalyst. The catalyst was to be tested in a commercial plant after initial tests at a pilot plant. The new process offered potential savings in energy and production costs.[13]

The Dow Chemical Co. developed a modular air separation system based on a newly designed membrane fiber. The fiber's thickness allows the system to have greater surface area for higher nitrogen absorption. The system was designed to yield 95% to 99% pure nitrogen.[14]

S. R. Martin, a chemical engineering consultant from Welwyn Garden City in the United Kingdom, developed a new method of steam reforming light hydrocarbons to produce synthesis gas for ammonia. The technology was centered around a thermic steam reformer. The method was more energy efficient than conventional reformers because of a low pressure drop across the heat transfer surface.[15]

[1]Physical scientist, Division of Industrial Minerals.
[2]European Chemical News. V. 44, No. 1181, 1985, p. 25.
[3]Green Markets. V. 9, No. 24, 1985, p. 1.
[4]Nitrogen (London). No. 155, 1985, p. 16.
[5]Page 13 of work cited in footnote 4.
[6]Work cited in footnote 4.
[7]Green Markets. V. 9, No. 14, 1985, p. 5.
[8]Nitrogen (London). No. 156, 1985, p. 17.
[9]———. No. 153, 1985, p. 13.
[10]Page 16 of work cited in footnote 8.
[11]Page 12 of work cited in footnote 9.
[12]Page 11 of work cited in footnote 9.
[13]European Chemical News. V. 45, No. 1194, 1985, p. 19.
[14]Chemical Marketing Reporter. V. 227, No. 8, 1985, pp. 7-19.
[15]Page 32 of work cited in footnote 9.

Peat

By Charles L. Davis[1]

Peat production in the United States increased slightly in 1985. In decreasing order of quantity, Florida, Michigan, Illinois, Colorado, and Indiana were the major peat producing States. Reed-sedge peat was the most common kind produced, followed by humus, hypnum, sphagnum, and unclassified. Peat sold in packaged form by domestic producers increased in quantity and value. Apparent consumption increased slightly. Imports for consumption, primarily from Canada, decreased somewhat and represented a large part of apparent consumption. The predominant end use of peat was for agricultural and horticultural purposes. About 11,000 short tons of peat was used for fuel, mostly in projects to evaluate the burn characteristics of peat for energy production.

Domestic Data Coverage.—Domestic production data for peat are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the 117 operations to which a survey request was sent, 98 responded, representing 95% of the total production shown in table 1. Production for the 19 nonrespondents was estimated using prior year production levels adjusted for regional production trends and inflation.

Table 1.—Salient peat statistics

	1981	1982	1983	1984	1985
United States:					
Number of active operations	90	93	94	101	99
Production ---- thousand short tons	686	798	704	800	839
Sales by producers ---- do	757	769	725	814	882
Bulk ---- do	276	259	223	373	396
Packaged ---- do	481	511	503	441	486
Value of sales ---- thousands	$18,784	$16,871	$18,667	$19,907	$21,892
Average per short ton	$24.82	$21.94	$25.73	$24.47	$24.81
Average per short ton, bulk	$17.28	$16.34	$18.34	$20.47	$20.29
Average per short ton, packaged or baled	$29.14	$24.77	$29.00	$27.85	$28.49
Imports for consumption ---- thousand short tons	342	370	419	485	477
Consumption, apparent[1] ---- do	1,089	1,080	1,042	1,146	1,255
Stocks, yearend producers' ---- do	269	357	438	577	638
World: Production ---- do	[r]276,267	[r]283,504	282,266	[p]282,719	[e]283,106

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Apparent consumption equals U.S. primary production plus imports minus exports plus adjustments for industry stock changes.

DOMESTIC PRODUCTION

Peat was produced by 99 active domestic operations. There were 11 large operations with capacities greater than 25,000 tons per year—4 reed-sedge operations and 1 humus operation in Michigan, 4 reed-sedge operations in Florida, 1 reed-sedge operation in Illinois, and 1 humus operation in Colorado—that accounted for 53% of production, compared with 41% in 1984. Reed-sedge production increased from 68% in 1984 to greater than 72% of total output in 1985. Humus accounted for 22%; hypnum, 3%; sphagnum, 2%; and unclassified, less than 1%. About 11,000 tons of peat was produced for use as a fuel to generate thermal energy for a lumber company and for peat fuel test burns.

Table 2.—Relative size of peat operations in the United States

Size in short tons per year	Active operations		Production (thousand short tons)	
	1984	1985	1984	1985
25,000 and over	8	11	329	446
15,000 to 24,999	7	7	137	116
10,000 to 14,999	11	7	131	84
5,000 to 9,999	14	17	97	115
2,000 to 4,999	25	15	81	48
1,000 to 1,999	13	15	18	21
Under 1,000	23	27	6	10
Total[1]	101	99	800	839

[1]Data may not add to totals shown because of independent rounding.

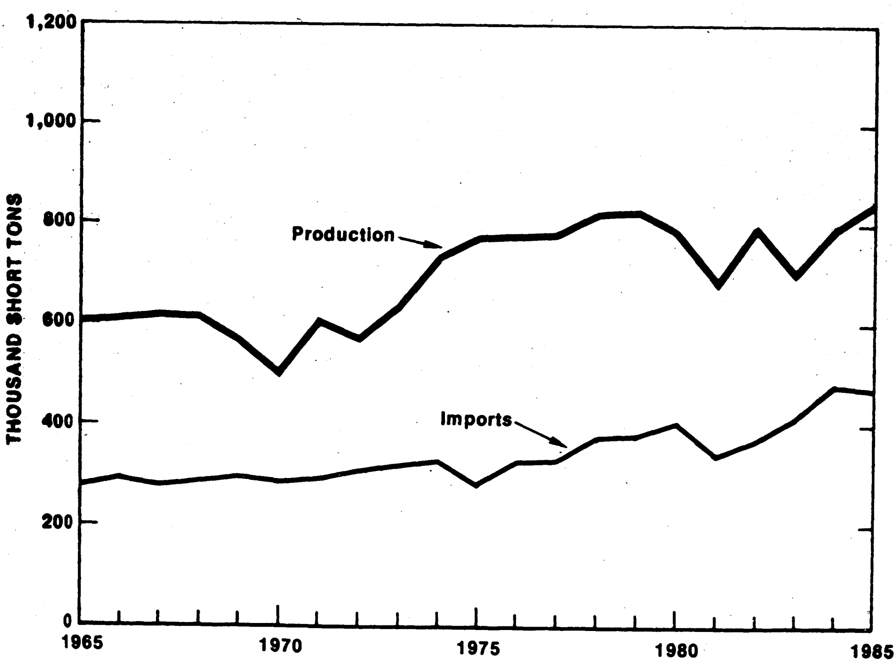

Figure 1.—Production and imports of peat in the United States.

CONSUMPTION AND USES

U.S. peat producers' domestic sales increased slightly and consisted of 73% reed-sedge, 20% humus, 3% hypnum, 3% sphagnum, and 1% unclassified. Sales of both bulk peat and packaged peat increased. Sales of bagged or baled peat were 55% of total sales and consisted of 83% reed-sedge, 8% humus, 5% hypnum, and 4% sphagnum. Peat sales increased for general soil improvement, golf courses, mixed fertilizers, nurseries, vegetable growing, and other uses. Sales decreased for peat used as an earthworm culture medium, an ingredient for potting soils, in mushroom beds, for packing flowers, and as a seed inoculant. Apparent consumption of peat increased as a result of an increase in demand.

Table 3.—U.S. peat sales by producers in 1985, by use

Use	In bulk		In packages		Total[1]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Earthworm culture medium	1,775	$34	112	$2	1,887	$36
General soil improvement	127,820	1,897	452,999	11,137	580,819	13,034
Golf courses	30,199	815	--	--	30,199	815
Ingredient for potting soils	99,423	2,437	18,765	831	118,188	3,268
Mixed fertilizers	15,535	167	--	--	15,535	167
Mushroom beds	3,831	64	--	--	3,831	64
Nurseries	100,852	2,198	4,118	280	104,970	2,477
Packing flowers, plants, shrubs, etc	1,030	14	--	--	1,030	14
Seed inoculant	352	119	3,935	1,308	4,287	1,427
Vegetable growing	3,691	59	9	(2)	3,700	59
Other	11,478	229	6,480	300	17,958	529
Total	395,986	8,033	486,418	13,858	882,404	[1]21,892

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 4.—U.S. peat production and sales by producers in 1985, by State

State	Active operations	Production	Sales		
		Quantity (thousand short tons)	Quantity (thousand short tons)	Value[1] (thousands)	Percent packaged
California	2	W	W	W	92
Colorado	4	W	W	W	34
Florida	13	263	243	$5,333	18
Georgia	2	W	W	W	98
Illinois	5	W	W	W	93
Indiana	6	38	54	W	76
Iowa	4	12	11	415	28
Maine	1	W	--	--	--
Maryland	1	W	W	W	14
Massachusetts	1	W	W	W	10
Michigan	17	243	282	5,414	72
Minnesota	5	27	34	1,720	63
Montana	2	W	W	W	100
New Jersey	5	W	W	311	86
New York	5	W	W	W	91
North Carolina	3	W	W	W	77
North Dakota	1	W	W	W	88
Ohio	7	12	16	413	56
Pennsylvania	7	20	21	602	26
South Carolina	1	W	W	173	36
Washington	3	12	12	292	--
Wisconsin	4	W	10	W	33
Total[2] or average	99	839	882	21,892	55

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Values are f.o.b. producing plant.
[2]Data may not add to totals shown because of independent rounding.

Table 5.—U.S. peat sales by producers in 1985, by use

Use	Sphagnum moss			Hypnum moss			Reed-sedge		
	Quantity		Value (thou-sands)	Quantity		Value (thou-sands)	Quantity		Value (thou-sands)
	Weight (short tons)	Volume[1] (cubic yards)		Weight (short tons)	Volume (cubic yards)		Weight (short tons)	Volume (cubic yards)	
Earthworm culture medium	450	1,500	$13	--	--	--	1,017	1,922	$19
General soil improvement	21,898	127,282	1,335	20,508	51,768	$743	431,536	879,225	9,507
Golf courses	780	2,600	22	500	1,000	7	19,027	39,692	577
Ingredient for potting soils	1,345	4,482	27	--	--	--	79,413	168,487	2,590
Mixed fertilizers	--	--	--	--	--	--	--	--	--
Mushroom beds	--	--	--	600	2,000	30	3,231	6,175	34
Nurseries	105	350	2	4,238	17,500	290	88,269	181,487	2,004
Packing flowers, plants, shrubs, etc	120	400	2	--	--	--	110	200	1
Seed inoculant	--	--	--	--	--	--	3,841	6,984	1,248
Vegetable growing	--	--	--	--	--	--	3,055	6,079	50
Other	--	--	--	--	--	--	15,480	42,000	500
Total[2]	24,698	136,614	1,402	25,846	72,268	1,069	644,979	1,332,251	16,530

Use	Humus			Other			Total[2]		
	Quantity		Value (thou-sands)	Quantity		Value (thou-sands)	Quantity		Value (thou-sands)
	Weight (short tons)	Volume (cubic yards)		Weight (short tons)	Volume (cubic yards)		Weight (short tons)	Volume (cubic yards)	
Earthworm culture medium	420	740	$4	--	--	--	1,887	4,162	$36
General soil improvement	104,027	151,770	1,409	2,850	6,000	$40	580,819	1,216,045	13,034
Golf courses	9,892	18,965	210	--	--	--	30,199	62,257	815
Ingredient for potting soils	37,430	73,018	652	--	--	--	118,188	245,987	3,268
Mixed fertilizers	15,535	23,900	167	--	--	--	15,535	23,900	167
Mushroom beds	--	--	--	--	--	--	3,831	8,175	64
Nurseries	11,858	23,315	172	500	1,000	10	104,970	223,652	2,477
Packing flowers, plants, shrubs, etc	800	1,500	10	--	--	--	1,030	2,100	14
Seed inoculant	446	595	178	--	--	--	4,287	7,579	1,427
Vegetable growing	645	1,263	9	--	--	--	3,700	7,342	59
Other	38	50	([3])	2,440	5,648	29	17,958	47,698	529
Total[2]	181,091	295,116	2,811	5,790	12,648	79	882,404	1,848,897	21,892

[1]Volume of nearly all sphagnum moss was measured after compaction and packaging.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

Table 6.—U.S. peat production and producers' yearend stocks in 1985, by kind

Kind	Active operations	Production (short tons)	Percent of production	Yearend stocks (short tons)
Sphagnum moss	5	15,840	1.9	10,679
Hypnum moss	6	28,277	3.4	10,621
Reed-sedge	55	608,113	72.5	553,167
Humus	29	184,123	21.9	35,545
Other	4	2,610	.3	28,300
Total	99	838,963	100.0	638,312

PRICES AND SPECIFICATIONS

The average reported price per ton for all types of peat, f.o.b. plant, increased slightly. The unit price for bulk peat decreased slightly, and that for packaged peat increased somewhat. The price per ton of imported sphagnum peat increased a small amount.

Table 7.—Prices[1] for peat in 1985

(Dollars per unit)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other	Average
Domestic:						
Bulk:						
Per short ton	20.48	36.90	24.20	13.73	13.64	20.29
Per cubic yard	8.93	12.81	11.63	8.26	6.24	10.45
Packaged or baled:						
Per short ton	77.78	41.91	26.45	22.13	--	28.49
Per cubic yard	10.50	15.05	12.86	14.66	--	12.83
Average:						
Per short ton	56.77	41.36	25.63	15.52	13.64	24.81
Per cubic yard	10.26	14.79	12.41	9.53	6.24	11.84
Imported, total, per short ton[2]	121.18	XX	XX	XX	XX	121.18

XX Not applicable.
[1]Prices are f.o.b. plant.
[2]Average customs price.

Table 8.—Average density of domestic peat sold in 1985

(Pounds per cubic yard)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other
Bulk	873	694	961	1,203	916
Packaged	270	718	972	1,325	--
Bulk and packaged	362	715	968	1,227	916

FOREIGN TRADE

Peat imports for domestic consumption decreased slightly in quantity and increased slightly in value. More than 99% of the imports was sphagnum moss peat from Canada. Canadian sphagnum moss peat was in demand because of consumer loyalty to brand and because in most areas domestic sphagnum moss peat had not entered the U.S. retail market. Almost 42% of the imported peat entered the United States through customs districts in New York. Large quantities also entered through customs districts in Maine, Michigan, Montana, North Dakota, Vermont, and Washington. Minor quantities of peat were imported from the Federal Republic of Germany, Mexico, and the Netherlands.

Table 9.—U.S. imports for consumption of peat moss in 1985, by country

Country	Poultry- and stable-grade		Fertilizer-grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Canada	25,174	$3,559	451,612	$54,207	476,786	$57,766
Germany, Federal Republic of	--	--	51	4	51	4
Mexico	107	30	--	--	107	30
Netherlands	16	2	110	6	126	8
Other[1]	73	15	245	27	318	42
Total	25,370	3,606	452,018	54,244	477,388	57,850

[1]Includes China, Denmark, Finland, France, Guatemala, Ireland, Japan, Kiribati, Morocco, New Caledonia, Panama, Sweden, the U.S.S.R., and the United Kingdom.

Source: Bureau of the Census.

Table 10.—U.S. imports for consumption of peat moss in 1985, by customs district

Customs district	Poultry- and stable-grade		Fertilizer-grade		Total[1]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Boston, MA	36	$2	--	--	36	$2
Buffalo, NY[2]	15,860	2,474	13,417	$1,676	29,277	4,151
Chicago, IL	25	2	--	--	25	2
Detroit, MI[2]	8,712	992	39,882	4,787	48,594	5,778
Duluth, MN[2]	--	--	1,110	160	1,110	160
Great Falls, MT[2]	--	--	53,976	8,488	53,976	8,488
Houston, TX	24	3	--	--	24	3
Laredo, TX	108	30	--	--	108	30
Los Angeles, CA	--	--	34	3	34	3
New Orleans, LA[2]	--	--	20	4	20	4
New York, NY	10	6	127	9	137	15
Norfolk, VA[2]	16	2	44	6	60	8
Ogdensburg, NY[2]	262	33	169,122	16,974	169,384	17,006
Pembina, ND	22	2	93,866	12,143	93,888	12,145
Philadelphia, PA[2]	--	--	121	21	121	21
Portland, ME[2]	129	22	34,074	3,750	34,203	3,772
St. Albans, VT[2]	22	6	27,648	3,037	27,670	3,043
San Francisco, CA	--	--	84	12	84	12
San Juan, PR[2]	34	7	--	--	34	7
Seattle, WA[2]	91	21	18,493	3,175	18,584	3,197
Virgin Islands	19	5	--	--	19	5
Total[1]	25,370	3,606	452,018	54,244	477,388	57,850

[1]Data may not add to totals shown because of independent rounding.
[2]Predominantly of Canadian origin.

Source: Bureau of the Census.

WORLD REVIEW

China.—An exploration team from the Chinese Academy of Sciences discovered deposits in central China containing an estimated 7 billion cubic meters of peat. Production from these deposits was expected to be used as fertilizer and fuel. The deposits were located on the Qingzang plateau at the juncture of the Gansu Quinghai, and Sichuan Provinces.[2]

Finland.—Vapo Oy, a Finnish company specializing in peat production and development worldwide, purchased Peatrex Ltd., a peat producing company in Minnesota. Vapo Oy supplied machinery and technical expertise to peat projects in Africa, Finland, Southeast Asia, Sweden, and Western Europe.[3]

Kemira Oy, a state-owned company, planned to build a new 80,000-ton-per-year ammonia plant that would use peat for feedstock. The plant was to be located at Oulu and employ over 250 people in the production and handling of the peat.[4]

Table 11.—Peat: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina: Agricultural use	3	4	4	3	3
Australia[e]	[r]17	[r]13	[r]13	15	15
Burundi	10	15	15	15	15
Canada: Agricultural use	509	537	583	[e]550	550
Denmark: Agricultural use[3]	36	[r]40	[r] [e]37	34	40
Finland:					
Agricultural use	225	637	303	248	220
Fuel	1,436	6,063	3,698	2,991	3,300
France: Agricultural use[e]	143	132	121	[r]250	220
Germany, Federal Republic of:					
Agricultural use	1,920	2,030	2,059	1,575	2,000
Fuel	271	279	285	305	290
Hungary: Agricultural use[e]	77	77	77	77	77
Ireland:					
Agricultural use	89	105	[e]105	106	105
Fuel	5,906	5,819	[r] [e]7,330	8,746	8,430
Israel: Agricultural use[e]	22	22	22	22	22
Netherlands[e]	441	441	441	496	500
Norway:[e]					
Agricultural use	66	66	66	66	66
Fuel	1	1	1	1	1
Poland: Fuel and agricultural use[e]	[4]222	220	220	220	220
Spain	43	66	44	61	55
Sweden: Agricultural use	144	[r]139	138	[e]138	138
U.S.S.R.:					
Agricultural use	[r]198,000	[r] [e]200,000	[r] [e]200,000	[r] [e]200,000	200,000
Fuel[e]	66,000	66,000	66,000	66,000	66,000
United States:					
Agricultural use	686	798	703	789	[4]828
Fuel	--	--	1	11	[4]11
Total	[r]276,267	[r]283,504	282,266	282,719	283,106
Fuel peat included in total	73,836	78,382	77,535	78,274	78,252

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 10, 1986.
[2]In addition to the countries listed, Austria, Iceland, and Italy produce negligible quantities of fuel peat, the German Democratic Republic is a major producer, and Venezuela produces small amounts of peat for agricultural use, but output is not officially reported, and available information is inadequate for formulation of reliable estimates of output levels.
[3]Sales.
[4]Reported figure.

TECHNOLOGY

Swedish researchers seeking to utilize peat as an organic raw material for chemicals determined that peat contains an enormously complex mixture of organic materials. The largest fractions are lignins, humic acids, hemicelluloses, celluloses, and bitumens.[5]

Research into the use of oxidatively solubilized coal (OSC) in alcohol to produce a diesel-like fuel determined that peat was also good feedstock for the process. Solutions of peat-derived OSC in methanol, containing as much as 50% by weight of the OSC, were similar to conventional diesel fuel in viscosity, lubricity, and cetane value. The combustion product was essentially smoke free and low in nitrogen oxides. The OSC derived from peat outperformed OSC made from some kinds of coal.[6]

[1]Physical scientist, Division of Industrial Minerals.
[2]Mining Magazine. China Peat Discovery. V. 152, No. 4, April 1985, p. 287.
[3]News—Tribune and Herald (Duluth, MN). Peatrex Sale to Finnish Firm Expected To End Controversy. Sept. 28, 1985.
[4]Fertilizer International. No. 213, 1985, p. 6.
[5]Foersvarets Forskningsanstalt, Umea (Sweden). Peat as a Raw Material for Chemicals. Aug. 1985, 31 pp.
[6]Chemical & Engineering News. Process Yields Diesel-Like Fuel From Coal, Peat, Biomass. V. 63, No. 26, July 1, 1985, p. 23.

Perlite

By A. C. Meisinger[1]

U.S. production of both processed and expanded perlite increased slightly in 1985. Processed perlite sold and used was 507,000 short tons valued at $17.2 million. Expanded perlite sold and used was 459,000 tons valued at $81 million. Imports of processed perlite from Greece continued to increase and were 52,000 tons compared with 46,000 tons (revised) in 1984. Construction-related uses continued to dominate the domestic market for expanded perlite with nearly 69% of total sales.

Domestic Data Coverage.—Domestic production data for perlite are developed by the Bureau of Mines from two separate voluntary surveys, one for domestic mine operations and the other for plant operations. Of the 12 mining operations to which a request was sent, 9, or 75%, responded, representing 90% of the total processed ore sold and used shown in table 1. Mine data for the three nonrespondents were estimated using reported prior year production levels adjusted by trends in employment and other guidelines. Of the 65 expanding plants to which a request was sent, 64 plants were active; of these, 43 plants, or 67%, responded, representing 82% of the total expanded perlite sold and used shown in table 1. Plant data for the 21 nonrespondents were estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

Table 1.—Perlite mined, processed, expanded, and sold and used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Perlite mined[1]	Processed perlite: Sold to expanders: Quantity	Processed perlite: Sold to expanders: Value	Processed perlite: Used at own plant to make expanded material: Quantity	Processed perlite: Used at own plant to make expanded material: Value	Processed perlite: Total quantity sold and used	Expanded perlite: Quantity produced	Expanded perlite: Sold and used: Quantity	Expanded perlite: Sold and used: Value
1981	710	324	9,928	267	7,530	591	494	485	66,300
1982	623	263	8,755	243	7,289	506	433	428	63,600
1983	608	293	9,942	181	5,722	474	387	385	63,500
1984	653	310	10,395	188	6,243	498	[r]440	[r]439	[r]74,000
1985	678	316	10,957	191	6,203	507	461	459	81,000

[r]Revised.
[1]Crude ore mined and stockpiled for processing.

DOMESTIC PRODUCTION

Processed Perlite.—The quantity of perlite mined for processing, by 10 companies from 12 operations in 5 Western States, was 678,000 tons, a slight increase over that of 1984. Of that total, five mines in New Mexico accounted for 86%. The remaining 14% was mined in Arizona, California, Colorado, and Nevada.

Production of processed perlite increased slightly to 507,000 tons sold and used valued at $17.2 million compared with 1984 production of 498,000 tons and $16.6 million. New Mexico mines accounted for 83% of the U.S. total processed perlite sold and used. Ore producers were Harborlite Corp. and Sil-Flo Inc. in Arizona; American Perlite Co. in

California; Persolite Products Inc. in Colorado; Oneida Perlite Corp. in Idaho; Delamar Perlite Co. and U.S.G. Corp. (formerly United States Gypsum Co.) in Nevada; and Grefco Inc., Manville Products Corp., Silbrico Corp., and U.S.G. in New Mexico.

Expanded Perlite.—Expanded perlite was produced by 64 plants in 31 States. The quantity produced increased 5% (revised) over that produced in 1984. Leading States, in descending order of sales, were Mississippi, Pennsylvania, California, Georgia, Illinois, Kentucky, Texas, Florida, Virginia, Indiana, and Colorado. California and Texas each had seven active plants, followed by Pennsylvania with five, and Florida and Indiana with four each.

Table 2.—Expanded perlite produced and sold and used by producers in the United States, by State

State	1984				1985			
	Quantity produced (short tons)	Sold and used			Quantity produced (short tons)	Sold and used		
		Quantity (short tons)	Value (thousands)	Average value per ton[1]		Quantity (short tons)	Value (thousands)	Average value per ton[1]
Arkansas	1,100	1,100	W	W	W	W	W	W
California	48,100	47,500	[r]$8,574	[r]$181	47,300	46,300	$8,516	$184
Florida	20,600	20,500	3,470	169	26,400	26,400	4,831	183
Indiana	22,500	22,200	4,982	225	22,200	22,300	5,501	247
Kansas	W	W	W	W	800	800	200	250
Massachusetts	2,400	2,300	779	339	2,300	2,200	708	322
Pennsylvania	[r]42,000	[r]42,000	[r]7,078	[r]169	48,300	48,100	8,260	172
Texas	27,200	27,100	5,805	214	27,900	27,400	5,915	216
Wisconsin	W	W	W	W	1,200	1,200	296	250
Other[2]	[r]275,700	[r]275,900	[r]43,610	[r]158	284,600	283,900	46,800	165
Total[3]	[r]440,000	[r]439,000	[r]74,000	[r]169	461,000	459,000	81,000	177

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]Average value based on unrounded data and rounded to nearest dollar.

[2]Includes Alabama, Arizona, Colorado, Georgia, Idaho, Illinois, Iowa, Kentucky, Louisiana, Maine, Michigan, Minnesota (1984), Mississippi, Missouri, Nevada, New Jersey, New York, North Carolina, Oregon, Tennessee, Utah, Virginia, Wyoming, and items indicated by symbol W.

[3]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Apparent domestic consumption of processed perlite was 539,000 tons compared with 524,000 tons in 1984. Domestic consumption of expanded perlite increased 5% to 459,000 tons. Construction-related uses, such as aggregates for concrete, plaster, formed products, and loose-fill insulation, continued to account for two-thirds of sales. All major end uses but plaster aggregates and low-temperature insulation increased in sales during the year.

Table 3.—Expanded perlite sold and used by producers in the United States, by use

(Short tons)

Use	1984	1985
Concrete aggregate	20,800	21,400
Fillers	12,100	16,800
Filter aid	60,600	62,400
Formed products[1]	[r]257,000	267,300
Horticultural aggregate[2]	36,100	39,600
Low-temperature insulation	5,000	4,100
Masonry and cavity-fill insulation	15,100	15,200
Plaster aggregate	[r]12,700	11,300
Other[3]	19,100	20,600
Total[4]	[r]439,000	459,000

[r]Revised.

[1]Includes acoustic ceiling tile, pipe insulation, roof insulation board, and unspecified formed products.

[2]Includes fertilizer carriers.

[3]Includes fines, high-temperature insulation, paint texturizer, refractories, and various nonspecified industrial uses.

[4]Data may not add to totals shown because of independent rounding.

PRICES

The average price of processed perlite sold to expanders increased slightly from $33.53 per ton to $34.67 per ton, but the average price of processed perlite used by producers in their own plants declined from $33.21 per ton to $32.48 per ton in 1985. The average value of all processed perlite sold and used was $33.85 per ton, a slight increase over that of 1984. The value of expanded perlite sold and used averaged $177 per ton compared with $169 per ton (revised) in 1984.

FOREIGN TRADE

The United States imported approximately 52,000 tons of processed perlite from Greece, compared with 46,000 tons (revised) in 1984. Exports of processed perlite were estimated to be 20,000 tons to Canada, the same as those of 1984.

WORLD REVIEW

Estimated world production of perlite totaled nearly 1.8 million tons in 1985, a slight decrease from that of 1984. Three countries, Greece, the U.S.S.R., and the United States, accounted for 76% of the world total.

[1]Industry economist, Division of Industrial Minerals.

Table 4.—Perlite: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Australia[3]	2	1	2	[e]2	2
Czechoslovakia	47	50	49	[e]49	49
Greece	145	167	167	196	195
Hungary[3]	105	99	103	113	112
Italy[e]	94	88	83	[r]88	88
Japan[e]	83	83	83	83	83
Mexico[3]	63	36	46	35	33
New Zealand[3]	1	2	1	(4)	--
Philippines	8	4	2	17	3
Turkey	50	134	32	67	66
U.S.S.R.[e]	[r]660	[r]660	[r]660	[r]660	660
United States (processed ore sold and used by producers)	591	506	474	498	[5]507
Total	[r]1,849	[r]1,830	1,702	1,808	1,798

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Unless otherwise specified, figures represent processed ore output. Table includes data available through June 3, 1986.
[2]In addition to the countries listed, Algeria, Bulgaria, China, Iceland, Mozambique, the Republic of South Africa, and Yugoslavia are believed to have produced perlite but output data are not reported and available information is inadequate for formulation of reliable estimates of output levels.
[3]Crude ore.
[4]Revised to zero.
[5]Reported figure.

Phosphate Rock

By William F. Stowasser[1]

Phosphate rock production marginally increased in 1985 but the depressed state of the U.S. agricultural sector limited demand for phosphate fertilizer raw materials. However, the export market for phosphate fertilizer was exceptionally strong. Sales of diammonium phosphate, for example, were a record high 7.2 million metric tons, with prices frequently below production costs. Without the export market, phosphate fertilizer producers' financial status would have been substantially weaker.

Phosphate rock inventories increased during the year as demand declined. Phosphate producing companies closed several mines and plants for an indefinite time: Some were for sale, some temporarily closed to reduce inventories, several filed for reorganization under chapter 11 of the Federal Bankruptcy Act, and some merged to reduce financial losses. Despite the restructuring of the phosphate industry, demand and supply were still out of balance. The plant shutdowns and curtailed production failed to reduce the phosphate surplus; inventory levels increased, prices were cut, and profitability was reduced for phosphate rock and phosphate fertilizer.

Electric furnaces traditionally have been used to smelt phosphate rock to produce

Table 1.—Salient phosphate rock statistics[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Mine production (crude ore)	183,733	104,135	125,691	163,012	175,058
Marketable production	53,624	37,414	42,573	49,197	50,835
P_2O_5 content	16,365	11,504	13,088	14,889	15,634
Value	$1,437,986	$950,326	$1,021,095	$1,182,244	[2]$1,203,265
Average per metric ton	[3]$26.82	[3]$25.40	[3]$23.98	[3]$24.03	[4]$23.67
Sold or used by producers[5]	45,526	38,571	46,839	53,277	46,634
P_2O_5 content	13,939	11,814	14,336	16,244	14,363
Value	$1,212,433	$983,465	$1,122,966	$1,278,356	[2]$1,103,827
Average per metric ton[4 6]	$26.63	$25.50	$23.97	$23.99	$23.67
Exports[7]	10,395	9,842	12,010	11,528	10,284
P_2O_5 content	3,300	3,138	3,839	3,646	3,263
Value	$373,192	$293,626	$327,345	$324,784	[2]$281,515
Average per metric ton[4]	$35.90	$29.83	$27.26	$28.17	$27.37
Imports for consumption	13	31	9	[8]9	[8]34
C.i.f. value	$420	$1,302	$376	$274	$1,747
Average per metric ton	$32.31	$42.00	$42.69	$31.71	[9]$51.54
Consumption[10]	35,144	28,760	34,838	41,758	36,384
Stocks, Dec. 31: Producer	19,619	18,287	14,500	11,897	15,534
World: Production	[r]143,001	[r]127,385	139,404	[p]152,488	[e]151,363

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Data for the same items appearing in this and other tables may not reconcile because of computer rounding.
[2]The total value is based on a weighted value.
[3]Arithmetic average of sold or used values.
[4]Computer calculated average value based on the weighted sold or used value.
[5]Includes domestic sales and exports.
[6]Weighted average of sold or used values.
[7]Exports reported to the Bureau of Mines by companies.
[8]Bureau of the Census data, excluding reported Canadian and Israeli imports.
[9]Average unit value obtained from unrounded data.
[10]Measured by sold or used plus imports minus exports.

elemental phosphorus (P_4). Most of the P_4, perhaps as much as 85%, was used to produce technical-grade phosphoric acid, as opposed to food-grade acid, which was then used to manufacture numerous phosphate salts. U.S. production of P_4 declined from a peak of 560,000 tons in 1969 to 370,000 tons in 1984. Overcapacity in this segment of the phosphate industry was comparable to that of the fertilizer industry. A new, significantly lower cost, wet acid process was used in Europe, Israel, and Japan to produce technical-grade phosphoric acid. Some of this acid was exported directly to the United States or converted into phosphate salts and exported. The decline in demand for U.S.-produced P_4 was attributed to the high cost of the thermal process, increased competition from foreign imports, and a nationwide campaign to prohibit phosphates in detergent products.

Domestic Data Coverage.—Domestic production data for phosphate rock are developed by the Bureau of Mines from two separate, voluntary surveys of U.S. operations. Typical of these surveys is the semiannual "Phosphate Rock Survey." Of the 24 operations to which a survey request was sent, all responded, representing 100% of the U.S. production data shown in table 1.

Legislation and Government Programs.—The Food Security Act of 1985 was expected to expand the potential for grain exports by reducing U.S. grain prices on world markets and supporting farm income by maintaining target prices at current levels over the next 2 years. The farm program also placed a 20% and 25% nonpaid acreage reduction maximum on the U.S. Department of Agriculture for corn and wheat, respectively, in 1986. This implied a smaller reduction in acreage in the spring of 1986 than had been anticipated.

DOMESTIC PRODUCTION

Florida and North Carolina produced about 6% more marketable phosphate rock than the 42.5 million tons produced in 1984. The Western States and Tennessee produced somewhat less than that produced in 1984.

Florida and North Carolina.—Companies that mined phosphate rock in central Florida were Agrico Chemical Co., Beker Phosphate Inc., Brewster Phosphates, CF Industries Inc., Estech Inc., Gardinier Inc., W. R. Grace & Co., Hopewell Land Corp., International Minerals & Chemical Corp. (IMC), Mobil Mining and Minerals Co., and USS Agri-Chemicals Inc. Occidental Chemical Agricultural Products Inc. produced phosphate rock in Hamilton County, north Florida.

Several small companies in north-central Florida recovered soft phosphate rock from tailing ponds remaining from old inactive hard-rock phosphate rock mines. The estimated combined annual capacity of 45,000 tons has seldom been achieved. The soft rock was sold as an animal feed supplement.

In North Carolina, Texasgulf Chemicals Co., a subsidiary of Société Nationale Elf Aquitaine, operated the Lee Creek Mine near Aurora. North Carolina Phosphate Corp., an Agrico mining company, sold its reserves and assets to Texasgulf. Agrico, a Williams Co. subsidiary, received 15% of Texasgulf's stock and a warrant to purchase up to an additional 4.9%. The merger, subject to Government antitrust review, was expected to be completed by yearend. Texasgulf was the only phosphate mining company producing in North Carolina.

After divesting its North Carolina phosphate reserves and assets, Agrico operated three phosphate rock mines in central Florida until April, when the Saddle Creek Mine was closed. The Payne Creek and Fort Green Mines continued to operate throughout the year. The Payne Creek Mine's reserves were expected to permit operation for another 2 years.

AMAX Phosphate Inc.'s Big Four Mine remained closed during the year. AMAX Inc. wrote down the value of its fertilizer business and was attempting to sell the assets of AMAX Phosphate.

Beker announced in October that it had filed for reorganization under chapter 11 of the Federal Bankruptcy Code. Beker was unable to convince holders of its debt to exchange their debentures for new debentures and common stock. Throughout this period of adversity, Beker continued to produce phosphate rock at its Wingate Creek Mine.

Brewster, a partnership of American Cyanamid Co., 75%, and Kerr-McGee Corp., 25%, operated the Haynsworth and Lonesome Mines in Polk and Hillsborough Counties, respectively. American Cyanamid, Kerr-McGee, and IMC reached an agreement in principle, subject to approval of their respective boards of directors and customary regulatory agencies, to lease the Haynsworth and Lonesome beneficiation plants. Remaining phosphate rock reserves at the two mines were to be mined under a royalty agreement.

CF Industries operated the Hardee Phosphate Complex I Mine at Fort Green to supply phosphate rock for its chemical complex at Bartow and Plant City, FL. The Hardee Complex II Mine was deferred, and the Complex I Mine expansion plans were also deferred.

At the beginning of the year, W. R. Grace and IMC opened the Four Corners Mine at the intersections of Polk, Hardee, Manatee, and Hillsborough Counties, FL. The design capacity of the mine, with three draglines, was 5.5 million tons per year. W. R. Grace also operated the Hookers Prairie Mine, south of Mulberry, in Polk County, FL, and purchased 14.5 million tons of phosphate rock reserves from Agrico.

Estech, an Esmark Inc. subsidiary, had divested many of its Florida phosphate rock properties in 1983 and 1984. In 1985, Estech's retail fertilizer division was sold and the company was left with the closed Silver City Mine and one-third ownership in the active Watson Mine. Indications were that Estech's remaining assets would be put up for sale.

Early in the year, Gardinier filed for court protection under chapter 11 of the Federal Bankruptcy Act in order to reorganize its finances. The phosphate rock mine near Fort Meade, FL, and the fertilizer manufacturing complex south of Tampa, FL, operated throughout the year, with occasional shutdowns to adjust inventories. Cargill Inc., an international marketer and processor of agricultural and other bulk commodities, offered to purchase 80% of Gardinier in October. The agreement was finalized by yearend.

Hopewell opened a 500,000-ton-per-year phosphate rock mine near Lithia, FL, at the beginning of the year.

IMC, with 50% equity in the Four Corners Mine, operated the Clear Springs, Kingsford, and Noralyn-Phosphoria Mines in central Florida. At yearend, IMC agreed in principle to lease the Lonesome and Haynsworth phosphate rock beneficiation plants from American Cyanamid and Kerr-McGee, owners of Brewster Phosphates, and mine the reserves of these mines under a royalty agreement. The merger was subject to Federal Trade Commission approval.

Mobil operated the Nichols and Fort Meade Mines in central Florida. The Fort Meade reserves were expected to permit operation for only another 4 years at its current rate of production. Plans to construct a mine on Mobil's South Fort Meade deposit were deferred because of unfavorable economics.

USS Agri-Chemicals, a subsidiary of United States Steel Corp., operated the Rockland Mine with Freeport Phosphate Rock Co., a 50% partner. United States Steel announced that USS Agri-Chemicals was for sale. USS Agri-Chemicals sold fertilizer through retail centers and was a partner in a joint venture, Fort Meade Chemical Products, with W. R. Grace, in Fort Meade, FL.

Occidental operated two phosphate rock mines, Swift Creek and Suwannee River, in northern Florida. Occidental had capacity to produce 1.1 million tons per year of phosphoric acid from two plants and the capability to convert the acid to superphosphoric acid to supply liquid fertilizer plants in the U.S.S.R.

Tennessee.—Occidental, Monsanto Co., and Stauffer Chemical Co. mined and beneficiated phosphate rock from deposits in Giles, Hickman, Maury, and Williamson Counties. All of the phosphate rock was smelted in electric furnaces to produce P_4. Monsanto announced plans to close its P_4 plant in Columbia, TN, at the end of 1986 and to consolidate production at its Soda Springs, ID, electric-furnace plant. Chesebrough-Pond's Inc. purchased Stauffer in March 1985.

Western States.—Phosphate rock was mined in Idaho, Montana, and Utah for smelting in electric furnaces to produce P_4 and phosphate fertilizer.

Cominco American Incorporated operated the only underground mine in the country in Powell County, MT. After primary crushing, the ore was loaded into railroad cars for delivery to Kimberley, British Columbia, Canada.

Stauffer mined phosphate rock from the Wooley Valley Mine, northeast of Soda Springs, ID. The phosphate rock was shipped to Silver Bow, MT, to produce P_4.

The Conda Partnership, a 50-50 partnership between Beker and Western Co-operative Fertilizers Ltd., Calgary, Canada, mined phosphate rock from the Maybie Canyon Mine in Idaho. Part of the phosphate rock was exported to Canada for conversion to phosphate fertilizers, and Beker's share was beneficiated, calcined, and converted into phosphate fertilizers at Beker's fertilizer complex at Conda, ID. Production continued at the Maybie Canyon

Mine.

Chevron Resources Co. mined phosphate rock from the Vernal Mine north of Vernal, UT. An expanded mine at Vernal, a pipeline, and a new chemical complex at Rock Springs, WY, were scheduled to start operating in 1986. The phosphate rock will be reground to pass through a 150-mesh screen and pumped as a slurry through a buried 152-kilometer pipeline to Rock Springs at an initial rate of 1.1 million tons per year.

J. R. Simplot Co. operated the Gay Mine on the Fort Hall Indian Reservation. With the addition of new reserves obtained from the Shoshone and Bannock Indian Tribes, the mine was expected to produce for 17 years at a rate of 1.7 million tons per year. FMC Corp. received 80% of the ore, a 24% to 25% phosphorus pentoxide (P_2O_5) shale for consumption in its 0.9-million-kilogram-per-year P_4 plant near Pocatello, ID. Simplot used the remaining 20% of the mine production in its phosphoric acid plant near Pocatello.

Simplot replaced the Woodall Peak Mine near Conda, ID, with the Smoky Canyon Mine near Afton, WY. The ore was beneficiated at the mine, pumped to the calcining kilns at Conda, and shipped by rail to the fertilizer plant at Pocatello. Operating at 2 million tons per year, the Smoky Canyon Mine was expected to produce for 25 years.

Table 2.—Production of phosphate rock in the United States, by region[1]

(Thousand metric tons and thousand dollars)

Region	Mine production		Marketable production							Ending stocks
			Used directly		Beneficiated		Total[2]			
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value[3]	
1984	163,012	21,017	8,104	2,343	41,094	12,546	49,197	14,889	1,182,244	11,897
1985:										
January-June:										
Florida and North Carolina	86,305	10,746	3,313	1,000	20,377	6,334	23,690	7,335	545,581	13,115
Tennessee	1,107	223	15	4	635	165	650	169	14,567	175
Western States[4]	3,241	841	881	237	1,620	501	2,501	738	68,928	906
Total[2]	90,652	11,810	4,209	1,242	22,632	7,000	26,841	8,242	[5]631,032	14,196
July-December:										
Florida and North Carolina	80,165	9,882	2,798	853	18,708	5,813	21,506	6,666	497,434	14,691
Tennessee	1,223	239	13	3	570	147	584	151	13,053	151
Western States[4]	3,018	894	787	229	1,118	346	1,905	576	61,265	692
Total[2]	84,405	11,015	3,598	1,086	20,396	6,307	23,994	7,393	[5]572,017	15,534
Grand total[2]	175,058	22,825	7,807	2,327	43,028	13,307	50,835	15,634	[5]1,203,265	XX

XX Not applicable.
[1]Data for the same items appearing in this and other tables may not reconcile because of computer rounding.
[2]Data may not add to totals shown because of independent rounding.
[3]Computer calculated value based on the weighted sold or used value.
[4]Includes Idaho, Montana, and Utah.
[5]The total value is based on a weighted value. The total value does not equal the sum of the regional or 1/2-year totals because weighted regional or overall 1/2-year unit values were used in the calculations. The regional and 1/2-year values are approximate.

CONSUMPTION AND USES

The U.S. primary demand for phosphate rock declined about 13% from its level in 1984 as the U.S. farm economy remained depressed. Phosphatic fertilizers sold well at unprofitable prices in the export market, which was the principal reason for sustaining demand in 1985.

With the exception of some low-grade phosphate pebble exported for electric-furnace consumption in Canada, phosphate rock from Florida and North Carolina was either consumed domestically or exported for fertilizer manufacture. Consumption of phosphate rock from Florida and North Carolina was about 12% less than the quantity consumed in 1984.

All of the phosphate rock mined in Tennessee was consumed in electric furnaces in Mount Pleasant and Columbia. Consumption was less than that of 1984. High-purity P_4 was used to produce technical- and food-grade phosphoric acid and other phosphate chemicals for multiple uses. The demand for sodium tripolyphosphate, the detergent builder, declined as the quantity permitted in the formulation of washing compounds was reduced by more States and municipalities.

In the Western States, a small percentage of the phosphate rock production was exported to fertilizer plants in western Canada. The domestic consumption pattern of phosphate rock from the Western States was about equally divided between fertilizer manufacturing and electric-furnace smelting. Overall demand was about 20% less than that of 1984 as consumption declined in the agricultural and industrial sectors.

Table 3.—U.S. phosphate rock sold or used grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1981	1982	1983	1984	1985
Less than 60	5.6	4.9	8.0	12.1	4.7
60 to less than 66	15.7	15.6	14.6	8.1	10.8
66 to less than 70	60.1	63.8	60.6	63.0	67.3
70 to less than 72	9.6	5.8	8.3	10.1	10.0
72 to less than 74	6.0	6.1	5.5	2.0	4.2
74 or more	3.0	3.8	3.0	4.7	3.0

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 4.—Florida and North Carolina phosphate rock sold or used grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1981	1982[2]	1983	1984	1985
Less than 60	0.2	0.6	3.3	7.8	0.6
60 to less than 66	14.4	12.2	13.0	7.0	10.2
66 to less than 70	67.0	68.5	64.2	67.5	70.8
70 to less than 72	7.7	6.9	9.6	9.9	10.2
72 to less than 74	7.1	7.2	6.4	2.4	4.8
74 or more	3.6	4.5	3.5	5.4	3.4

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.
[2]Data do not add to 100% because of independent rounding.

Table 5.—Tennessee phosphate rock sold or used grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1981	1982	1983	1984	1985
Less than 60	50.6	38.0	89.4	100.0	100.0
60 to less than 66	49.4	62.0	10.6	--	--

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 6.—Western States phosphate rock sold or used grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1981	1982	1983	1984	1985[2]
Less than 60	31.4	27.2	25.2	27.0	15.7
60 to less than 66	16.0	29.4	27.5	19.1	19.6
66 to less than 70	28.5	43.4	47.3	39.6	54.2
70 to less than 72	24.1	--	--	14.3	10.4

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.
[2]Data do not add to 100% because of independent rounding.

Table 7.—Phosphate rock sold or used by producers in the United States, by grade and region[1]

(Thousand metric tons and thousand dollars)

Grade (percent BPL[2] content)	Florida and North Carolina			Tennessee		
	Rock	P_2O_5 content	Value[3]	Rock	P_2O_5 content	Value[3]
January-June 1984	23,022	7,096	541,349	725	183	18,672
July-December 1984	23,388	7,212	548,215	615	156	13,924
January-June 1985:						
Below 60	--	--	--	669	173	14,992
60 to less than 66	2,019	574	37,654	--	--	--
66 to less than 70	15,709	4,853	354,866	--	--	--
70 to less than 72	1,799	586	45,155	--	--	--
72 to less than 74	700	234	16,926	--	--	--
74 or more	763	261	28,902	--	--	--
Total	20,990	6,508	483,400	669	173	14,992
July-December 1985:						
Below 60	236	64	5,074	607	157	13,566
60 to less than 66	2,158	617	41,067	--	--	--
66 to less than 70	13,226	4,105	301,420	--	--	--
70 to less than 72	2,374	772	53,747	--	--	--
72 to less than 74	1,265	426	34,497	--	--	--
74 or more	609	210	23,721	--	--	--
Total	19,868	6,194	459,547	607	157	13,566

Grade (percent BPL[2] content)	Western States[4]			Total		
	Rock	P_2O_5 content	Value[3]	Rock	P_2O_5 content	Value[3] [5]
January-June 1984	2,431	711	73,045	26,178	7,990	633,066
July-December 1984	3,096	887	83,097	27,098	8,254	645,203
January-June 1985:						
Below 60	645	159	8,649	1,314	332	23,639
60 to less than 66	491	136	8,725	2,510	710	46,360
66 to less than 70	1,295	401	44,626	17,004	5,254	399,424
70 to less than 72	261	84	12,196	2,060	670	57,350
72 to less than 74	--	--	--	700	234	16,926
74 or more	--	--	--	763	261	28,902
Total	2,692	780	74,191	24,351	7,461	572,422
July-December 1985:						
Below 60	61	16	1,338	904	237	19,978
60 to less than 66	394	112	9,026	2,552	729	50,096
66 to less than 70	1,147	355	36,004	14,373	4,460	337,478
70 to less than 72	209	67	11,869	2,583	839	65,608
72 to less than 74	--	--	--	1,265	426	34,497
74 or more	--	--	--	609	210	23,721
Total	1,811	550	58,242	22,286	6,901	531,275

[1]Data for the same items appearing in this and other tables may not reconcile because of computer rounding.
[2]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.
[3]F.o.b. mine.
[4]Includes Idaho, Montana, and Utah.
[5]The total value is based on a weighted value. The total value does not equal the sum of the regional totals because weighted regional unit values were used in the calculations. The regional values are approximate.

Table 8.—Phosphate rock sold or used by producers in the United States, by use[1]

(Thousand metric tons)

Use	1984 total		1985 January-June		1985 July-December		1985 Total[2]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
Domestic:[3]								
Wet-process phosphoric acid	36,651	11,207	16,650	5,121	15,394	4,752	32,044	9,873
Normal superphosphate	103	34	47	16	25	8	72	24
Triple superphosphate	1,062	336	806	255	635	209	1,441	463
Defluorinated rock	68	24	26	9	29	10	55	19
Direct applications	95	33	51	17	44	15	94	32
Elemental phosphorus	3,722	953	1,689	436	910	241	2,599	677
Ferrophosphorus	48	12	22	6	22	6	45	12
Total[2]	41,748	12,598	19,291	5,859	17,059	5,241	36,350	11,100
Exports[4]	11,528	3,646	5,057	1,602	5,226	1,660	10,284	3,263
Grand total[2]	53,277	16,244	24,348	7,461	22,285	6,901	46,634	14,363

[1]Data for the same items appearing in this and other tables may not reconcile because of computer rounding.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes rock converted to products and exported.
[4]Exports reported to the Bureau of Mines by companies.

Table 9.—Phosphate rock sold or used by producers in the United States, by use and region[1]

(Thousand metric tons)

Use	Florida and North Carolina		Tennessee		Western States[2]		Total[3]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1984	46,411	14,309	1,340	338	5,526	1,597	53,277	16,244
1985:								
January-June:								
Domestic:[4]								
Agricultural	16,436	5,064	--	--	1,143	353	17,579	5,418
Industrial	7	2	669	173	1,036	266	1,712	442
Total	16,443	5,066	669	173	2,179	619	19,291	5,860
Exports[5]	4,547	1,442	--	--	511	161	5,057	1,602
Total	20,990	6,508	669	173	2,690	780	24,348	7,462
July-December:								
Domestic:[4]								
Agricultural	15,106	4,678	--	--	1,021	316	16,127	4,994
Industrial	6	2	607	157	319	88	932	247
Total	15,112	4,680	607	157	1,340	404	17,059	5,241
Exports[5]	4,756	1,514	--	--	470	146	5,229	1,660
Total[3]	19,868	6,194	607	157	1,810	550	22,285	6,901
Grand total[3]	40,857	12,701	1,276	330	4,501	1,331	46,634	14,364

[1]Data for the same items appearing in this and other tables may not reconcile because of computer rounding.
[2]Includes Idaho, Montana, and Utah.
[3]Data may not add to totals shown because of independent rounding.
[4]Includes rock converted to products and exported.
[5]Exports reported to the Bureau of Mines by companies.

Table 10.—Florida and North Carolina phosphate rock sold or used by producers[1]

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton
1981	38,458	11,935	$1,064,459	$27.68
1982	32,806	10,192	850,794	25.93
1983	40,223	12,456	944,509	23.48
1984	46,411	14,309	1,089,647	23.48
1985	40,856	12,703	942,956	23.08

[1]Data for the same items appearing in this or other tables may not reconcile because of computer rounding.

Table 11.—Tennessee phosphate rock sold or used by producers[1]

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton
1981	1,379	357	$17,401	$12.62
1982	960	248	12,972	13.51
1983	1,187	307	28,935	24.38
1984	1,340	338	32,590	24.32
1985	1,276	330	28,557	22.38

[1]Data for the same items appearing in this or other tables may not reconcile because of computer rounding.

Table 12.—Western States phosphate rock sold or used by producers[1]

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton
1981	5,672	1,644	$130,194	$22.95
1982	4,807	1,375	119,699	24.90
1983	5,428	1,573	149,520	27.55
1984	5,526	1,597	156,119	28.25
1985	4,500	1,330	[2]132,345	29.41

[1]Data for the same items appearing in this and other tables may not reconcile because of computer rounding.
[2]The total value is based on a weighted value.

STOCKS

Inventories of marketable phosphate rock were reported to the Bureau of Mines by producing companies on a monthly and semiannual basis. The data from the monthly surveys permitted the Bureau to publish the increase or decrease of stocks throughout the year in the monthly "Phosphate Rock Mineral Industry Survey." The semiannual surveys permitted respondents to adjust or correct reported stock levels, and these changes were reported in the "Annual Advance Summary Mineral Industry Survey," the "Crop Year Mineral Industry Survey," and the "Minerals Yearbook."

The significant decrease in 1984 stock levels from those of 1981, 1982, and 1983 reflected improvement in phosphate rock demand during 1984. During 1985, inventories of phosphate rock gradually increased as demand declined throughout the year.

Table 13.—Marketable phosphate rock yearend stocks

(Million metric tons)

Year	Quantity
1976	15.2
1977	13.7
1978	15.7
1979	14.5
1980	13.7
1981	19.6
1982	18.3
1983	14.5
1984	11.9
1985	15.5

PRICES

Phosphate rock was sold under contracts negotiated between buyers and sellers. Although list prices were occasionally published by producing organizations, actual contract prices negotiated between buyer and seller were not published.

Phosphate rock export prices from Tampa and Jacksonville, FL, included a freight, loading, and weighing cost of $6.10 and $7.90 per ton, respectively. The severance tax, included in the export price, was $2.52 per ton.

The weighted average prices or values, f.o.b. mine, for each grade of phosphate rock and for each producing State were calculated by the Bureau of Mines from the semiannual survey of producing mines.

Table 14.—Phosphate rock estimated export prices[1] per metric ton, unground, f.o.b. vessel Tampa Range or Jacksonville, FL, by grade

Grade (percent BPL[2] content)	1982[3]	1983[4]	1984[5]	1985[6]
68	$23.00	$27.00	$26.50	$26.00
70	23.50	28.00	27.50	28.00
72	27.00	30.00	30.50	30.50
75	34.00	35.00	35.00	34.00

[1]Prices include severance taxes, rail freight costs from mine to port, and port loading and weighing charges.
[2]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.
[3]Estimated selling price including $2.03 severance tax.
[4]Estimated selling price including $2.25 severance tax.
[5]Estimated selling price including $2.39 severance tax.
[6]Estimated selling price including $2.52 severance tax.

Table 15.—Moroccan phosphate rock export prices, U.S. dollars per metric ton, f.a.s. Safi or Casablanca,[e] by grade

Grade (percent BPL[1] content)	1982	1983	1984	1985
Khouribga:				
70 to 71	42.00	35.00	36.00	36.00
76 to 77	50.00	45.00	47.00	47.00
Youssoufia:				
68 to 69	38.00	29.00	30.00	30.00
74 to 75	47.00	41.00	43.00	43.00

[e]Estimated.
[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 16.—Price or value of Florida and North Carolina phosphate rock, by grade

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1984			1985		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	25.14	25.64	25.28	21.50	--	21.50
60 to less than 66	20.90	20.10	20.75	18.59	20.69	18.84
66 to less than 70	22.19	24.51	22.45	22.75	22.28	22.68
70 to less than 72	25.34	25.75	25.65	21.98	24.63	23.70
72 to less than 74	24.49	32.10	28.08	22.59	30.86	26.17
74 or more	29.31	33.01	31.40	34.44	40.77	38.35
Average	22.67	26.28	23.48	22.41	25.35	23.08

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 17.—Price or value of Western States phosphate rock, by grade

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1984			1985		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	15.22	--	15.22	14.14	--	14.14
60 to less than 66	11.15	41.51	16.33	11.81	42.95	20.06
66 to less than 70	32.14	44.81	35.80	31.90	41.79	33.02
70 to less than 72	45.78	51.45	47.87	--	51.20	51.20
Average	23.81	46.03	28.25	24.63	46.58	29.41

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 18.—Price or value of Tennessee phosphate rock, by grade

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1984	1985
Less than 60	24.32	22.38

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

Table 19.—Price or value of U.S. phosphate rock, by grade

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1984			1985		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	22.25	25.64	22.75	19.66	--	19.66
60 to less than 66	18.47	24.94	19.67	17.57	27.76	19.06
66 to less than 70	22.72	27.62	23.32	23.49	23.44	23.48
70 to less than 72	31.55	27.77	28.93	21.98	28.56	26.48
72 to less than 74	24.49	32.10	28.08	22.59	30.86	26.17
74 or more	29.31	33.01	31.40	34.44	40.77	38.35
Average	22.84	28.17	23.99	22.62	27.38	23.67

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.

FOREIGN TRADE

Phosphate rock export tonnage declined 11% from that of 1984, breaking a trend of increasing phosphate rock exports that began in 1981. The decline in exports was attributed to increased competition from other phosphate rock exporting countries and a reduction in world demand. Erosion of trade in phosphate rock was further exacerbated by increased trade in high analysis phosphate fertilizers. Trade in ammonium phosphates, triple superphosphate, and phosphoric acid increased as more countries with phosphate rock reserves produced phosphoric acid and phosphate fertilizers for export markets.

In Florida, increases in rail freight rates from mine to port, port charges, and the severance tax reduced the competitive position of phosphate rock exports.

Trade in phosphate fertilizers was characterized by oversupply and weakening prices throughout the year. Nameplate capacity of phosphate fertilizer plants exceeded the demand for these commodities. The plant capacity utilization rate was reduced to 65% or 70%.

The quantity of phosphate rock imported into the United States in 1985, as reported by the Bureau of the Census, is shown in the following tabulation:

Country of origin	Metric tons
Belgium	36
Dominican Republic	60
Israel	47
Mexico	208
Netherlands	2,791
Netherlands Antilles	4,158
Togo	26,200
United Kingdom	391
Total	33,891

NOTE: Reported imports from Canada are excluded.

Table 20.—U.S. exports of phosphate rock, by country

(Thousand metric tons and thousand dollars)

(Schedule B No. 480.4500)

Country	1984		1985	
	Quantity	Value[1]	Quantity	Value[1]
Australia	212	6,199	98	
Austria	20	6	--	
Belgium-Luxembourg	549	17,454	383	
Brazil	12	709	27	
Canada	2,998	106,479	2,643	
Finland	149	4,967	162	
France	702	23,856	668	
Germany, Federal Republic of	541	16,770	665	
India	248	9,954	480	
Italy	85	2,640	97	
Japan	1,274	50,843	803	NA
Korea, Republic of	1,501	46,750	1,540	
Mexico	429	12,861	258	
Netherlands	640	18,957	555	
New Zealand	51	1,578	116	
Philippines	25	974	30	
Poland	[e]700	[e]20,894	754	
Romania	433	17,435	223	
Sweden	187	6,797	83	
Taiwan	23	854	--	
United Kingdom	26	854	--	
Other	[r]511	[r]24,201	699	
Total	11,316	392,032	[2]10,284	[2]281,515

[e]Estimated. [r]Revised. NA Not available.
[1]All values f.a.s. (free alongside ship).
[2]Total quantity and value reported to the Bureau of Mines, f.o.b. mine.

Source: Bureau of the Census.

Table 21.—U.S. exports of superphosphates, more than 40% P_2O_5, by country

(Thousand metric tons and thousand dollars)

(Schedule B No. 480.7050)

Country	1984		1985	
	Quantity	Value[1]	Quantity	Value[1]
Argentina	9	1,107	3	
Belgium-Luxembourg	78	9,208	111	
Brazil	44	6,031	158	
Bulgaria	92	11,781	20	
Burma	15	2,840	--	
Canada	204	30,867	289	
Chile	182	15,660	158	
Colombia	15	2,720	17	NA
Costa Rica	8	1,035	9	
Dominican Republic	8	1,490	31	
France	9	1,063	62	
Germany, Federal Republic of	80	9,772	58	
Hungary	15	1,739	--	
Ireland	38	4,887	27	
Italy	7	924	10	
Japan	30	4,286	34	

See footnotes at end of table.

Table 21.—U.S. exports of superphosphates, more than 40% P_2O_5, by country—Continued

(Thousand metric tons and thousand dollars)

(Schedule B No. 480.7050)

Country	1984 Quantity	1984 Value[1]	1985 Quantity	1985 Value[1]
Peru	14	1,987	16	
Uruguay	6	829	9	NA
Venezuela	8	1,548	1	
Other	228	39,322	403	
Total	1,090	149,096	1,416	176,417

NA Not available.
[1]All values f.a.s. (free alongside ship).

Source: Bureau of the Census.

Table 22.—U.S. exports of superphosphates, less than 40% P_2O_5, by country

(Schedule B No. 480.7030)

Country	1984 Quantity (metric tons)	1984 Value[1] (thousands)	1985 Quantity (metric tons)	1985 Value[1] (thousands)
Canada	1,097	$24	3,651	$79
Other	660	30	457	19
Total	1,757	54	4,108	98

[1]All values f.a.s. (free alongside ship).

Source: Bureau of the Census.

Table 23.—U.S. exports of diammonium phosphates, by country

(Thousand metric tons and thousand dollars)

(Schedule B No. 480.8005)

Country	1984 Quantity	1984 Value[1]	1985 Quantity	1985 Value[1]
Argentina	84	15,901	59	
Australia	206	41,339	230	
Belgium-Luxembourg	748	139,672	482	
Brazil	91	17,660	35	
Canada	115	22,753	193	
Chile	51	10,257	65	
China	1,229	230,928	789	
Colombia	61	11,920	97	
Costa Rica	19	3,838	25	
Dominican Republic	31	5,849	38	
Ecuador	39	7,788	33	
France	19	3,769	50	
Germany, Federal Republic of	27	5,028	81	
Guatemala	13	2,962	18	NA
India	1,189	227,337	1,853	
Ireland	34	5,775	51	
Italy	128	24,357	174	
Japan	488	92,197	349	
Mexico	267	52,049	186	
Netherlands	19	3,394	70	
New Zealand	45	8,978	36	
Nicaragua	19	2,812	--	
Pakistan	247	48,680	326	
Thailand	68	12,335	34	
Turkey	60	11,844	230	
Uruguay	--	--	49	
Yugoslavia	79	15,268	120	
Other	970	175,889	458	
Total	6,346	1,200,579	6,131	1,048,322

NA Not available.
[1]All values f.a.s. (free alongside ship).

Source: Bureau of the Census.

Table 24.—U.S. exports of phosphoric acid, less than 65% P_2O_5, by country

(Thousand metric tons and thousand dollars)

(Schedule B No. 480.7015)

Country	1984 Quantity	1984 Value[1]	1985 Quantity	1985 Value[1]
Canada	3	520	2	
Colombia	9	2,061	6	
Germany, Federal Republic of	54	13,397	24	
India	212	45,001	378	NA
Indonesia	95	20,465	42	
Mexico	21	4,051	--	
Turkey	140	25,612	63	
Venezuela	100	23,322	146	
Other	233	46,626	55	
Total	867	181,055	716	141,162

NA Not available.
[1]All values f.a.s. (free alongside ship).

Source: Bureau of the Census.

Table 25.—U.S. exports of elemental phosphorus, by country

(Schedule B No. 415.3500)

Country	1984 Quantity (metric tons)	1984 Value[1] (thousands)	1985 Quantity (metric tons)	1985 Value[1] (thousands)
Brazil	3,270	$5,068	1,504	
Canada	1,518	1,888	6,093	
China	2,300	2,816	--	
Japan	5,776	9,647	7,706	
Korea, Republic of	496	752	718	NA
Mexico	19	78	17	
Taiwan	793	986	835	
Other	680	1,140	258	
Total	14,852	22,375	17,131	$27,024

NA Not available.
[1]All values f.a.s. (free alongside ship).

Source: Bureau of the Census.

Table 26.—U.S. imports for consumption of phosphate rock and phosphatic materials

(Thousand metric tons and thousand dollars)

Fertilizer	TSUS No.	1984 Quantity	1984 Value[1]	1985 Quantity	1985 Value[1]
Phosphates, crude and apatite[2]	480.4500	9	274	34	1,593
Phosphatic fertilizers and fertilizer materials	480.7070, 480.8095	119	7,536	30	5,929
Dicalcium phosphate	418.2800	[r]1	378	1	841
Phosphorus	415.3500	[r]4	6,482	2	3,530
Phosphoric acid, technical- and food-grade	416.3000	[r]10	4,060	--	--
Phosphoric acid, fertilizer-grade	480.7010	1	380	([3])	68
Normal superphosphate	480.7030	1	141	1	120
Triple superphosphate	480.7050	9	1,029	2	304

[r]Revised.
[1]Declared customs valuation.
[2]Excludes reported imports from Canada and Israel.
[3]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

During the past decade, world phosphoric acid capacity had increased from 19 million tons P_2O_5 equivalent to 35 million tons P_2O_5 as countries with phosphate rock mines determined that it was economically advantageous to upgrade phosphate rock to phosphoric acid or ammonium phosphates. New, efficient, low-cost wet-process phosphoric acid plants were constructed in countries with indigenous phosphate rock deposits to increase exports of these higher value commodities. Historically, the United States had been the only country exporting phosphoric acid and solid fertilizers produced from domestic raw materials. One of the effects of new downstream plants constructed for the export market was to limit phosphate rock trade. The rate of increase of phosphate rock trade has been steadily declining.

The International Fertilizer Industry Association reported that in 1984, the latest full year of data available, Morocco was the largest exporter of phosphoric acid, followed by the United States, Tunisia, the Republic of South Africa, and Jordan. The total phosphoric acid traded internationally in 1984 was 2.5 million tons P_2O_5, which was equivalent to about 8.3 million tons of 70% bone phosphate of lime (BPL) phosphate rock. For comparison purposes, international trade in phosphate rock in 1984 was about 48 million tons.

Brazil.—With the exception of a local supply for the Sotave Amazonia Quimica project on Caratateua Island near Belém, Brazil has been self-sufficient in phosphate rock. Phosphate rock for annual production of 300,000 tons of complex fertilizers and 300,000 tons of single and triple superphosphate at the project was to be imported from the United States. The plants were scheduled to start in 1986.

China.—The principal phosphate rock producing Provinces in China were Guizhou, Hubei, Hunan, Jiangsu, Sichuan, and Yunnan. In a report[2] given at the 10th enlarged council meeting of the International Fertilizer Industry Association, phosphate rock production was reported to be 11.7 million tons in 1984 and increasing at an average rate of 7.8% per year. Phosphate rock reserves were reported to be 11.8 billion tons. Over 90% of the phosphatic fertilizer produced in China was single superphosphate and fused magnesium phosphate.

Christmas Island.—Phosphate Mining Co. of Christmas Island shipped phosphate rock to China, Japan, the Republic of Korea, Malaysia, and Taiwan. A Grade phosphate rock, 35% P_2O_5, was exported. It was estimated by the operators that only a few million tons of A Grade material remained in the reserve. The remaining reserve, classified as B Grade, was about 50 million tons.

Egypt.—A contract was awarded to construct a washing and flotation plant at the West Sabaeya Mine in Upper Egypt. The plant was designed to process 3,500 tons per day of ore. Plans were to pump the concentrates 4 kilometers to a site on the Nile for shipment by barge to the Zaabal Fertilizer & Chemical Co. plant in Lower Egypt.[3]

Finland.—Production from the Siilinjarvi Mine increased from 200,000 tons in 1980 to 500,000 tons in 1985. The flotation concentrates averaged 35.5% P_2O_5 and 1.45% magnesium oxide (MgO). Byproduct recovery of calcite was accomplished by flotation of the apatite flotation tailings. About 100,000 tons of the calcite was sold as agricultural lime in the adjacent farming districts. Phosphogypsum recovered from the phosphoric acid plant was stockpiled. A 50,000-ton-per-year coating-pigment plant had been constructed in 1984 to use the stockpiled phosphogypsum.

India.—Of the three main Indian phosphate rock deposits, Mussoorie in Utter Pradesh and Jhamar Kotra and Jhabua in Rajasthan, only the Jhamar Kotra rock has been suitable for manufacturing phosphate fertilizers. Mussoorie and Jhabua phosphate rock has been ground for direct application. With limited domestic supplies of phosphate rock, India has relied on imported processed phosphates to meet increasing fertilizer demand.

Israel.—Negev Phosphates Ltd. operated the Nahal Zin and Oron Mines in the Negev Desert. To increase phosphate rock capacity, a secondary crushing station was installed at the Nahal Zin Mine and a coal-fired calcining kiln was installed at Oron. Reserves of the recently discovered high-grade Bikaal deposit between Arad and Beersheba were estimated to be 100 million tons. To increase phosphate rock production and meet Negev Phosphates' targets for 1990, plans were to expand the Nahal Zin Mine and mine the Bikaal deposit.[4]

Jordan.—Jordan Phosphate Mines Co. (JPMC) demonstrated that large areas of the country have phosphate resources. The three principal areas are Ruseifa, 15 kilometers north of Amman; El Abyad and El Hasa, 120 to 140 kilometers south of Amman; and Shidiya, 230 kilometers south of Amman. Most of JPMC's production, about 5 million tons per year, has been from El Hasa. Production from Ruseifa has been about 800,000 tons per year. The phosphate rock from both mining areas was beneficiated by wet screening, desliming, and drying. JPMC planned to produce 3 million tons per year from the Shidiya deposit, with reported reserves of 500 million tons. Plans were to expand the mine to 9 million tons per year by the end of the century.

Mexico.—Construction of a 3-million-ton-per-year P_2O_5 addition to the fertilizer complex at Lázaro Cárdenas was scheduled for completion in 1985. The expansion was designed for annual production of 396,000 tons of phosphoric acid, 215,000 tons of nitric acid, 215,000 tons of ammonium nitrate, and more than 1 million tons of compound fertilizers. At the San Juan de la Costa Mine on the Baja California Sur, a concentrate drying plant was installed to augment sun drying. With the drying facility, additional trucks, and front-end loaders, Roca Fosfórica Mexicana S.A. de C.V. (ROFOMEX) planned to be able to achieve the original design capacity of 700,000 tons per year by 1985. Additional phosphate rock mining was planned for ROFOMEX's San Hilario and Tembabiche deposits.

Morocco.—Production of phosphate rock continued from the Sidi Daoui and Meraa el Arech open pit mines in the Khouribga

District. Five active underground mines at Khouribga were programmed to be phased out as more open pit capacity was developed. At Youssoufia, surface mining ended. White rock was mined from Recette 4 and 5. Black rock from Recette 7 was calcined in a fluidized bed kiln at a rate of 600,000 tons per year. Three additional kilns were being erected, each with a design capacity of 1.2 million tons per year. A new 4-million-ton-per-year dry beneficiation plant began operating with concentrates from the Beni-Idir drying plant. Concentrates from the Ben Guerir Mine were shipped to Safi, washed with seawater to reduce the MgO content, and processed at Maroc Phosphore II into phosphoric acid for export. The initial exploration of the Meskala deposits ended. A drilling program was planned in cooperation with the U.S.S.R. to obtain more information on favorable areas. Production from the Bu Craa Mine in the Western Sahara was limited to about 1 million tons per year by inadequate crushing and screening capacity at the mine and insufficient freshwater at the Laayoun beneficiating plant. These bottlenecks were being corrected to increase capacity to 2 million tons per year. The port and chemical complex at Jorf Lasfar was expected to be completed in the first quarter of 1986. The complex was designed for annual production of 1.5 million tons P_2O_5 phosphoric acid, 600,000 tons per year triple superphosphate, and 396,000 tons per year monoammonium phosphate from Khouribga District phosphate rock.

Pakistan.—A new phosphate rock mine near Kakul, in the Northwest Frontier Province, about 75 kilometers north of Islamabad, was expected to produce about 1 million tons per year for consumption by National Fertilizer Corp.

Senegal.—Compagnie Sénégalaise des Phosphates de Taïba (CSPT) produced approximately 2 million tons of calcium phosphate concentrates, and Société Sénégalaise des Phosphates de Thies produced 600,000 tons of aluminum phosphates. CSPT had reserves of 20 million tons in the Keur Mor Fall deposit and 60 million tons in the nearby Tobene deposit. The Société d'Etudes des Industries Chimiques du Senegal constructed a 476,000-ton, merchant-grade phosphoric acid plant at Darow-Khoudoss near the Taïba Mine.

South Africa, Republic of.—Phosphate Development Corp. Ltd. was working on the reclamation of phosphate rock from tailings and on improving the efficiency of classification in the phosphate rock grinding circuits. Increased production of 86% BPL phosphate rock was anticipated with installation of more effective filters in early 1986. In the foskorite flotation plant, a new desliming system was installed. The advantages expected were reduced consumption of flotation reagents and decreased MgO content.[5]

Togo.—Feasibility studies were authorized by the Office Togolaise des Phosphates to develop a new phosphate rock mine at Dagbati. Demand for Togo's high-grade phosphate rock prompted reopening of the Hahotoe-K'pogame Mine's fifth beneficiation line, which had been closed since 1981. The high price of sulfur was in part responsible for increased exports of Togolese phosphate rock, because high-grade phosphate rock usually requires less sulfuric acid per ton of phosphoric acid produced.

Tunisia.—Société Tunisienne de Exploritation Phosphatieres Co. mined the Kalaa Djerda deposit in central Tunisia. In the Gafsa Basin, phosphate rock was mined by Compagnie des Phosphates de Gafsa (CPG). CPG was modernizing facilities at the Moulares, M'Dilla, and Sehib Mines to raise capacities and the quality of the phosphate rock. New mines and plants at Kef Eddour and Jellabia were planned for operation in 1986. Tunisia and Kuwait established the Société Sra Ourtane Co. to plan the production of 10 million tons per year of phosphate rock from the Sra Ourtane deposit by the year 2000.

U.S.S.R.—The U.S.S.R. announced the discovery of phosphate deposits in the Kyzyl Kum Desert. The deposits are within a 1,500-kilometer radius of Muruntau.[6] At the Black Sea port of Yuzhnyy, two mechanical ship unloaders, conveyor systems, storage sheds, stackers, and scraper reclaimers were being installed to handle 1.2 million tons per year of phosphate rock from Morocco. It was planned to double the capacity of the installation to accept increasing phosphate rock tonnage from Morocco. At the "Apatit" industrial complex of Khibiny on the Kola Peninsula, which produces about 80% of the U.S.S.R.'s phosphate rock, mining was conducted in three underground and two open pit sites. About 45 million tons of ore was mined from the open pits and 17 million tons from the underground mines. As the open pits are depleted, the U.S.S.R. intends to increase production from the underground mines.[7]

Table 27.—Phosphate rock, basic slag, and guano: World production, by country[1]

(Thousand metric tons)

Commodity and country[2]	Gross weight					P_2O_5 content				
	1981	1982	1983	1984[p]	1985[e]	1981	1982	1983	1984[p]	1985[e]
Phosphate rock:										
Algeria	916	947	893	1,000	[3]1,207	262	289	276	309	381
Australia	22	211	21	17	34	6	59	1	4	8
Brazil	3,238	2,732	3,208	3,855	4,214	979	1,141	1,119	1,345	1,475
China[e]	11,500	11,720	12,500	[r]14,210	12,000	2,530	2,580	3,750	[r]4,263	3,600
Christmas Island (Indian Ocean)	1,423	1,328	1,094	1,259	[3]1,200	499	466	385	443	421
Colombia	17	20	17	28	23	4	4	4	7	6
Egypt	720	711	647	1,043	1,074	203	200	205	253	246
Finland	201	233	381	477	[3]510	72	83	141	176	[3]177
India	[r]565	[r]631	688	800	748	[r]176	[r]197	212	275	233
Indonesia	8	5	6	2	3	3	2	2	1	1
Iraq	[e]50	363	[e]1,199	1,000	1,000	[e]16	[e]113	[e]261	[r e]218	218
Israel	1,919	2,148	2,969	3,312	4,076	624	698	892	995	1,210
Jordan	4,244	4,390	4,749	6,263	[3]6,067	1,379	1,427	1,548	2,042	2,005
Korea, North[e]	500	500	500	500	500	150	150	160	160	160
Mexico	252	379	389	375	350	150	195	114	110	107
Morocco[4]	18,562	17,754	20,106	21,245	[3]20,737	[e]5,958	[e]5,700	[e]6,400	[e]6,762	6,574
Nauru	1,480	1,359	1,684	1,358	[3]1,508	570	523	648	523	581
Peru	[r]12	29	3	13	12	[r]4	9	1	4	4
Philippines	8	6	4	([5])	--	2	2	1	([5])	--
Senegal	1,699	1,182	1,521	1,912	1,702	[e]518	361	534	583	617
South Africa, Republic of	2,718	[r]3,161	2,887	2,585	[3]2,421	[e]942	[e]1,149	996	939	880
Sri Lanka	15	[e]20	16	14	17	4	7	6	5	6
Sweden	124	131	107	128	[3]187	48	50	41	49	[3]72
Syria	1,321	1,455	1,229	1,514	1,270	402	443	375	461	385
Tanzania	--	--	20	15	15	--	--	6	4	4
Thailand	[r]3	4	5	3	3	1	1	1	1	1
Togo	2,215	2,800	2,081	2,696	2,452	806	1,005	755	979	890
Tunisia	4,596	4,196	5,924	5,346	[3]4,530	1,287	1,213	1,700	1,554	1,303
Turkey	43	[r e]26	50	96	37	11	9	15	29	12
U.S.S.R.[e]	30,700	31,300	31,600	31,900	32,200	9,700	9,800	10,000	10,100	10,004
United States	53,624	37,414	42,573	49,197	[3]50,835	16,365	11,504	13,088	14,889	15,634
Vietnam[e]	181	110	200	200	300	60	36	66	66	105
Zimbabwe	125	120	133	125	131	44	42	47	44	45
Total	[r]143,001	[r]127,385	139,404	152,488	151,363	[r]43,775	[r]39,458	43,750	47,593	47,365

Basic (Thomas converter) slag:										
Argentina	1	1	1	1	1	(7)	(7)	(7)	(7)	(7)
Belgium	496	393	250	r e254	260	89	71	45	46	47
Egypt	e10	10	10	10	10	e2	e2	e2	e2	2
France	1,451	1,343	1,224	1,194	1,200	261	242	216	210	210
Germany, Federal Republic of	824	502	409	e400	490	138	130	82	80	74
Luxembourg	595	572	586	728	750	106	103	105	131	135
United Kingdom	4	4	4	4	4	1	1	1	1	1
Total	3,381	2,825	2,484	2,591	2,715	597	549	451	470	469
Guano:										
Chile	1	1	1	1	1	(7)	(7)	(7)	(7)	(7)
Kenya	--	(7)	(7)	(7)	(7)	--	(7)	(7)	(7)	(7)
Philippines	2	15	1	1	1	(7)	3	(7)	(7)	(7)
Seychelles Islands (exports)	e5	e5	e5	e5	5	2	2	2	2	2
Total	8	21	7	7	7	2	5	2	2	2

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through Apr. 16, 1986. Data for major phosphate rock producing countries derived in part from the International Fertilizer Industry Association; other figures are from official country sources where available.

[2]In addition to the countries listed, Belgium and Uganda may have produced small quantities of phosphate rock, and Namibia may have produced small quantities of guano, but output is not officially reported, and available information is inadequate for formulation of reliable estimates of output levels.

[3]Reported figure.

[4]Production from Western Sahara area included with Morocco.

[5]Revised to zero.

[6]Run-of-mine ore.

[7]Less than 1/2 unit.

TECHNOLOGY

Processing Florida phosphate rock typically involves screening and washing the matrix to separate a plus 16-mesh pebble fraction and a minus 150-mesh slime fraction, which is stored in slime ponds and slowly dewatered. The slime fraction of the Florida matrix is about one-third by weight and analyzes from 5% to 15% P_2O_5. In some instances, the total P_2O_5 in the slimes represents as much as one-third of the total P_2O_5 in the original matrix. If the P_2O_5 could be recovered profitably from impounded slimes, the life of the Florida phosphatic industry would be extended. Bureau of Mines investigators conducted batch flotation tests on the minus 150-mesh, plus 20-micrometer fraction of bulk samples from slime ponds. Concentrates were produced that analyzed 22% P_2O_5 with a P_2O_5 recovery of 60%.[8]

Demand for elemental sulfur for conversion to sulfuric acid to leach phosphate rock and produce phosphoric acid and a byproduct waste, phosphogypsum, has markedly increased during the past several years. As the selling price of sulfur increased, the feasibility of recovering sulfur from the phosphogypsum improved. Bureau of Mines process development work has showed that 99% of the calcium sulfate in the phosphogypsum could be converted to calcium sulfide by heating with coal, which provides a reducing atmosphere, at 875° C. Calcium sulfide was converted to elemental sulfur by reacting aqueous calcium sulfide slurry with ammonia and carbon dioxide to produce calcium carbonate and ammonium bisulfide. The precipitated calcium carbonate was separated by filtration and the ammonium bisulfide was oxidized with air, using a carbon catalyst, to form ammonium polysulfides. When the ammonium polysulfides were distilled, elemental sulfur precipitated and the ammonia and sulfide sulfur were condensed and recycled to the initial reaction.[9]

In the production of phosphate rock for phosphoric acid manufacture, P_2O_5 recovery from the phosphate matrix is limited by losses during mining and beneficiation. If the established beneficiation process could be eliminated by acidulating the matrix directly, potential recovery of the phosphate values could exceed the current level of 60% recovery. Attempts to recover phosphate values by direct acidulation had not been successful previously because impurities such as iron and aluminum were leached as well as the phosphate. These dissolved metals are difficult to separate from phosphoric acid. To overcome the problem of impurities, the Bureau of Mines investigated the use of an acid-alcohol mixture as the leaching agent. Iron and aluminum, which were insoluble in the mixture, were separated from the phosphoric acid by filtration. Phosphate recoveries as high as 88% were obtained in the laboratory.[10]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Dunxun, Z. Fertilizer in China. Pres. at the 10th enlarged council meeting, International Fertilizer Industry Association (IFA), Hong Kong, Dec. 3-4, 1984, 8 pp.; available from IFA, Paris, France.

[3]European Chemical News. V. 44, No. 1160, Jan. 21, 1985, p. 23.

[4]Industrial Minerals (London). V. 211, Apr. 1985, p. 11.

[5]Phosphate Development Corp. 1985 Annual Report. Oct. 14, 1985, 25 pp.

[6]European Chemical News. V. 45, No. 1188, July 15, 1985, p. 22.

[7]Mining Magazine. June 1985, p. 571.

[8]Pederson, J. R. (ed.). Bureau of Mines Research 1985. BuMines SP 2-85, 1985, p. 64.

[9]Page 65 of work cited in footnote 8.

[10]Page 47 of work cited in footnote 8.

Platinum-Group Metals

By J. Roger Loebenstein[1]

World mine production of platinum-group metals (PGM) in 1985 was 8.0 million troy ounces, 94% of which was accounted for by the U.S.S.R. and the Republic of South Africa. The Republic of South Africa remained the leading producer of platinum, and the U.S.S.R. remained the leading producer of palladium.

Imports of waste and scrap, having more than doubled since 1980, remained high in 1985. The principal sources of waste and scrap were Canada and Mexico.

Table 1.—Salient platinum-group metals[1] statistics

(Thousand troy ounces unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Mine production[2]	7	8	6	15	W
Value[3] ____thousand dollars	[r]$1,303	[r]$819	[r]$1,118	[r]$2,456	$523
Refinery production:					
Primary refined	7	9	9	24	5
Secondary:					
Nontoll-refined	392	344	303	[r]340	259
Toll-refined	1,191	868	995	1,157	1,038
Total refined metal	1,590	1,221	1,307	[r]1,521	1,302
Stocks, yearend:					
Industry (refined)	918	1,107	943	[r]1,319	1,191
National Defense Stockpile:					
Platinum	453	453	453	453	453
Palladium[4]	1,255	1,255	1,255	1,262	1,265
Iridium[5]	17	[r]24	28	30	30
Exports:					
Refined[6]	651	439	446	[r]599	526
Total	863	836	1,229	1,162	889
Imports for consumption:					
Refined[6]	2,611	2,150	2,790	3,928	3,438
Total	2,850	2,494	3,218	4,474	3,990
Imports, general	[r]2,850	2,494	3,218	[r]4,474	3,990
Consumption (reported sales to industry)	1,921	1,873	1,914	[r]2,471	2,595
Consumption, apparent[7]	2,414	[r]1,869	[r]2,813	[r]3,299	3,295
Net import reliance[8] as a percent of apparent consumption	83	81	89	89	92
Price, dealer, average, per ounce:					
Platinum	$446	$327	$424	$357	$291
Palladium	$95	$67	$136	$148	$107
World: Mine production[9]	6,931	6,424	6,525	[p]7,648	[e]7,951

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]The platinum group comprises six metals: platinum, palladium, iridium, osmium, rhodium, and ruthenium.

[2]Byproduct of copper refining.

[3]Value based on dealer prices.

[4]Includes 7,200 ounces purchased in 1984 and 2,400 ounces purchased in 1985, but not added to inventory in those years.

[5]Includes 2,400 ounces purchased in 1982, another 2,400 ounces purchased in 1983, and 1,800 ounces purchased in 1984, but not added to inventory in those years.

[6]Includes both unwrought and semimanufactured.

[7]1981-84 includes mine production plus nontoll-refined production plus refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks. 1985 mine production excluded to avoid disclosing company proprietary data.

[8]Refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks.

[9]1985 total excludes U.S. mine production in order to avoid disclosing company proprietary data.

The price of osmium remained fairly stable in 1985, after increasing almost sevenfold in 1984. Reportedly, industry sources suggested that the rapid price increase was the result of a combination of only a modest increase in demand base and because of the small size of the industry.

Domestic Data Coverage.—Domestic production data for PGM are developed by the Bureau of Mines from a voluntary survey of U.S. refiners. Of the 17 refiners to which a survey request was sent, 16 responded, representing an estimated 45% of the total refined metal production shown in tables 1 and 2. Production of refined metal for the one nonrespondent was estimated using reported prior year production levels.

Legislation and Government Programs.—The General Services Administration purchased 2,400 ounces of grade B (99.8% minimum) palladium sponge for the National Defense Stockpile in January 1985.

On July 8, the President approved the National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. The status of platinum, palladium, and iridium was deferred until further detailed studies could be made. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

DOMESTIC PRODUCTION

ASARCO Incorporated and Kennecott produced platinum and palladium as byproducts of copper refining. Secondary metal was refined by about 17 firms, mostly on the east and west coasts. Most PGM scrap was refined on a toll basis. The largest scrap processor in the United States was Johnson Matthey Inc.

U.S. Metals Refining Co. in Carteret, NJ, a subsidiary of AMAX Copper Inc., began phasing out its precious metals scrap refining and copper smelting and refining operations. The phaseout was expected to be complete by the end of 1986. The company was a major toll refiner of PGM and a small refiner of byproduct PGM from copper refineries. The company's decision was reportedly based on continuing losses from operations at the plant combined with the poor economic outlook for secondary smelting and refining activities in the United States.[2]

Anaconda Minerals Co. sold its one-third partnership interest in Stillwater Mining Co. (SMC) to Lac Minerals Ltd., Toronto, Canada, for $15 million. SMC is a partnership between Chevron Resources Inc., Manville International Corp., and Lac Minerals, that was engaged in developing a palladium-platinum mine at the Stillwater Complex in Montana. In September, SMC contracted American Mine Services Inc. to conduct underground test mining over a 12-month period. In December, the U.S. Forest Service approved the company's operating permit, and the State of Montana issued an Environmental Impact Statement for the project. According to the company, if ore grades prove favorable, construction of the mine could begin in 1986 and production could start in 1987. Initially, SMC would process 500 metric tons of ore per day, yielding 75,000 ounces of palladium and 25,000 ounces of platinum per year, rates that could be doubled later.

The Bureau of Mines reported that a palladium-platinum mine in the Stillwater Complex in Montana could yield a rate of return approaching 20%. The Bureau estimated costs for PGM from the Stillwater Complex to be potentially 15% lower than for PGM recovered from the Merensky Reef in the Republic of South Africa, based on a 2,500-ton-per-day mining system at Stillwater for both PGM and chromite ores. However, the revenue per ounce of PGM recovered would be 33.5% less than is typical for the South African PGM producers, owing mostly to the much higher palladium content of the Stillwater ores.[3]

Engelhard Corp. began construction of a custom catalyst plant near Seneca, SC. The new $25 million plant will replace the company's Newark, NJ, plant. The catalysts produced will be based on palladium, platinum, rhodium, and ruthenium.

Handy & Harman opened a new precious

metals recovery plant at a cost of $7 million in South Windsor, CT. The plant will specialize in processing electronic scrap from the computer industry.[4]

Table 2.—Platinum-group metals refined in the United States

(Troy ounces)

	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
PRIMARY METAL							
Nontoll-refined:							
1981	1,005	4,602	--	--	--	--	5,607
1982	947	6,131	--	--	--	--	7,078
1983	879	5,005	--	--	--	--	5,884
1984	1,430	13,003	--	--	--	--	14,433
1985	524	3,463	--	--	--	--	3,987
Toll-refined:							
1981	235	934	--	--	--	--	1,169
1982	434	1,421	--	--	--	--	1,855
1983	1,150	2,026	--	--	--	--	3,176
1984	1,153	4,895	1,000	250	--	2,000	9,298
1985	1,100	--	--	--	--	--	1,100
SECONDARY METAL							
Nontoll-refined:							
1981	187,883	185,764	3,318	64	11,317	3,291	391,637
1982	190,249	139,286	2,896	--	11,302	427	344,160
1983	118,579	177,816	2,357	--	3,663	750	303,165
1984	r89,702	r243,347	735	27	r3,668	2,047	r339,526
1985	52,382	201,416	252	--	3,126	1,474	258,650
Toll-refined:							
1981	520,717	607,397	7,826	1,865	34,870	18,471	1,191,146
1982	393,832	430,564	10,108	885	26,693	6,301	868,383
1983	433,700	456,732	5,820	925	41,624	55,788	994,589
1984	524,158	568,489	7,826	49	37,584	19,288	1,157,394
1985	490,571	490,647	7,007	3	36,336	13,356	1,037,920
1984 TOTALS							
Total primary	2,583	17,898	1,000	250	--	2,000	23,731
Total secondary	r613,860	r811,836	8,561	76	r41,252	21,335	r1,496,920
Total refined metal	r616,443	r829,734	9,561	326	r41,252	23,335	r1,520,651
1985 TOTALS							
Total primary	1,624	3,463	--	--	--	--	5,087
Total secondary	542,953	692,063	7,259	3	39,462	14,830	1,296,570
Total refined metal	544,577	695,526	7,259	3	39,462	14,830	1,301,657

rRevised.

CONSUMPTION AND USES

PGM were used principally in catalysts for the control of automobile and industrial plant emissions; in reforming catalysts used to upgrade the octane rating of gasolines; in catalysts used to produce acids, organic chemicals, and pharmaceuticals; in bushings for making glass fibers used in fiber-reinforced-plastic and other materials; in electrical contacts; in capacitors; in conductive and resistive films used in electronic circuits; and in dental alloys used for making crowns and bridges.

In electronic applications, ruthenium was the principal PGM used in thick film resistors, while palladium was the principal PGM used in thick film conductors, multilayer ceramic capacitors, and connectors.[5]

For glass applications, the greatest amounts of PGM, specifically platinum, rhodium, and palladium, were used in the production of textile or continuous filament glass fiber.

Table 3.—Platinum-group metals[1] sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1981	872,639	889,186	8,416	663	62,110	87,658	1,920,672
1982	780,146	926,304	10,600	1,358	49,915	104,930	1,873,253
1983	796,716	921,829	5,023	1,389	44,225	144,777	1,913,959
1984:							
Automotive[2]	722,000	286,000	217	--	63,000	1,035	1,072,252
Chemical	73,496	78,600	735	10	4,631	24,743	182,215
Dental and medical	18,644	347,043	381	1,062	427	62	367,619
Electrical	r99,155	r389,695	1,514	--	r7,461	r54,155	r551,980
Glass	12,184	10	106	--	2,941	--	15,241
Jewelry and decorative	r9,549	r6,884	1,173	--	r2,116	r813	r20,535
Petroleum	28,045	92,134	--	--	11	600	120,790
Miscellaneous	66,154	57,134	2,991	--	6,666	7,211	140,156
Total	r1,029,227	r1,257,500	7,117	1,072	r87,253	r88,619	r2,470,788
1985:							
Automotive[2]	811,000	295,000	287	--	74,000	1,035	1,181,322
Chemical	85,227	63,236	966	17	4,096	19,090	172,632
Dental and medical	24,563	350,678	645	868	352	96	377,202
Electrical	115,840	300,677	1,843	--	5,665	50,956	474,981
Glass	20,651	416	177	--	2,467	14	23,725
Jewelry and decorative	16,040	7,096	1,889	--	2,222	661	27,908
Petroleum	28,771	80,940	--	--	31	--	109,742
Miscellaneous	115,722	87,970	4,857	--	5,419	13,722	227,690
Total	1,217,814	1,186,013	10,664	885	94,252	85,574	2,595,202

rRevised.
[1]Comprises primary and nontoll-refined secondary metals.
[2]Platinum, palladium, and rhodium sales to the automotive industry are estimated based on purchases by the major U.S. automobile manufacturers.

STOCKS

In addition to the reported stocks held by refiners, importers, and dealers, end users of PGM held sizable quantities of PGM that were not reported to the Bureau of Mines. Overall, PGM stocks declined 10% in 1985; only the stocks of iridium and rhodium increased.

Table 4.—Refiner, importer, and dealer stocks of refined platinum-group metals[1] in the United States, December 31

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1981	401,389	398,933	16,819	37	43,355	57,645	918,178
1982	604,632	384,184	13,348	138	40,562	63,764	1,106,628
1983	433,457	412,178	16,944	489	51,107	28,973	943,148
1984	r648,130	r524,924	r19,600	1,302	r53,120	r71,571	r1,318,647
1985	564,363	478,348	20,301	262	60,947	67,093	1,191,314

rRevised.
[1]Includes metal in depositories of the New York Mercantile Exchange (NYMEX); on Dec. 27, 1985, this comprised 270,500 troy ounces of platinum and 111,400 troy ounces of palladium.

PRICES

Throughout the year, dealer prices for platinum and palladium decreased. Average dealer prices for rhodium and osmium increased significantly in 1985, iridium and ruthenium remained about the same as in 1984.

Impala Platinum Holdings Ltd. of the Republic of South Africa was the sole producer retaining producer price quotes for platinum, palladium, rhodium, and iridium, following a decision in 1984 by Rustenburg Platinum Holdings Ltd. to suspend all of its producer price quotes for PGM.[6]

Table 5.—Average producer and dealer prices[1] of platinum-group metals

(Dollars per troy ounce)

	Platinum		Palladium		Rhodium		Iridium		Ruthenium		Osmium	
	Producer	Dealer	Producer	Dealer	Producer	Dealer	Producer	Dealer	Producer	Dealer	Producer	Dealer
1981	475	446	130	95	641	498	600	529	45	32	150	130
1982	475	327	110	67	600	323	600	359	45	26	137	130
1983	475	424	130	136	600	312	600	309	45	28	110	132
1984:												
January	475	377	130	157	600	346	600	331	45	45	(2)	140
February	475	389	130	160	600	354	600	345	45	55	(2)	140
March	475	399	150	161	600	382	600	350	45	62	(2)	151
April	475	392	150	160	600	468	600	391	45	63	(2)	179
May	475	386	150	155	600	551	600	439	45	65	(2)	272
June	475	381	150	153	600	655	600	468	45	80	(2)	364
July	475	341	150	138	600	687	600	496	(3)	152	(2)	420
August	475	338	150	137	600	721	600	483	(3)	145	(2)	432
September	475	326	150	138	600	717	600	468	(3)	143	(2)	692
October	475	324	150	138	600	759	600	438	(3)	137	(2)	873
November	475	327	150	146	750	799	600	424	(3)	134	(2)	900
December	475	303	150	134	750	846	600	449	(3)	155	(2)	900
Average	475	357	147	148	625	607	600	424	(3)	103	(2)	455
1985:												
January	475	274	150	121	766	948	600	458	(3)	158	(2)	935
February	475	269	150	124	1,000	1,086	600	546	(3)	160	(2)	950
March	475	260	143	113	1,000	1,018	600	496	(3)	151	(2)	956
April	475	282	120	112	1,000	1,003	600	471	(3)	143	(2)	1,000
May	475	269	120	124	1,000	828	600	435	(3)	101	(2)	1,000
June	475	264	120	93	880	658	600	404	(3)	80	(2)	1,000
July	475	268	120	94	800	643	600	378	(3)	68	(2)	1,000
August	475	308	120	103	1,000	812	600	409	(3)	73	(2)	861
September	475	309	120	99	880	933	600	416	(3)	70	(2)	807
October	475	323	120	101	851	1,016	600	414	(3)	69	(2)	818
November	475	334	120	100	800	1,078	600	410	(3)	70	(2)	825
December	475	334	120	95	1,003	1,119	600	414	(3)	70	(2)	830
Average	475	291	127	107	915	929	600	438	(3)	101	(2)	915

[1]Average prices calculated at the low end of the range and rounded to the nearest dollar.
[2]Producer price suspended on Jan. 13, 1984.
[3]Producer price suspended on June 7, 1984.

Source: Metals Week.

Trading volume on the New York Mercantile Exchange in futures contracts for 1983-85, is shown in the following tabulation:

	Platinum[1]	Palladium[2]
1983	1,053,282	241,224
1984	571,127	159,019
1985	693,256	133,223

[1]50 troy ounces per contract.
[2]100 troy ounces per contract.

FOREIGN TRADE

The major sources for imports of PGM, in descending order, were the Republic of South Africa, the United Kingdom, the U.S.S.R., Canada, and Belgium-Luxembourg. Some of the imports from the United Kingdom originated from ore mined in the Republic of South Africa, and some of the imports from the Netherlands and other European countries may have originated from ore mined in the U.S.S.R. The major recipients of exports, in descending order, were Japan, the United Kingdom, and Canada. The United States exported sizable quantities of PGM-bearing scrap, some of which was concentrated from used automobile catalytic converters.

Table 6.—U.S. exports of platinum-group metals, by year and country

Year and country	Ores and concentrates (troy ounces)	Waste, scrap, and sweepings (troy ounces)	Metal not rolled (troy ounces): Platinum	Metal not rolled (troy ounces): Palladium	Metal not rolled (troy ounces): Other platinum group	Metal rolled (troy ounces): Platinum	Metal rolled (troy ounces): Other platinum group	Total: Troy ounces	Total: Value (thousands)
1981	8,246	204,180	327,328	149,794	81,848	63,866	28,103	863,365	$301,890
1982	8,870	388,437	125,581	167,397	84,832	50,224	10,535	835,876	182,460
1983	31,827	751,140	138,928	155,607	71,289	45,671	34,292	1,228,754	309,917
1984	r40,920	522,425	177,401	182,692	r167,635	43,484	27,475	r1,162,032	r274,775
1985:									
Australia	--	147	352	1,659	1,342	--	91	3,591	770
Belgium-Luxembourg	40	75,554	1,929	1,775	170	--	87	79,555	16,158
Brazil	--	--	961	2,844	--	347	4	4,156	763
Canada	1,942	54,049	1,017	20,935	24,868	243	621	103,675	23,477
China	--	--	1,654	2,572	--	--	--	4,226	663
France	--	1,092	760	18,560	11,564	1,642	1,064	34,682	2,815
Germany, Federal Republic of	--	19,303	923	30,554	1,267	58	119	52,224	8,573
Greece	--	--	--	752	141	--	--	893	148
Hong Kong	--	--	6,419	652	141	--	--	7,212	1,842
Israel	--	--	5	8	860	--	69	942	191
Italy	--	2,393	452	1,480	2,445	656	198	7,624	1,775
Japan	716	7,043	159,737	73,028	19,206	1,109	5,613	266,452	64,584
Korea, Republic of	131	136	78	715	1,506	176	24	2,766	383
Netherlands	--	--	3,694	1,652	482	100	24,323	30,251	3,906
Singapore	--	10,500	200	5,045	22	2	--	15,769	583
South Africa, Republic of	--	2	--	226	1,078	--	--	1,306	200
Spain	--	401	--	1,200	97	--	--	1,698	196
Sweden	--	5,419	--	60	4,202	--	--	9,681	2,482
Switzerland	--	--	--	3,779	10,013	--	22	13,814	3,638
Taiwan	--	--	198	4,005	12	--	--	4,215	563
United Kingdom	512	182,210	3,876	41,457	7,069	104	3,371	238,599	52,087
Uruguay	607	--	9	373	161	--	--	1,150	158
Other	19	168	223	2,295	1,081	89	295	4,170	1,206
Total	3,967	358,417	182,487	215,626	87,727	4,526	35,901	888,651	187,161

rRevised.

Source: Bureau of the Census.

Table 7.—U.S. imports for consumption of platinum-group metals, by year and country

Year and country	Unwrought (troy ounces)										
	Platinum grains and nuggets	Platinum sponge	Palladium	Iridium	Osmium	Osmiridium	Rhodium	Ruthenium	Unspecified combinations	Platinum-group metals from precious metal ores	Sweepings, waste, and scrap
1981	1,891	888,995	1,114,313	11,110	850	9,309	73,738	180,438	32,736	1,442	235,379
1982	3,298	689,647	1,039,210	19,402	1,600	5,576	68,968	133,798	14,880	1,373	339,095
1983	8,513	1,005,208	1,223,951	23,266	1,747	848	119,958	163,623	18,143	2,137	417,431
1984	19,786	1,527,841	1,795,939	18,225	1,630	150	155,671	198,257	8,822	--	526,738
1985:											
Australia	39	1,513	4,502	--	--	--	--	--	--	--	2,697
Belgium-Luxembourg	1,384	36,063	134,277	--	50	--	570	--	--	--	48,597
Canada	--	14,669	83,106	40	--	--	3,288	500	173	--	187,604
Colombia	8,730	11,700	--	--	--	--	--	--	1,800	--	26,487
Germany, Federal Republic of	552	36,026	46,864	1,001	3	--	3,999	446	--	--	52,982
Italy	--	10,461	6,450	--	--	--	--	--	--	--	--
Japan	500	2,293	13,349	230	--	--	500	13,557	--	--	803
Mexico	--	--	2,000	--	--	--	--	--	--	--	130,083
Netherlands	--	52,539	66,049	1,279	2,552	--	6,837	2,089	--	--	2,648
Saudi Arabia	--	23,006	12,250	532	10	--	2,524	2,000	--	--	1,047
South Africa, Republic of	590	1,018,258	579,628	12,415	308	--	115,484	82,947	3,973	--	3,427
Sweden	--	29	--	--	--	--	9	--	--	--	19,417
Switzerland	--	13,000	16,489	100	--	--	156	500	--	--	--
Taiwan	--	--	457	--	--	--	--	--	--	--	35,624
U.S.S.R	1,717	14,938	234,497	990	--	--	13,098	1,911	664	--	--
United Kingdom	7,010	226,490	187,601	4,105	2,230	--	50,634	57,937	3,413	--	434
Other	305	3,660	9,291	280	--	--	3,929	1,000	307	218	18,874
Total	20,827	1,464,645	1,396,810	20,972	5,153	--	201,028	162,887	10,330	218	530,724

Table 7.—U.S. imports for consumption of platinum-group metals, by year and country—Continued

Year and country	Semimanufactured (troy ounces)					Platinum-group metals in materials not elsewhere specified (troy ounces)	Total	
	Platinum	Palladium	Iridium	Rhodium	Unspecified combinations		Troy ounces	Value (thousands)
1981	179,321	116,548	248	1,733	3	1,563	2,849,617	$800,256
1982	114,028	60,760	907	1,005	159	--	2,493,706	553,935
1983	109,376	108,247	213	11,245	--	4,116	3,218,022	752,756
1984	60,140	158,012	164	2,389	10	332	4,474,106	1,118,088
1985:								
Australia	--	--	--	--	--	--	8,751	2,050
Belgium-Luxembourg	--	--	--	--	--	107	221,048	50,300
Canada	222	28	--	--	--	86	289,716	29,567
Colombia	--	--	--	--	--	1,800	50,517	14,160
Germany, Federal Republic of	116	16,282	--	35	--	--	158,306	22,844
Italy	--	--	--	--	--	--	16,911	3,937
Japan	5,045	948	--	--	--	--	37,225	6,279
Mexico	--	--	--	--	--	--	132,083	1,519
Netherlands	301	982	--	--	--	--	135,276	39,866
Saudi Arabia	--	--	--	--	--	--	41,369	14,466
South Africa, Republic of	3,767	--	--	--	--	4,955	1,825,752	586,276
Sweden	--	--	--	--	--	--	19,455	8,564
Switzerland	9,931	600	--	--	--	--	40,776	12,080
Taiwan	--	--	--	--	--	--	36,081	445
U.S.S.R.	5,548	38,495	1,929	--	--	--	313,787	48,788
United Kingdom	53,276	27,157	1,194	110	--	--	621,591	173,768
Other	--	--	577	--	1,480	1,029	40,950	10,783
Total	78,206	84,492	3,700	145	1,480	7,977	3,989,594	1,025,692

Source: Bureau of the Census.

Table 8.—Estimated U.S. imports of platinum and palladium, by year and country[1]

(Thousand troy ounces)

Country	Platinum 1984	Platinum 1985	Palladium 1984	Palladium 1985
South Africa, Republic of	1,043	1,029	587	584
U.S.S.R	20	23	495	273
United Kingdom	300	288	391	216
Other	411	395	824	759
Total[2]	1,774	1,735	2,296	1,833

[1]This table is based on the figures shown in table 7. Estimates are based on the explicit categories of palladium plus estimates of the metal content in the following categories: unspecified combinations, ores, and scrap, and materials not elsewhere specified.

[2]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

PGM were mined in 10 countries in 1985. The Republic of South Africa and the U.S.S.R. together accounted for 94% of world mine production. Three companies in the Republic of South Africa produced PGM from platinum ores, while the U.S.S.R. and two companies in Canada produced PGM from nickel-copper ores. Production of the principal metals of the group, platinum and palladium, was 3.4 million ounces and 3.7 million ounces, respectively, of which the U.S.S.R. produced an estimated 950 million ounces of platinum and 2.5 million ounces of palladium.

World supply and demand in market economy countries for palladium were well balanced in 1985, while there was a slight deficit in supply for platinum, as shown in the tabulation below in units of thousand ounces:

	Platinum	Palladium
SUPPLY[1]		
Mine production:		
South Africa, Republic of[e]	2,257	962
Canada	150	158
Other	38	67
Total	2,445	1,187
Secondary, old scrap:		
United States	52	201
Japan[2]	29	195
Other[3]	51	150
Total	132	546
Soviet sales[3]	200	1,360
Total	2,777	3,093
DEMAND[1]		
Industrial:		
Japan[2]	1,280	1,270
United States	1,218	1,186
Other[3]	413	650
Total	2,911	3,106

[e]Estimated.

[1]Market economy countries.

[2]Sumitomo Corp. Precious Metals Market in Japan. 16th ed., Feb. 1986, 18 pp.

[3]J. Aron & Co., Goldman, Sachs & Co. Commodity Market Perspectives—Platinum Group Metals. Dec. 1985, 48 pp.

According to a recent publication by Johnson Matthey P.L.C., the demand in market economy countries for platinum used in automobiles, jewelry, glass fiber bushings, and investment bars and coins increased in 1985 from the level of 1984.[7] Factors that may have influenced investors to purchase additional platinum were a strike by South African gold miners in September and, a month later, a U.S. Government ban on the importation of South African Krugerrand gold coins. In view of the widening interest in platinum as an investment, an industry organization called the Platinum Guild (USA) was formed in September to disseminate information concerning the investment benefits of platinum ownership. In Europe, Ayrton Metals Inc., the marketing agent for Impala, announced plans to begin selling fractional ounce platinum "noble" coins, equal to one-tenth of the current 1-ounce coin weight.[8] The platinum "noble" had been introduced in November 1983 in Switzerland, the Federal Republic of Germany, and the United Kingdom, and had proven to be popular among investors.

In June, the European Economic Community (EEC) agreed to introduce restrictions on automobile emissions to be implemented in stages between 1988 and 1993.[9] Currently, the only way to meet the EEC standard, which is roughly equivalent to the current U.S. standard, is by using catalytic exhaust converters. The EEC standard was expected to have a major impact on world demand for platinum and rhodium, and a lesser impact on demand for palladium, over the next decade.

Canada.—Among companies exploring and/or developing PGM deposits were Fleck Resources Ltd. in Marathon, Ontario; Boston Bay Mines Ltd. near Thunder Bay, Ontario; Nexus Resource Corp. on Vancouver Island, British Columbia; and Dumont Nickel Corp. in Quebec.[10]

Japan.—Imports totaled about 1.3 million ounces of platinum, primarily from the Republic of South Africa, and about 1.1 million ounces of palladium, primarily from the U.S.S.R. Imports of platinum increased, while imports of palladium decreased from the amounts reported in 1984.[11]

Consumption of platinum in jewelry increased, and consumption of palladium in electrical uses decreased in 1985. Estimated total consumption of platinum and palladium in Japan, in thousand troy ounces, was reported as follows:

	Platinum	Palladium
Automotive	170	100
Chemical	120	400
Dental	--	210
Electrical	150	470
Jewelry	630	60
Miscellaneous[1]	210	30
Total	1,280	1,270

[1]Glass is included in "Miscellaneous" category for platinum.

Source: Sumitomo Corp.

South Africa, Republic of.—Matthey Rustenburg Refiners Ltd., jointly owned by Johnson Matthey P.L.C. and Rustenburg Platinum, reportedly decided to build a new Solvex PGM refining plant in the Republic of South Africa. The plant, which was expected to be completed by 1990, was to be modeled after the Royston, United Kingdom, plant and would treat 100% of Rustenburg's primary PGM output. The Royston plant would then be converted into a PGM scrap refinery.[12]

Western Platinum Ltd., the smallest of the three PGM producers in the Republic of South Africa, sent its last shipment of PGM-bearing nickel-copper matte to Norway for refining by Falconbridge Nickel Ltd. Western expected its newly commissioned $9 million nickel-copper-cobalt refinery, at its Marikana Mine in the Transvaal, to greatly speed up the recovery of base metals and PGM, as well as reduce shipping costs. Previously, the PGM included in the matte shipped to Norway were returned in the form of a concentrate for final platinum-palladium refining in the Republic of South Africa. Western completed expansion of its precious metals plant at Brakpan, acquiring the capacity to refine the minor PGM as well as platinum and palladium. Falconbridge, which owns 25% of Western, was to continue its exclusive marketing agreement with Western.[13]

Table 9.—Platinum-group metals: World production, by country[1]

(Troy ounces)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Australia, metal content, from domestic nickel ore:[3]					
Palladium	12,896	13,379	[e]12,000	[e]12,000	13,600
Platinum	2,093	2,388	[e]1,900	[r] [e]1,900	2,400
Canada: Platinum-group metals from nickel ore	382,658	228,425	223,925	348,216	350,000
Colombia: Placer platinum	14,804	11,886	10,303	10,106	11,400
Ethiopia: Placer platinum[e]	125	125	125	125	125
Finland:					
Palladium	1,993	4,662	2,283	1,093	1,100
Platinum	1,608	4,147	2,186	1,061	1,100
Japan, metal recovered from nickel-copper ores:[4]					
Palladium	25,748	27,862	37,122	33,802	[5]43,703
Platinum	10,521	15,411	21,460	19,523	[5]22,216
South Africa, Republic of: Platinum-group metals from platinum ore[e] [6]	3,110,000	2,600,000	2,600,000	[r]3,500,000	3,700,000
U.S.S.R.: Placer platinum and platinum-group metals recovered from nickel-copper ores[e]	3,350,000	3,500,000	3,600,000	3,700,000	3,800,000
United States: Placer platinum and platinum-group metals from gold-copper ores	7,318	8,033	6,257	14,635	W
Yugoslavia:					
Palladium	3,119	2,893	2,926	[r] [e]3,100	3,300
Platinum	482	418	193	[r] [e]200	250
Zimbabwe:					
Palladium	5,200	2,765	2,395	1,222	1,300
Platinum	2,300	1,704	1,695	772	800
Total	6,930,865	[r]6,424,098	6,524,770	7,647,755	7,951,294

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total."

[1]Table includes data available through May 20, 1986. Platinum-group metal production by the Federal Republic of Germany, Norway, and the United Kingdom is not included in this table because the production is derived wholly from imported metallurgical products and to include it would result in double counting.

[2]In addition to the countries listed, China, Indonesia, Papua New Guinea, and the Philippines are believed to produce platinum-group metals, and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. However, a part of this output not specifically reported by country is presumably included in this table credited to Japan. (See footnote 4.)

[3]Partial figure; excludes platinum-group metals recovered in other countries from nickel ore of Australian origin; however, a part of this output may be credited to Japan. (See footnote 4.)

[4]Japanese figures do not refer to Japanese mine production, but rather represent Japanese smelter-refinery recovery from ores originating in a number of countries; this output cannot be credited to the country of origin because of a lack of data. Countries producing and exporting such ores to Japan include (but are not necessarily limited to) Australia, Canada, Indonesia, Papua New Guinea, and the Philippines. Output from ores of Australian, Indonesian, Papua New Guinean, and the Philippine origin are not duplicative, but output from Canadian material might duplicate a part of reported Canadian production.

[5]Reported figure.

[6]Includes osmiridium produced in gold mines.

TECHNOLOGY

The Office of Technology Assessment, U.S. Congress, published a report on PGM and three other critical metals.[14] The purpose of the report was to probe ways to reduce U.S. import dependence on the Republic of South Africa and the U.S.S.R. With regard to PGM, the report concluded that the United States could conserve PGM by increasing recycling of used automobile catalytic converters to recover 500,000 ounces of PGM annually by 1995. In addition, the study concluded that development of the Stillwater Complex deposit in Montana could produce about 175,000 ounces of PGM annually, provided that demand for palladium and platinum remains high.

The International Precious Metals Institute sponsored a seminar on PGM in October 1985 in Washington, DC. Experts on mining, economics, and uses of PGM presented papers at the meeting. European automotive emission legislation and automotive catalyst technology were discussed, among other topics.[15]

Progress on future commercial use of platinum in phosphoric acid fuel cells was discussed at a seminar in Italy in June. One researcher concluded that platinum supplies will be adequate to meet even the most optimistic projections of fuel cell usage, even though possible platinum requirements for fuel cells is very large.[16] The researcher cited, as an example of research and development progress, United Technologies Corp.'s completion of a 4.5-megawatt powerplant in Japan in 1982 that had produced electricity continuously since 1983. That success had encouraged United Technologies to develop an 11-megawatt plant, and Westinghouse to build a 7.5-megawatt plant, both of which were to be located in the United States. In addition, the Ministry of International Trade and Industry in Japan was underwriting the development of a number of 1-megawatt plants to be operational by 1986.

Using a supported ruthenium catalyst, scientists at the Stanford Research Institute succeeded for the first time in electrochemically producing appreciable amounts of methane from water and carbon dioxide. Synthetic methane produced in this way could eventually supplement natural gas as a fuel or chemical feedstock, but problems remain in determining the mechanisms at work in the process, and in removing the need to use ultrapure ruthenium.[17]

Cisplatin is a drug made from platinum that is used for treating some types of cancer. The Kitasato University in Tokyo announced preliminary evidence that administration of sodium selenite along with cisplatin reduces the toxic side effects of the drug on both the kidney and the intestine without compromising its antitumor activity.[18]

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Potash

By James P. Searls[1]

U.S. potash production and apparent consumption in terms of potassium oxide (K_2O) equivalent decreased significantly in 1985. Spring production again exceeded fall production. Sales by U.S. producers fell 23% for the year, and average prices decreased to a lesser extent. Yearend stocks increased slightly. The United States continued to be a net importer of potash; net import reliance as a percentage of apparent consumption was 76%. Canada provided an amount equal to 80% of the domestic apparent consumption. U.S. exports rose, however, with increased exports to India, Japan, and Mexico.

Three Carlsbad, NM, mines and plants were sold during the year. Two Carlsbad mines and plants were closed temporarily at yearend. A Utah plant remained closed throughout the year to repair flood damage.

Domestic Data Coverage.—Domestic production data for potash are developed by the Bureau of Mines from a voluntary semiannual survey of U.S. operations. Of the 10 operations to which a survey request was sent, all responded, representing 100% of the total production shown in table 1. The temporarily closed plants reported beginning stocks, sales, and ending stocks.

Table 1.—Salient potash[1] statistics

(Thousand metric tons and thousand dollars unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production	4,153	3,366	2,770	3,039	2,569
K_2O equivalent	2,156	1,784	1,429	1,564	1,296
Sales by producers	3,670	3,387	2,950	3,184	2,505
K_2O equivalent	1,908	1,784	1,513	1,639	1,266
Value[2]	$328,900	$265,600	$220,800	$241,800	$178,400
Average value per ton of product dollars	$89.62	$78.42	$74.85	$75.95	$71.22
Average value per ton of K_2O equivalent do	$172.40	$148.87	$145.97	$147.55	$140.89
Exports[3]	887	952	564	836	973
K_2O equivalent	491	519	300	446	513
Value[4]	$107,950	$93,200	$55,760	$85,660	NA
Imports for consumption[3 5]	7,903	6,338	7,322	7,948	7,571
K_2O equivalent	4,796	3,858	4,440	4,829	4,593
Customs value	$750,400	$575,400	$600,600	$658,100	$499,100
Apparent consumption[6]	10,686	8,773	9,708	10,296	9,103
K_2O equivalent	6,213	5,123	5,653	6,022	5,346
Yearend producers' stocks, K_2O equivalent	520	520	[7]391	[8]312	[9]336
World: Production, marketable K_2O equivalent	[r]27,075	[r]24,509	27,418	[p]29,348	[e]28,618

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Includes muriate and sulfate of potash, potassium magnesium sulfate, glaserite, and some parent salts. Excludes other chemical compounds containing potassium.
[2]F.o.b. mine.
[3]Excludes potassium chemicals and mixed fertilizers.
[4]F.a.s. U.S. port.
[5]Includes nitrate of potash.
[6]Measured by production plus imports minus exports plus industry and Government stock changes.
[7]Inventory adjustment of minus 46,000 tons.
[8]Inventory adjustment of minus 4,000 tons.
[9]Inventory adjustment of minus 6,000 tons.

DOMESTIC PRODUCTION

Domestic K_2O production fell 17% in 1985. Of the total production for the year, 75% was standard, coarse, and granular muriate of potash, also known as potassium chloride, and 8% was sulfate of potash, also known as potassium sulfate. The remaining production comprised manure salts, glaserite, soluble and chemical grades of muriate of potash, and sulfate of potash-magnesia, also known as potassium magnesium sulfate. The terms "standard," "coarse," and "granular" refer to particle sizes of the finished product.

The New Mexico producers accounted for 85% of the total marketable salts production. New Mexico crude salt mine production was 11.3 million metric tons with an average K_2O content of 13.3%. Five companies produced potash from underground, bedded sylvinite and langbeinite deposits east of Carlsbad. At the beginning of the year, the producers were AMAX Chemical Corp. of AMAX Inc.; the Duval Corp. of Pennzoil Co.; International Minerals & Chemical Corp. (IMC); Kerr-McGee Chemical Corp. of Kerr-McGee Corp.; and Potash Co. of America (PCA) of Ideal Basic Industries Inc.

All of the Carlsbad producers operated at reduced levels during the year. AMAX Chemical's operation was closed indefinitely in November. The Duval operation was renamed Potash Producers Inc. early in the year, then sold and renamed Western Ag-Minerals Corp. The new owners of Western Ag-Minerals were Warburg, Pincus Capital Partners, 75%, a New York venture banking firm, and Rayrock Resources Ltd., 25%, a Toronto, Canada, mining firm. The Kerr-McGee Chemical Hobbs facility was sold to Vertac Chemical Corp. of Memphis, TN, and renamed New Mexico Potash Co. The new owner sold potash primarily to its potassium nitrate manufacturing plant in Vicksburg, TN, and to the oil drilling and chemical industries; only excess material was sold to the agricultural industry. PCA, which closed in December to reduce stocks of finished product, was sold at yearend and renamed Lundberg Industries Ltd.

Mississippi Chemical Corp., whose mine had been closed since January 1983, purchased the permanently closed National Potash Co. property and started salvage operations on the underground equipment and materiel.

Sylvinite ore was used for muriate of potash production, and langbeinite ore was used for sulfate of potash-magnesia production. IMC mined both ores and reacted fractions of each potash product to produce sulfate of potash.

Sulfate of potash was also manufactured at two plants in Texas. The PCA, subsequently Lundberg Industries, plant produced sulfate of potash from Hargreaves furnaces using muriate of potash and sulfur dioxide; that production was included in Bureau of Mines statistics because PCA had mined the potash feed in New Mexico. The Permian Chemical Corp. plant reported production of about 15,000 tons[2] from its Mannheim furnaces using muriate of potash and sulfuric acid, but its production was not included in Bureau of Mines statistics because Permian was not a mining firm. Both firms sold byproduct hydrochloric acid to the Texas petroleum industry for oil well acidification.

In Utah, Texasgulf Chemicals Co. of Texasgulf Inc., which is owned by Elf Aquitaine Inc. of the Paris-based Société Nationale Elf Aquitaine, produced muriate of potash from underground, bedded sylvinite deposits by solution mining and solar evaporation. Kaiser Chemicals of Kaiser Aluminum & Chemical Corp. produced muriate of potash from near-surface brines at the west end of the Bonneville Salt Flats by solar evaporation and flotation. Great Salt Lake Minerals & Chemicals Corp., a subsidiary of Gulf Resources & Chemical Corp., remained closed throughout the year while repairing flood damage. A new sulfate of potash manufacturer, Climax Chemical Co., produced about 8,000 tons, but its production was not included in Bureau of Mines statistics because Climax Chemical was not a mining firm. Climax Chemical had been a sodium sulfate producer that converted to potassium sulfate production.

In California, Kerr-McGee Chemical continued to produce both muriate and sulfate of potash along with other products from underground brines at Searles Lake.

Table 2.—Production, sales, and inventory of U.S. produced potash, by type and grade

(Thousand metric tons and thousand dollars)

Type and grade	Production				Sold or used						Stocks, end of 6-month period			
	Gross weight		K_2O equivalent		Gross weight		K_2O equivalent		Value[1]		Gross weight		K_2O equivalent	
	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
January-June:														
Muriate of potash, 60% K_2O minimum:														
Standard	368	434	226	266	467	431	286	264	30,500	27,000	133	143	82	88
Coarse	[r]150	95	92	58	196	96	121	59	13,900	6,100	46	60	28	37
Granular	543	369	331	223	529	417	322	252	37,200	25,600	149	111	91	68
Chemical	31	21	20	14	32	20	20	13	W	W	(2)	5	(2)	3
Potassium sulfate	100	99	51	51	145	98	74	50	27,600	18,500	49	61	25	32
Other potassium salts[3]	381	342	94	92	426	393	104	104	W	W	228	200	51	46
Total[4]	1,573	1,360	813	704	1,794	1,455	927	742	139,300	106,000	607	580	278	274
July-December:														
Muriate of potash, 60% K_2O minimum:														
Standard	418	396	256	242	406	307	249	188	26,400	18,400	140	232	85	141
Coarse	157	58	97	35	142	67	88	41	9,100	3,600	61	48	38	30
Granular	385	254	233	154	373	264	227	160	23,600	12,600	160	95	97	58
Chemical	19	21	12	14	15	17	9	11	W	W	4	10	3	6
Potassium sulfate	112	108	57	55	101	103	52	53	19,600	18,000	60	66	31	34
Other potassium salts[3]	375	372	95	92	352	292	88	71	W	W	251	279	58	67
Total[4]	1,466	1,209	751	592	1,389	1,050	712	524	102,500	72,400	677	730	312	336
Grand total[4]	3,039	2,569	1,564	1,296	3,184	2,505	1,639	1,266	241,800	178,400	XX	XX	XX	XX

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]F.o.b. mine.
[2]Less than 1/2 unit.
[3]Includes soluble muriate, glaserite, manure salts, and potassium magnesium sulfate.
[4]Data may not add to totals shown because of independent rounding.

Table 3.—Production and sales of potash in New Mexico

(Thousand metric tons and thousand dollars)

Period	Crude salts[1] (mine production)		Marketable potassium salts				
			Production		Sold or used		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value[2]
1984:							
January-June	7,209	973	1,434	733	1,575	801	$118,000
July-December	r6,903	r919	1,302	655	1,225	618	86,100
Total[3]	r14,112	r1,892	2,735	1,388	2,799	1,418	204,100
1985:							
January-June	6,160	827	1,221	623	1,322	666	93,900
July-December	5,152	683	1,014	479	927	454	62,100
Total	11,312	1,510	2,235	1,102	2,249	1,120	156,000

rRevised.
[1]Sylvinite and langbeinite.
[2]F.o.b. mine.
[3]Data may not add to totals shown because of independent rounding.

Table 4.—Salient U.S. sulfate of potash[1] statistics

(Thousand metric tons of K_2O equivalent and thousand dollars)

	1981	1982	1983	1984	1985
Production	200	166	168	109	106
Sales by producers	178	176	156	126	103
Value[2]	$61,993	$61,934	$55,453	$47,197	$36,465
Exports[3]	40	71	44	34	46
Value[4]	$16,095	$27,648	$16,390	$13,940	NA
Imports[3]	18	6	29	29	25
Value[5]	$7,380	$2,409	$12,300	$12,600	$10,400
Apparent consumption[6]	156	111	141	121	82
Yearend producers' stocks	46	36	44	31	34

NA Not available.
[1]Excludes potassium magnesium sulfate.
[2]F.o.b. mine.
[3]Bureau of the Census.
[4]F.a.s. U.S. port.
[5]C.i.f. to U.S. port.
[6]Measured by production plus imports minus exports plus industry and Government stock changes.

CONSUMPTION AND USES

Apparent domestic consumption of all forms of potash decreased from that of 1984. Downward pressure on demand for fertilizers in the United States continued to come from the decline in demand for U.S.-produced crops and the stockpile remaining from previous record crop-years. Crop buyers from foreign countries found U.S. crops to be relatively expensive because of the combination of the high value of the U.S. dollar and the level at which the U.S. Government supported crop prices relative to the world market price. Even U.S. farmers who could earn profits without price supports lost money-borrowing power for fertilizer purchases because of the strongly declining value of their cropland, which was used as collateral for bank loans. Corn Belt land values had declined an average of 44% between 1981 and 1985. Farmers expected calendar year 1986 to be a poor year for exports, and because the Food Security Act of 1985 was not passed until December, they failed to make large fertilizer purchases in the fall, which usually accounted for 60% of the year's consumption.

According to the Potash & Phosphate Institute, the major consumers of agricultural potash from Canadian and U.S. potash producers, in decreasing order, were Illinois, Iowa, Indiana, Ohio, Minnesota, and Wisconsin. These six States consumed 54% of the total from Canadian and U.S. producers. However, domestic producers provided only 6% of Illinois' potash consumption, 2% of Iowa's consumption, 1% of Indiana's consumption, 1% of Ohio's consumption, 10% of Minnesota's consumption, and 4% of Wisconsin's consumption. Potash from other countries was consumed in these States, but quantities are unknown. The major agricultural consumers of domestically produced potash, in decreasing order, were Texas, Missouri, California, Illinois, Minnesota, and Florida. These six States accounted for 56% of the total. The major agricultural consumers of domestically produced sulfates of potash, in decreasing order, were Florida, Georgia, California, Texas, Kentucky, and North Carolina. These six States accounted for 59% of the total.

Table 5.—Sales of North American potash, by State of destination

(Metric tons of K_2O equivalent)

State	Agricultural potash		Nonagricultural potash	
	1984	1985	1984	1985
Alabama	78,041	65,558	61,940	63,576
Alaska	257	217	--	--
Arizona	438	390	22	112
Arkansas	44,179	54,803	140	620
California	62,054	51,059	10,992	8,848
Colorado	13,051	8,323	6,083	7,044
Connecticut	4,282	5,625	52	119
Delaware	27,694	16,394	35,755	33,500
Florida	148,230	114,560	865	3,891
Georgia	162,351	155,822	957	1,990
Hawaii	16,056	13,561	--	--
Idaho	19,008	24,223	--	51
Illinois	717,548	663,632	32,942	22,347
Indiana	362,757	399,639	2,352	357
Iowa	493,110	400,412	1,226	454
Kansas	33,653	30,199	2,549	1,984
Kentucky	149,555	132,288	364	341
Louisiana	49,783	54,181	1,775	1,444
Maine	7,160	7,711	114	416
Maryland	24,088	27,875	509	175
Massachusetts	5,015	3,382	534	586
Michigan	204,048	185,586	1,702	1,501
Minnesota	360,667	350,467	36	335
Mississippi	49,804	32,010	3,165	28,382
Missouri	247,720	232,460	3,458	3,281
Montana	13,029	10,185	135	71
Nebraska	39,180	32,252	113	462
Nevada	12	--	249	59
New Hampshire	553	767	--	24
New Jersey	6,819	7,907	11,463	13,250
New Mexico	6,831	11,373	29,685	34,673
New York	78,520	82,410	976	1,261
North Carolina	103,421	117,822	46	158
North Dakota	22,099	20,092	104	384
Ohio	396,761	399,025	60,423	58,922
Oklahoma	41,778	22,729	7,796	9,105
Oregon	26,154	24,612	1,485	1,437
Pennsylvania	48,601	63,018	4,036	2,427
Rhode Island	2,258	2,207	110	92
South Carolina	65,909	66,496	117	167
South Dakota	11,769	10,894	7	--
Tennessee	131,052	140,373	423	591
Texas	140,996	135,722	47,317	42,998
Utah	4,254	14,491	13,563	11,880
Vermont	3,712	5,029	--	14
Virginia	65,384	63,037	331	200
Washington	40,241	38,735	2,905	2,546
West Virginia	4,150	4,911	1,280	601
Wisconsin	280,336	292,508	201	487
Wyoming	1,854	2,188	824	643
Total	4,816,222	4,599,160	351,121	363,806

Source: Potash & Phosphate Institute.

Table 6.—Sales of North American muriate of potash to U.S. customers, by grade

(Thousand metric tons of K_2O equivalent)

Grade	1982	1983	1984	1985
Agricultural:				
Standard	563	399	446	346
Coarse	1,750	2,402	2,219	2,065
Granular	1,237	1,533	1,511	1,666
Soluble	357	451	471	392
Total	3,907	4,785	4,647	4,469
Nonagricultural:				
Soluble	106	114	120	138
Other	210	195	227	227
Total	316	309	347	365
Grand total	4,223	5,094	4,994	4,834

Source: Potash & Phosphate Institute.

According to the Potash & Phosphate Institute, which reported sales of U.S. and Canadian producers by grade and State, domestic sales of muriate of potash for agricultural uses changed as follows: Standard grade fell 22%, coarse grade fell about 7%, granular grade rose about 10%, and sulfate of potash and sulfate of potash-magnesia combined fell 23%. The percentage breakdown of total sales by grade and type was 45% coarse muriate, 36% granular muriate, 9% soluble muriate, 7% standard muriate, and 3% sulfates of both types and all sizes. Potash sales of the domestic producers as a percentage of total domestic sales represented 5% of the coarse muriate, 17% of the granular muriate, 3% of the soluble muriate, 27% of the standard muriate, and 100% of both types and all sizes of sulfates.

The Potash & Phosphate Institute also reported a slight increase in potash sold for nonagricultural uses. Of this, standard muriate was 60%, soluble muriate was 38%, and sulfates of both types and all sizes was 2%. Nonagricultural uses of potash were primarily for producing caustic potash and chlorine. Caustic potash, or potassium hydroxide, was used as a caustic chemical and as the major precursor to other potassium chemicals. A minor industrial use of muriate of potash was as an addition to oil well drilling muds. Diamond Shamrock Corp. announced an expansion of caustic potash capacity at its plant in Mobile, AL. Monsanto Co. announced the cessation of caustic potash manufacturing at its Sauget, IL, chlor-alkali plant. The demise of Allied Chemical Corp.'s synthetic soda ash plant at Syracuse, NY, left only Diamond Shamrock's Muscle Shoals, AL, plant producing potassium carbonate.

STOCKS

Yearend producers' stocks of potash increased slightly over that of 1984. Yearend stocks were 26% of annual production or 13.5 weeks of production. Several producers reported inventory adjustments between December 1984 and January 1985, and between June and July 1985. The effective total stock adjustment between December 1984 and December 1985 was minus 6,000 tons.

TRANSPORTATION

Ocean freight rates from Hamburg, Federal Republic of Germany, to India and from Vancouver, Canada, to India fell slowly throughout the year. Both fell from about \$30 per ton to the lower or middle \$20's. Published U.S. rail tariffs were unchanged in the southern half of the country, whereas some railroads in the northern half of the country reduced their rates to compete with truck backhauls. Unpublished, i.e., Staggers Act, contracts and contract rates declined. The Canadian railroads raised their published rates to the United States by 7% in November. The collapse in October of an underwater section of a lock on the Welland Canal between Lake Erie and Lake Ontario delayed grain movements from the Central United States and Canada to the Atlantic Basin for nearly 1 month, but the potash trade was unaffected. The Tennessee-Tombigbee Waterway opened on June 1 between the Tombigbee River, which passes to the sea at Mobile, AL, and the Tennessee River in northeastern Mississippi; the effect on potash trade has been negligible.

About 900,000 tons of Canadian muriate of potash passed through Thunder Bay, Ontario, Canada, for lake freightage to U.S. Great Lakes ports. About 900,000 tons of Canadian muriate of potash was shipped to Minneapolis or St. Louis for transfer to barges.

PRICES

The domestic potash market was oversupplied, with ensuing low prices. Potash prices near yearend, f.o.b. plant for domestic producers and at the U.S. border for foreign producers, appeared to be below costs of production for some domestic producers. The average price, f.o.b. mine, of U.S. potash sales of all types and grades decreased slightly to $140.89 per ton. The average price was $142.71 in the first half of the year and $138.31 in the second half. The average annual price for the three grades of muriate fell to $96 per ton. Standard-grade muriate of potash averaged $100 per ton, coarse-grade averaged $96 per ton, and granular-grade, which had the greatest price decrease, averaged $93 per ton. The average annual price for sulfate of potash declined to $353 per ton.

Table 7.—Prices[1] of U.S. potash, by type and grade

(Dollars per metric ton of K_2O equivalent)

Type and grade	1983		1984		1985	
	January-June	July-December	January-June	July-December	January-June	July-December
Muriate, 60% K_2O minimum:						
Standard	93.56	98.52	106.44	106.20	101.99	97.37
Coarse	108.13	104.73	115.23	103.33	102.42	87.35
Granular	104.46	99.44	115.68	103.97	101.30	78.85
All muriate[2]	100.10	99.75	111.98	104.86	101.73	88.71
Sulfate, 50% K_2O minimum	353.19	359.03	374.22	377.21	367.24	339.98

[1]Average prices, f.o.b. mine, based on sales.
[2]Excluding soluble and chemical muriates.

FOREIGN TRADE

U.S. potash exports rose 16%, by ton product. The major destinations in Latin America, which received 53% of the exports, by ton product, were Brazil, Mexico, Colombia, the Dominican Republic, Costa Rica, and Chile. These countries represented 90% of the exports to Latin America. Exports to Brazil, Colombia, and the Dominican Republic declined slightly while exports to Chile rose nearly 70%; to Mexico, nearly 60%; and to Costa Rica, nearly 15%. Exports to Japan rose by 67% and to New Zealand, by nearly 37%. Exports to Canada fell nearly 18%, and exports to India rose from zero.

A 5% decrease in total U.S. imports of potash was represented primarily by decreases in muriate from the U.S.S.R. and the German Democratic Republic. Imports of muriate from Canada were essentially unchanged from that of 1984 and amounted to 94% of all muriate imports and 93%, by K_2O equivalent, of all potash imports. Israel was the second largest source of imports, with 6% of muriate of potash imports and 6%, by K_2O equivalent, of total potash imports.

The remaining dumping petitions before the International Trade Commission (ITC) were against the German Democratic Republic and the U.S.S.R. These investigations were completed in early 1985 with determinations in both cases that potash had not been sold for less than fair value; the preliminary findings had called for greater than 100% antidumping duties on imports from both countries. The countervailing duty petitions against these two countries had been dropped in 1984 by the International Trade Administration of the U.S. Department of Commerce because of the difficulty of the analysis. The petitioners joined an appeal in the U.S. Court of International Trade concerning a similar decision. The Court Opinion and Order reversed and remanded the Commerce determinations that "...subsidies... could not be found in countries with nonmarket economies." An appeal by Commerce was in progress at yearend.

Table 8.—U.S. exports of potash

	Approximate average K_2O content (percent)	Quantity (metric tons)		Value (thousands)
		Product	K_2O equivalent	
1984[1]				
Potassium chloride, all grades	61	621,820	379,300	[2]$57,200
Potassium sulfate	51	67,320	34,340	[2]13,940
Potassium magnesium sulfate	22	147,160	32,380	[2]14,550
Total	XX	836,300	446,020	[2 3]85,660
1985[4]				
Potassium chloride, all grades	61	699,770	426,860	NA
Potassium sulfate	51	91,000	46,410	NA
Potassium magnesium sulfate	22	182,290	40,100	NA
Total	XX	973,060	513,370	NA

NA Not available XX Not applicable.
[1]Source: Bureau of the Census, as adjusted by the Bureau of Mines.
[2]F.a.s. U.S. port.
[3]Data do not add to total shown because of independent rounding.
[4]Source: Bureau of the Census. Census ceased reporting value of shipments as of July 1985.

Table 9.—U.S. exports of potash, by country

Country	Metric tons of product: Potassium chloride		Potassium sulfates, all grades[1]		Total[2]		Total value[3] (thousands)	
	1984[4]	1985[5]	1984[4]	1985[5]	1984[4]	1985[5]	1984[4]	1985[5]
Argentina	2,000	3,150	--	1,490	2,000	4,640	$200	NA
Australia	11,520	11,810	9,050	10,000	20,570	21,810	2,940	NA
Bahamas	--	--	1,790	2,650	1,790	2,650	380	NA
Belgium	--	--	3,000	43	3,000	43	270	NA
Belize	--	1,350	--	--	--	1,350	--	NA
Brazil	289,930	272,070	4,000	5,500	293,930	277,570	28,200	NA
Canada	1,590	3,430	73,440	58,430	75,030	61,860	9,500	NA
Chile	--	--	12,350	20,910	12,350	20,910	2,560	NA
Colombia	43,480	48,860	16,130	8,840	59,610	57,700	5,940	NA
Costa Rica	6,450	8,520	14,690	15,620	21,140	24,140	2,340	NA
Dominican Republic	26,770	20,840	1,740	5,710	28,500	26,550	2,860	NA
Ecuador	14,980	12,100	5,110	3,350	20,090	15,450	1,810	NA
French West Indies	--	5,250	3,150	4,580	3,150	9,830	340	NA
Guatemala	3,160	14	420	3,040	3,580	3,050	400	NA
Haiti	600	74	10	27	611	100	67	NA
Honduras	620	--	90	240	710	240	67	NA
India	--	43,780	--	--	--	43,780	--	NA
Italy	--	110	7	250	7	360	2	NA
Jamaica	--	120	--	--	--	120	--	NA
Japan	74,910	76,650	10,220	65,150	85,130	141,800	6,830	NA
Korea, Republic of	--	--	46	6,950	46	6,950	5	NA
Leeward and Windward Islands	1,550	--	64	--	1,610	--	170	NA
Malaysia	--	14,250	23,800	12,100	23,800	26,350	1,900	NA
Mexico	42,190	77,820	26,310	30,100	68,500	107,920	8,530	NA
New Zealand	59,090	81,820	370	--	59,460	81,280	5,260	NA
Panama	4,250	1,450	150	290	4,400	1,740	440	NA
Peru	19,160	14,420	1,210	1,260	20,380	15,680	1,840	NA
Philippines	35	--	2,130	11,600	2,160	11,600	420	NA
Salvador	--	--	--	550	--	550	--	NA
Saudi Arabia	7	--	180	60	180	60	20	NA
Sweden	--	500	640	--	640	500	150	NA
Taiwan	400	--	--	490	400	490	30	NA
Thailand	--	--	4,000	--	4,000	--	360	NA
Uruguay	--	1,270	--	--	--	1,270	--	NA
Venezuela	19,040	130	34	--	19,080	130	1,760	NA
Zambia	--	--	--	3,280	--	3,280	--	NA
Other	101	520	350	780	460	1,300	54	NA
Total[2]	621,820	699,770	214,480	273,290	836,300	973,060	85,660	NA

NA Not available.
[1]Includes potassium magnesium sulfate.
[2]Data may not add to totals shown because of independent rounding.
[3]F.a.s. U.S. port.
[4]Source: Bureau of the Census, as adjusted by the Bureau of Mines.
[5]Source: Bureau of the Census. Census ceased reporting value of shipments as of July 1985.

Table 10.—U.S. imports for consumption of potash, by country

Country	Metric tons of product										Total value (thousands)			
	Potassium chloride		Potassium sulfate		Potassium nitrate		Potassium sodium nitrate		Total[1]		Customs		C.i.f.	
	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
Belgium-Luxembourg	--	18	27,600	--	--	--	--	--	27,600	18	$5,500	$11	$5,900	$11
Canada	7,188,400	7,005,200	--	--	--	58	--	--	7,188,400	7,005,300	578,000	438,500	607,300	471,200
Chile	--	--	--	--	--	--	22,000	33,600	22,000	33,600	2,900	4,300	3,200	4,900
China	--	--	--	--	1	--	--	--	1	--	(2)		(2)	
France	14	--	--	--	--	--	--	--	14	--	20	--	24	--
German Democratic Republic	100,900	24,200	--	--	--	--	--	--	100,900	24,200	7,900	1,700	9,700	2,100
Germany, Federal Republic of	5,500	4,400	29,000	49,800	--	--	--	--	34,500	54,200	7,100	10,100	7,800	11,000
Israel	412,800	420,400	--	--	20,500	30,400	--	--	433,300	450,800	45,800	43,700	50,900	49,800
Japan	--	--	--	--	--	2	380	200	380	200	100	100	140	100
Netherlands	4,100	2,000	200	--	1	--	--	--	4,300	2,000	540	300	650	300
Spain	10,500	--	--	--	--	--	--	--	10,500	--	900	--	1,000	--
U.S.S.R	125,200	--	--	--	--	--	--	--	125,200	--	9,000	--	10,300	--
United Kingdom	650	600	--	--	--	--	--	--	650	600	300	400	400	400
Total[1]	7,848,100	7,456,800	56,800	49,800	20,500	30,500	22,300	33,800	7,947,700	7,570,900	658,100	499,100	697,400	539,900

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Source: Bureau of the Census, as adjusted by the Bureau of Mines.

Table 11.—U.S. imports for consumption of potash

	Approximate average K_2O content (percent)	Quantity (metric tons)		Value (thousands)	
		Product	K_2O equivalent[e]	Customs	C.i.f.
1984					
Potassium chloride	61	7,848,100	4,787,300	$637,200	$674,500
Potassium sulfate	50	56,800	29,000	11,700	12,600
Potassium nitrate	45	20,500	9,200	6,300	6,900
Potassium sodium nitrate mixtures	14	22,300	3,100	3,000	3,300
Total[1]	XX	7,947,700	4,828,600	658,100	697,400
1985					
Potassium chloride	61	7,456,800	4,548,700	476,000	514,600
Potassium sulfate	50	49,800	25,400	9,600	10,400
Potassium nitrate	45	30,500	13,700	9,100	9,900
Potassium sodium nitrate mixtures	14	33,800	4,700	4,400	5,000
Total	XX	7,570,900	4,592,500	499,100	539,900

[e]Estimated. XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census, as adjusted by the Bureau of Mines.

WORLD REVIEW

World production remained about the same as that in 1984 as Canadian potash producers limited production in an effort to maintain reasonable stock levels. World prices, as exemplified by the price of standard muriate of potash, f.o.b. Vancouver, Canada, reported by British Sulphur Corp., were in the middle $80's during the first half of 1985 and fell to the middle $70's by yearend. Potash was generally in oversupply at prices less than many producers' total costs.

Argentina.—An Argentinian firm, Cía. Minera Tea, and the U.S. subsidiary, Texasgulf, of the French firm Elf Aquitaine were exploring a reportedly large potash resource in Mendoza Province, which is on the western border of Argentina.

Bolivia.—The Government formed a new company, Complejo Industrial de los Recursos Evaporíticos del Salar de Uyuni, to develop the Salar de Uyuni. Proposals for a multiproduct plant included a 200,000-ton-per-year muriate of potash plant.

Brazil.—The new potash mine at Taquari-Vassouras was reported to have opened during the spring. In December 1983, the Government had estimated Brazil's total potash reserves to be 188 million tons.

Canada.—In the fall of 1984, during mining operations at the PCS Rocanville Mine, a connection with the overlying Dawson Bay water-bearing strata was encountered that caused some flooding of a gallery. The leak was stopped in the spring of 1985, by casting a large concrete plug in the gallery. Rocanville was closed for nearly 3 months. The Denison-Potacan Potash Co. mine and mill started production during the year. This muriate of potash plant had an 800,000-ton-per-year capacity. According to the Potash & Phosphate Institute, Denmark, France, Ireland, and Switzerland imported 124,000 tons of potash from Canada. Denmark had been importing potash from North America for many years; France was a partial owner of Denison-Potacan Potash. The PCS plan for a sulfate potash production plant on Quill Lake awaited a final decision. Quill Lake, east of Saskatoon in the Province of Saskatchewan, was considered to be a source of sulfate ions for the "glaserite" process.

The Central Canada Potash plant of Noranda Inc. was closed for about 3 months. The Cominco Ltd. plant at Vanscoy was closed for more than 2 months. The International Minerals & Chemical Corp. (Canada) Ltd. plants were closed for about 1.5 months. The PCA plant at Patience Lake was closed for more than 1 month. Three other PCS mines were closed for more than 3 months.

The Canadian subsidiary of PCA was sold

to Rio Algom Ltd., the Canadian subsidiary of Rio Tinto Zinc Corp. PLC of the United Kingdom. The sale included the Saskatchewan and New Brunswick mines and mills and the St. John, New Brunswick, loading dock and dockside warehouse. Rio Algom planned to invest nearly $22 million[3] into the Sussex, New Brunswick mine and mill to remove bottlenecks to full production.

Table 12.—Salient Canadian potash statistics

(Thousand metric tons of K_2O equivalent)

	1982	1983	1984	1985
Production[1]	5,208	5,928	7,749	6,637
Domestic sales by domestic producers[1]	273	385	436	434
Exports:				
United States[1]	3,202	3,965	3,892	4,163
Overseas[1]	1,576	2,026	2,544	1,928
Imports for consumption[2]	13	17	20	14
Domestic consumption[3]	286	402	456	448
Yearend producers' stocks[1]	1,486	862	1,543	1,766

[1]Data supplied by the Potash & Phosphate Institute.
[2]From Bureau of the Census export data. Muriate and nitrate of potash were landed on the Canadian east coast from European and Middle Eastern sources.
[3]Domestic sales by domestic producers plus imports.

Chile.—Sociedad Química y Minera de Chile announced plans for potassium nitrate production from facilities at Coya Sur in the Atacama Desert.

Denmark.—Superfos A/S annouced plans for a sulfate of potash manufacturing plant using gypsum and purchased muriate of potash.

German Democratic Republic.—The new port facilities at Rostock, to import urea and export potash, were completed. The potash storage facility was 35,000 tons of product with an annual flowthrough capacity of 400,000 tons. The vessel size limit was estimated to be 35,000 deadweight tons.

Israel.—The old flotation plant at the Dead Sea Works Ltd. (DSW) was closed from April through yearend to maintain reasonable potash stock levels. The parent company, Israel Chemicals Ltd., decided to reduce its 5-year, $1 billion investment plans by one-half. The planned investment in potash was cut to $125 million from $150 million, which was to have increased the plant capacity from 1.3 to 1.8 million tons. Declining oil prices have reduced the foreseeable profits from the Mediterranean Sea to Dead Sea electricity generation proposal, and the project has been abandoned. This project was expected to destructively change the Dead Sea's chemical composition and thereby alter the chemistry of the solar evaporation ponds for both the DSW and the Arab Potash Co. in Jordan. Construction of the 18-kilometer conveyor belt from Sdom to the Israel Railways terminal at Tsefa was started. The belt was designed to transport 800 tons per hour of potash from 400 meters below sea level to 400 meters above sea level.

Jordan.—The Arab Potash plant produced muriate of potash at more than one-third of the design capacity of 1.2 million tons in 1984 and one-half of capacity in 1985. The goal for 1985 production had been more than two-thirds of capacity. Near yearend, the firm asked for bids to modify the plant.

Mexico.—A potash recovery plant was reported to be under construction at the Cerro Prieto geothermal field.[4] Design capacity was 200,000 tons per year by solar evaporation and fractional crystallization from a feed of 2 cubic meters per second of brine from three powerplants.

Spain.—The Potasas de Navarra S.A. Mine south of Pamplona, owned by the Instituto Nacional de Industria (INI), was closed and reopened as the Potasas de Subiza Mine, owned 50% by INI and 50% by the government of the Province of Navarra. The rate of production was reduced from 325,000 tons to about 130,000 tons per year to extend the life of the mine. The work force dropped from about 2,000 to 600 employees. A new mine in Cataluña was being considered by either INI or Unión Explosivos Río Tinto S.A., the owner of Potasas de Llobregat and of Cardona.

Thailand.—The Sakon Nakon concession was offered for bid after AMAX Exploration Inc. failed to sign for the exploration rights.

U.S.S.R.—The potash resource that had been reported to be 70 billion tons along the Baykal-Amur Railway was named the Nepskoye deposit and reported to be 300 kilometers east of Ust-Kut in the Irkutsk Oblast on the Lena River. The Soligorsk No. 4 plant was reportedly experiencing continuing production difficulties. The plant had been placed into operation in 1979-80.

[1]Physical scientist, Division of Industrial Minerals.
[2]All tonnages reported in metric tons, K_2O equivalent, unless otherwise specified.
[3]Where necessary, values have been converted from Canadian dollars (CAN$) to U.S. dollars at a rate of CAN$1.3655=US$1.00, the average exchange rate for 1985.
[4]Espinosa, H. A. Geothermal, An Alternate Energy Source for Power Generation. Geotherm. Resour. Counc. Bull., Feb. 1985, pp. 9-12.

Table 13.—Marketable potash: World production, by country[1]

(Thousand metric tons of K_2O equivalent)

Country	1981	1982	1983	1984[p]	1985[e]
Canada (sales)[2]	6,549	5,309	6,938	7,527	6,600
Chile[3]	21	21	21	18	19
China[4]	20	26	29	40	40
France	1,831	1,704	1,536	1,739	1,750
German Democratic Republic	3,460	3,434	3,431	3,465	3,475
Germany, Federal Republic of	2,591	2,056	2,419	2,644	2,580
Israel	839	1,004	[e]1,000	[e]1,100	1,100
Italy	[r]142	146	184	178	[5]205
Jordan	--	9	172	295	550
Spain	732	692	657	[e]677	660
U.S.S.R	8,449	8,079	9,294	9,776	10,000
United Kingdom	285	[r]245	308	325	343
United States	2,156	1,784	1,429	1,564	[5]1,296
Total	[r]27,075	[r]24,509	27,418	29,348	28,618

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through Apr. 29, 1986.

[2]Official Government figures. Potash & Phosphate Institute production data are given in table 12.

[3]Data represent officially reported output of potassium nitrate product (gross weight basis) converted assuming 14% K_2O equivalent.

[4]Chinese data on production of potassic fertilizers are in terms of nutrient content; small additional quantities may be produced and used by the nonfertilizer chemical industry.

[5]Reported figure.

Pumice and Pumicite

By A. C. Meisinger[1]

Production of pumice and pumicite by 21 domestic producers in 1985 was 508,000 short tons valued at $4.6 million compared with 502,000 tons valued at $4.9 million in 1984. U.S. apparent consumption declined 6% to 749,000 tons, primarily because of a 17% decrease in imported pumice. Greece continued to be the major source of pumice imports with 98%. Estimated world production declined slightly to 12.1 million tons.

Domestic Data Coverage.—Domestic production data for pumice and pumicite are developed by the Bureau of Mines from one voluntary survey of U.S. operations. Of the 22 operations to which a survey request was sent, 18, or 82%, responded, representing 97% of total production data shown in table 1. Production for the four nonrespondents was estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

Table 1.—Salient pumice and pumicite statistics

(Thousand short tons and thousand dollars unless otherwise specified)

	1981	1982	1983	1984	1985
United States: Sold and used by producers:					
Pumice and pumicite	499	416	449	502	508
Value (f.o.b. mine and/or mill)	$4,311	$3,750	$4,486	$4,929	$4,553
Average value per ton	$8.64	$9.01	$9.99	$9.82	$8.96
Exports[e]	1	1	1	1	1
Imports for consumption	92	121	184	293	242
Apparent consumption[1]	590	536	632	794	749
World: Production, pumice and related volcanic materials	[r]13,694	[r]13,446	11,966	[p]12,662	[e]12,110

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Production plus imports, minus exports, plus adjustments for Government and industry stock changes.

DOMESTIC PRODUCTION

Production of pumice and pumicite by domestic producers increased slightly to 508,000 tons, but decreased 8% in value to $4.6 million compared with 1984 output. Twenty-two mines and/or plants were operated by 21 companies in 8 States, with California, Idaho, New Mexico, and Oregon accounting for 96% of U.S. production.

Principal domestic producers were American Pumice Products Inc., Littlelake, CA; Tionesta Aggregates Co., Tulelake, CA; Amcor Inc., Idaho Falls, ID; Hess Pumice Products, Malad City, ID; Producers Pumice Inc., Boise, ID; Copar Pumice Co. Inc., Santa Fe, NM; General Pumice Co., Santa Fe, NM; Utility Block Co., Albuquerque, NM; Cascade Pumice Co., Bend, OR; and Central Oregon Pumice Co., Bend, OR. Together, these 10 companies accounted for 92% of the tonnage and 68% of the value of total

U.S. production of pumice and pumicite.

Hess Pumice Products announced the relocation of the company's milling operations and construction of a new mill in the Malad City Industrial Park during the year. Construction was expected to be completed in early 1986 and will be financed by industrial revenue bonds. The company's pumice mine is about twenty miles northwest of Malad City, ID.

Table 2.—Pumice and pumicite sold and used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1984		1985	
	Quantity	Value	Quantity	Value
Arizona	2	21	W	2
California	80	1,600	78	1,491
New Mexico	132	1,269	152	1,114
Other[1]	288	2,039	279	1,947
Total[2]	502	4,929	508	4,553

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Hawaii, Idaho, Kansas, Oklahoma, Oregon, and data indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

U.S. apparent consumption decreased 6% to 749,000 tons, owing, in large part, to a 17% decline in pumice imports compared with that of 1984. Principal uses of domestically produced pumice and pumicite increased 12% for abrasives and 20% for landscaping, but declined slightly for both concrete admixture and aggregate and decorative building block. Other uses of pumice increased 110%, primarily owing to increased use in road construction and maintenance during the year.

Table 3.—Pumice and pumicite sold and used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1984		1985	
	Quantity	Value	Quantity	Value
Abrasives (includes cleaning and scouring compounds)	25	810	28	497
Concrete admixture and aggregate	169	876	158	818
Decorative building block	272	2,801	260	2,400
Landscaping	15	129	18	133
Other[1]	21	313	44	705
Total	502	4,929	508	4,553

[1]Includes heat-or-cold insulating medium, pesticide carriers, road construction material, roofing granules, and miscellaneous uses.

PRICES

The average value, f.o.b. mine or mill, for domestic pumice and pumicite sold and used was $8.96 per ton, a 9% decrease from that of 1984, and the second straight year of decline.

Prices quoted in Chemical Marketing Reporter for domestic grades of pumice bagged in 1-ton lots were, at yearend, $270 per ton for fine and $300 per ton for medium, coarse, and 2-extra coarse. Yearend quoted prices on imported (Italian) pumice, f.o.b. east coast, bagged in 1-ton lots, were $280 per ton for fine, $350 per ton for medium, and $300 per ton for coarse.

The average declared customs value of pumice imported from Greece for use in concrete masonry products decreased from $6.82 to $6.47 per ton.

FOREIGN TRADE

Pumice imported for consumption declined 17% to 242,000 tons. Greece was the principal source with a total of 237,600 tons, of which 237,535 tons was used to produce concrete masonry products.

Table 4.—U.S. imports for consumption of pumice, by class and country

Country	Crude or unmanufactured		Wholly or partly manufactured		For use in the manufacture of concrete masonry products		Manufactured, n.s.p.f.
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Value (thousands)
1984:							
Greece	5,167	$75	--	--	275,756	$1,880	--
Iceland	8,228	153	--	--	--	--	--
Italy	3,297	156	172	$36	--	--	$23
Mexico	--	--	--	--	72	2	1
Other[1]	11	18	20	12	3	3	124
Total	16,703	402	192	48	275,831	1,885	148
1985:							
Greece	24	10	41	15	237,535	1,537	30
Iceland	498	92	--	--	--	--	--
India	--	--	--	--	2,176	2	--
Italy	120	42	294	79	1,051	7	44
Mexico	90	32	--	--	--	--	--
Other[2]	49	22	22	9	1	1	144
Total	781	198	357	103	240,763	1,547	218

[1]Includes Austria, Canada, China, Denmark, France, the Federal Republic of Germany, Hong Kong, Japan, Nigeria, Spain, Switzerland, Taiwan, and the United Kingdom.
[2]Includes Austria, Canada, Denmark, Ecuador, France, the Federal Republic of Germany, Japan, Spain, Switzerland, Taiwan, and the United Kingdom.

Source: Bureau of the Census.

WORLD REVIEW

World production of pumice and related volcanic materials declined 4% to an estimated 12.1 million tons. The combined output of Greece and Italy accounted for 65% of the world's total production. Of the remaining 35%, France, Spain, the United States, and Yugoslavia accounted for 63%.

[1]Industry economist, Division of Industrial Minerals.

Table 5.—Pumice and related volcanic materials: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina[3]	56	59	76	60	62
Austria: Trass	9	12	3	11	7
Cameroon: Pozzolan	58	89	NA	NA	NA
Cape Verde Islands: Pozzolan[e]	11	11	11	11	11
Chile: Pozzolan	306	190	192	190	188
Costa Rica[e]	1	2	2	2	2
Dominica: Pumice and volcanic ash[e]	120	120	120	120	120
France: Pozzolan and lapilli	518	790	669	[r] [e]550	610
Germany, Federal Republic of:					
Pumice (marketable)	[r]882	[r]441	441	717	660
Pozzolan[e]	220	220	NA	NA	NA
Greece:					
Pumice	[r]802	707	552	691	695
Pozzolan	[r]1,312	[r]1,297	1,004	1,001	1,005
Guadeloupe: Pozzolan[e]	265	265	265	265	265
Guatemala:					
Pumice[e]	17	13	[4]17	[r]15	15
Volcanic ash	6	[e]4	([5])	([5])	([5])
Iceland	37	[r]21	50	[r] [e]60	65
Italy:[e]					
Pumice and pumiceous lapilli	[4]671	825	770	720	660
Pozzolan	[4]6,073	6,100	5,500	6,100	5,500
Martinique: Pumice[e]	[4]172	170	165	165	165
New Zealand	37	55	19	17	22
Spain[6]	1,034	1,070	1,105	915	990
United States (sold and used by producers)	499	416	449	502	[4]508
Yugoslavia: Volcanic tuff	588	569	556	[r] [e]550	560
Total	[r]13,694	[r]13,446	11,966	12,662	12,110

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 20, 1986.
[2]Pumice and related volcanic materials are also produced in a number of other countries, including (but not limited to) Ethiopia, Iran, Japan, Mexico, Turkey, and the U.S.S.R., but output is not reported quantitatively, and available information is inadequate for the formulation of reliable estimates of output levels.
[3]Unspecified volcanic materials produced mainly for use in construction products.
[4]Reported figure.
[5]Less than 1/2 unit.
[6]Includes Canary Islands.

Rare-Earth Minerals and Metals

By James B. Hedrick[1]

Domestic production of rare earths in 1985 dropped to its lowest level in 9 years as a result of decreased demand in certain market sectors. Producers operated at about one-half of their rated production capacity. Foreign sources of rare earths gained a larger share of the U.S. market, while domestic exports remained essentially unchanged from 1984 levels. Molycorp Inc., a wholly owned subsidiary of Unocal Corp., and Associated Minerals (USA) Ltd. Inc., a subsidiary of the Australian-owned company Renison Goldfields Consolidated Ltd., were the only domestic mine producers of rare-earth minerals. Mine production by Molycorp accounted for the significant decline in domestic rare-earth production in 1985, while Associated Minerals operated at a record-high level. Molycorp, Rhône-Poulenc Inc., W. R. Grace & Co.'s Davison Chemical Div., and NUCOR Corp.'s Research Chemicals Div. were the principal processors of rare earths in the United States. Major end uses were in petroleum cracking catalysts, metallurgical applications, glass and ceramics, and permanent magnets.

Domestic Data Coverage.—Domestic mine production data for rare earths are developed by the Bureau of Mines from a voluntary survey of U.S. operations, the "Rare Earths and Thorium" survey. Both mines to which a survey request was sent responded, representing 100% of total production. Production data are withheld to avoid disclosing company proprietary data.

Table 1.—Salient U.S. rare earth statistics

(Metric tons of rare-earth oxides (REO) unless otherwise specified)

	1981	1982	1983	1984	1985
Production of rare-earth concentrates[1]	17,082	17,501	17,083	25,311	13,428
Exports:[e]					
Ore and concentrate	5,056	2,565	2,684	4,304	4,419
Ferrocerium and pyrophoric alloys	9	22	59	27	23
Imports for consumption:[e]					
Monazite	4,108	3,962	2,215	3,114	3,132
Metals, alloys, oxides, compounds	1,631	1,695	1,857	2,926	1,124
Shipments from Government stockpile	802	364	--	--	--
Stocks, producers and processors, yearend	W	W	W	W	W
Consumption, apparent[e]	20,000	17,100	19,600	21,400	12,100
Prices, yearend, dollars per kilogram:					
Bastnasite concentrate, REO basis	$2.14	$2.31	$2.14	$2.14	$2.14
Monazite concentrate, REO basis	$0.83	$0.75	$0.71	$0.64	$1.09
Mischmetal, metal basis	$12.35	$12.35	$12.35	$12.35	$12.35
Employment, mine and mill[e 2]	275	303	266	321	330
Net import reliance[e 3] as a percent of apparent consumption	14	(4)	12	(4)	(4)

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Comprises only the rare earths derived from bastnasite, as reported in Unocal Corp. (previously Union Oil Co. of California) annual reports.
[2]Employment at a rare-earth mine in California and at minerals sands operations in Florida and Georgia. The latter mines produced monazite concentrate as a byproduct of mining ilmenite, rutile, and zircon, and employees were not assigned to specific commodities.
[3]Imports minus exports plus adjustments for Government and industry stock changes.
[4]Increase in industry stocks exceeded net imports.

DOMESTIC PRODUCTION

According to Unocal's annual report, Molycorp's sales of rare earths declined in 1985, primarily as a result of decreased demand for rare-earth-containing fluid cracking catalysts used in leaded fuel production. New regulations by the Environmental Protection Agency, which sharply reduced the amount of lead that can be added to boost octane levels in gasoline, were cited as the cause of the reduced rare-earth demand. Sales of Molycorp's lower volume, higher value separated rare earths, especially those compounds used in the manufacture of phosphors and permanent magnets, were reportedly strong.

Unocal's Canadian subsidiary, Unocal Canada Ltd., formed a joint venture with two other Canadian companies, Denison Mines Ltd., and a new company, SM Yttrium of Canada, which represents the interests of the Japanese companies Shin-Etsu Chemical Co. and Mitsui & Co., to recover yttrium and rare-earth concentrate as a byproduct of processing uranium leach solutions from Denison's Elliot Lake Mine. Molycorp planned to process the concentrate at its Louviers, CO, facilities to produce high-purity yttrium and rare-earth compounds. Molycorp's decision to obtain its own yttrium concentrate was believed to be the result of increasing costs and the uncertainty of adequate supplies of imported yttrium concentrate, produced mainly as a byproduct of processing tin in Malaysia. Yttrium's strong and growing demand as a phosphor and ceramic material was probably another consideration in the joint venture investment.

General Motors Corp. planned to produce neodymium-iron-boron permanent magnets using a General Motors-developed rapid solidification process at a new plant in Anderson, IN. The company was scheduled to initially produce the magnets for use in starter motors in selected late-1986-model year cars and further expand use and applications to its other vehicles in 1987.[2] General Motors expected to market 80% of its neodymium-iron-boron magnet production outside the company.

M&M Minerals Inc. will reportedly recover monazite and other heavy minerals from three streams in the vicinity of Concord, NC, beginning in 1986. The placer operation was to have a capacity of about 40,000 metric tons per year of ore containing about 18% heavy minerals, including 5% monazite.[3]

Associated Minerals installed a bucket wheel excavator on the floating dredge at its Green Cove Springs, FL, minerals sands operations. The equipment was expected to increase recovery and throughput of heavy minerals, including monazite, by dredging faster in the harder, shallower layers of the Green Cove Springs ore body.[4]

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 12,700 tons of equivalent rare-earth oxides (REO) in various forms in 1985, 49% less than was consumed in 1984. Consumption of bastnasite and monazite decreased 51% and 21%, respectively, from that of 1984. The decreased consumption was attributed principally to lower demand in the rare-earth petroleum catalyst market.

Shipments of rare-earth products from domestic processors of ore, concentrates, and intermediate concentrates amounted to 14,000 tons of equivalent REO, a decrease of 32% from the revised 1984 shipments of 20,500 tons.

Consumption of mixed rare-earth compounds (REO basis) was essentially unchanged from the 1984 level, while consumption of purified compounds (REO basis) increased 6%. Higher consumption of purified compounds was the result of strong demand for samarium, neodymium, dysprosium, and certain other rare earths used in high-strength permanent magnets, for yttrium and europium oxides used in phosphors, and for yttrium oxide used in high-temperature ceramics and refractory applications.

The producers of mischmetal, rare-earth silicide, and other rare-earth alloys consumed 24% less rare earths in 1985 than in 1984, while shipments of these goods fell 38% during the same period. Shipments of high-purity rare-earth metals increased 4% during the year.

The approximate distribution of rare earths by end use, based on information supplied by primary processors and some consumers, was as follows: petroleum catalysts (including chemical processing catalysts), 46%; metallurgical uses (including iron and steel additives, alloys, and mischmetal), 32%; ceramics and glass (including polishing compounds and glass additives), 18%; and miscellaneous uses (including phosphors, electronics, permanent magnets, lighting, and research), 4%.

The glass industry's principal use of rare earths, mainly cerium concentrate or cerium oxide, was as polishing compounds for lenses, mirrors, cut crystal, television and cathode-ray tube faceplates, gem stones, and plate glass. Purified rare-earth compounds were also used as additives to glass used in containers, television and cathode-ray tube faceplates, radiation shielding windows, opthalmic lenses, lasers, incandescent and fluorescent lights, and optical, photochromic, filter, and photographic lenses. The rare-earth additives acted as colorants, color correctors, and decolorizers, as stabilizers against discoloration from ultraviolet light and against browning caused by high-energy radiation, as dopants in laser glass, as modifiers to increase refractive indices and decrease dispersion, and as absorbers of ultraviolet and visible light.

Phosphors containing rare earths were used in color television tubes, radar screens, avionic and data displays, X-ray intensifying screens, low- and high-pressure mercury vapor lights, electronic thermometers, and trichromatic fluorescent lamps.

The ceramics industry used purified rare earths in pigments, heating elements, dielectric and conductive ceramics, thermal and/or flash protective devices, stereoviewing systems, data printers, image storage devices, and as principal constituents and stabilizers in high-temperature refractories such as yttria-stabilized zirconia and in glasses and paints.

Purified rare-earth compounds also had applications in petroleum cracking catalysts, noncracking catalysts, oxygen-sensing electrolytes, computer bubble domain memories, substrates for bubble domain memories, dyes and softeners for textiles, electronic components, nuclear fuel reprocessing, microwave applications, incandescent gas mantles, gas lasers, fiber optics, carbon arc lighting, fertilizers, and synthetic gem stones.

Rare-earth permanent magnets were used in electric motors, alternators, generators, line printers, computer disk-drive actuators, proton linear accelerators, synchronous torque couples, eddy current brakes, microwave focusing, magnetrons, klystrons, medical and dental applications, including nuclear magnetic resonance imaging, traveling wave tubes, metallic separators, aerospace applications including electric actuators for ailerons and rudders, and in speakers, headphones, microphones, and tape drives.

Metallurgical applications of rare earths included alloys and additives in high-strength low-alloy steels, gray and ductile iron, stainless and carbon steels, high-temperature and corrosion-resistant metals, hydrogen storage alloys used in heat exchangers and fuel cells, lighter flints, armaments, permanent magnets, neutron convertor foils, special lead fuses, target materials for sealed-tube neutron generators, and high-voltage transmission cable.

STOCKS

U.S. Government stocks of rare earths in the National Defense Stockpile (NDS), all classified as excess to goal, remained at 457 tons throughout 1985. Rare-earth stocks held in the NDS were contained in sodium sulfate and were inventoried on a contained-REO basis. Authority to dispose of these excess rare earths was suspended effective October 1, 1984, by section 902 of the Department of Defense Authorization Act, 1985. Stocks of yttrium oxide held in non-NDS Government inventories remained at 108 kilograms, all declared excess and authorized for disposal.

Industry stocks of rare earths held by 23 producing, processing, and consuming companies increased 6%. Bastnasite concentrate stocks held by the principal producer and four other processors remained essentially unchanged from the yearend 1984 level. Yearend stocks of monazite concentrates increased 92%, while stocks of other concentrates, including yttrium, increased 10%.

Stocks of mixed rare-earth compounds decreased 9%, while stocks of purified compounds, mostly separated rare-earth oxides, increased 5%. Yearend stocks of mischmetal, rare-earth silicide, and other alloys containing rare earths were down 8%, while inventories of high-purity rare-earth metals were 27% higher.

PRICES

The price of Australian monazite (minimum 55% rare-earth oxide including thoria, f.o.b./f.i.d.),[5] as quoted in Metal Bulletin (London), in Australian dollars (A$), increased substantially from the range A$410 to A$450 per ton at yearend 1984 to A$850 to A$900 per ton by yearend 1985. Changes in the foreign exchange rate in 1985, resulting from the continued economic strength of the U.S. dollar against the Australian dollar, caused the corresponding U.S. price to rise less sharply from the range US$340 to US$365 in 1984[6] to US$580 to US$614 in 1985.[7]

The yearend price quoted in Industrial Minerals (London) for yttrium concentrate (60% Y_2O_3, f.o.b. Malaysia) was $46 per kilogram. Domestic prices quoted for yttrium concentrate during 1985, developed by the Bureau of Mines from various sources, ranged from $51 to $63 per kilogram of contained yttrium oxide.

Prices quoted by Molycorp for unleached, leached, and calcined bastnasite, containing 60%, 70%, and 85% REO, were $0.92, $0.97, and $1.17 per pound of contained REO, respectively, at yearend 1985, unchanged since 1983.

The price of cerium concentrate quoted by American Metal Market was $1.40 per pound of contained cerium oxide at yearend 1985; the yearend 1984 price was $1.32. The price of lanthanum concentrate also increased in 1985 to $1.40 per pound of REO contained, up 8 cents per pound from that of yearend 1984.

The mischmetal (99.8%, lots over 100 pounds, f.o.b. shipping point) price, quoted in American Metal Market, declined from the yearend 1984 price of $5.60 per pound to the range $5.00 to $5.60 per pound at yearend 1985.

Molycorp quoted prices for lanthanide (rare-earth) and yttrium oxides, net 30 days, f.o.b. Louviers, CO, Mountain Pass, CA, or York, PA, effective January 2, 1985, as follows:

Product (oxide)	Percent[1] purity	Quantity (pounds)	Price per pound
Cerium	99.0	200	$8.00
Europium	99.99	25	725.00
Gadolinium	99.99	55	60.00
Lanthanum	99.99	300	7.00
Neodymium	96.0	300	4.00
Do	99.9	50	40.00
Praseodymium	96.0	300	16.80
Samarium	96.0	55	30.00
Terbium	99.9	55	375.00
Yttrium	99.99	50	50.00

[1]Purity expressed as percent of total REO.

Molycorp also quoted prices for lanthanide (rare-earth) compounds, net 30 days, f.o.b. York, PA, or Louviers, CO, effective January 2, 1985, as follows:

Product (compound)	Percent purity	Quantity (pounds)	Price[1] per pound
Cerium carbonate	99.0	150	$4.00
Cerium fluoride	Tech grade	250	2.50
Cerium nitrate	95.0	250	2.15
Lanthanide chloride	46.0	525	.84
Lanthanum carbonate	99.9	300	4.60
Lanthanum chloride	46.0	525	.95
Lanthanum-lanthanide carbonate	60.0	200	2.45
Lanthanum-lanthanide nitrate	39.0	250	1.75
Neodymium carbonate	96.0	300	2.65

[1]Priced on a contained REO basis.

Rhône-Poulenc quoted rare-earth prices, per kilogram, net 30 days, f.o.b. New Brunswick, NJ, or duty paid at point of entry, effective January 1, 1985, as follows:

Product[1] (oxide)	Percent purity	Quantity (kilograms)	Price per kilogram
Cerium	99.5	20	$20.35
Erbium	96.0	50	190.00
Europium	99.99	40	1,725.00
Gadolinium	99.99	50	136.50
Lanthanum	99.99	25	17.25
Praseodymium	96.0	20	38.85
Samarium	96.0	25	70.00
Terbium	99.9	20	875.00
Yttrium	99.99	50	115.50

[1]Dysprosium, holmium, lutetium, thulium, and ytterbium oxide prices on request from Rhône-Poulenc Inc.

Rhône-Poulenc also quoted prices for rare earths produced at its Freeport, TX, plant, net 30 days, f.o.b. Freeport, TX, effective January 1, 1985, as follows:

Product (compound)	Percent[1] purity	Quantity (kilograms)	Price[2] per kilogram
Cerium carbonate	95.0	20	$8.60
Cerium hydroxide	95.0	20	11.25
Cerium nitrate	95.0	200	11.05
Cerium oxide	99.5	20	17.75
Lanthanum carbonate	99.5	20	12.60
Lanthanum-neodymium carbonate	98.0	20	7.20
Lanthanum nitrate	99.5	200	11.90
Lanthanum oxide	99.5	20	13.25
Neodymium carbonate	95.0	20	7.75
Neodymium nitrate	95.0	200	8.40
Neodymium oxide	95.0	20	9.25

[1]Purity expressed as percent of total REO.
[2]Priced on a contained REO basis.

Nominal prices for various rare-earth products were quoted by Research Chemicals, net 30 days, f.o.b. Phoenix, AZ, effective October 1, 1982, and throughout 1983, 1984, and 1985, as follows:

Element	Oxide[1] price per kilogram	Metal[2] price per kilogram
Cerium	$20	$125
Dysprosium	110	300
Erbium	200	650
Europium	1,900	7,500
Gadolinium	140	485
Holmium	650	1,600
Lanthanum	19	125
Lutetium	5,200	14,200
Neodymium	80	260
Praseodymium	130	310
Samarium	130	330
Terbium	1,200	2,800
Thulium	3,400	8,000
Ytterbium	225	875
Yttrium	118	510

[1]Minimum 99.9% purity, 1- to 20-kilogram quantities.
[2]Ingot form, 1 to 5 kilograms, from 99.9%-grade oxides.

FOREIGN TRADE

Exports of rare-earth concentrates, produced primarily from bastnasite, originated mainly from Molycorp's Mountain Pass Mine in California. Exports of rare-earth metal ores, including bastnasite and a variety of mixed and individual rare-earth concentrates, but excluding monazite, decreased slightly from 8.0 million kilograms in 1984 to 7.7 million kilograms in 1985. They were valued at $14.8 million in 1985. Major destinations were Japan, 62%; Austria, 9%; and the United Kingdom, 7%.

Exports of ferrocerium and other pyrophoric alloys containing rare earths totaled 25,840 kilograms, 16% less than those of 1984. Major destinations for these exports were Japan, 59%; Yugoslavia, 19%; and Canada, 14%.

Exports of thorium ore, including monazite, increased significantly for the second consecutive year. France was the destination of all of the reported total of 743,103 kilograms, valued at $415,024, approximately $558.50 per ton.

The import tariff for yttrium-bearing ores, materials, and compounds, which excludes high-purity yttrium oxide, was suspended in 1984 for nations having most-favored-nation status. The revised import classification for yttrium ores and concentrates was TSUS (Tariff Schedule of the United States) No. 907.51, which was scheduled to remain in effect until July 1, 1988.

Table 2.—U.S. import duties on rare earths

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Ore and concentrate[1]	601.12, 601.45	Free	Free	Free.
Cerium chloride, oxide, compounds	418.40, 418.42, 418.44	9.2% ad valorem.	7.2% ad valorem.	35% ad valorem.
Rare-earth oxides except cerium oxide	423.0030	4% ad valorem.	3.7% ad valorem.	25% ad valorem.
Rare-earth metals (including scandium and yttrium).	632.38	do	do	Do.
Alloys wholly or almost wholly of rare-earth metals (mischmetal).	632.78	38 cents per pound.	32 cents per pound.	$2 per pound.
Other alloys wholly or almost wholly of rare-earth metals.	632.79	27 cents per pound plus 3.3% ad valorem.	20 cents per pound plus 2.4% ad valorem.	$2 per pound plus 25% ad valorem.
Ferrocerium and other pyrophoric alloys	755.35	29 cents per pound plus 3.5% ad valorem.	22 cents per pound plus 2.6% ad valorem.	Do.
Yttrium-bearing materials and compounds (includes yttrium concentrates).	907.51	Free	Free	25% ad valorem or 30% ad valorem.[2]

[1]Crude or concentrated by crushing, flotation, washing, or by other physical or mechanical processes that do not involve substantial chemical change.
[2]Tariff is 25% if previous import item classification was 423.00 or 423.96, part 2, schedule 4, or 30% if 603.70, part 1, schedule 6.

Table 3.—U.S. imports for consumption of monazite, by country

Country	1981 Quantity (metric tons)	1981 Value (thousands)	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Australia	7,469	$3,158	6,600	$2,830	3,726	$1,395	5,610	$2,156	5,694	$1,984
Malaysia	--	--	603	240	302	122	--	--	--	--
South Africa, Republic of	--	--	--	--	--	--	51	46	--	--
Total	7,469	3,158	7,203	3,070	4,028	1,517	5,661	2,202	5,694	1,984
REO content[e]	4,108	XX	3,962	XX	2,215	XX	3,114	XX	3,132	XX

[e]Estimated. XX Not applicable.

Source: Bureau of the Census. REO content estimated by the Bureau of Mines.

Table 4.—U.S. imports for consumption of rare earths, by country

Country	1983 Quantity (kilograms)	1983 Value	1984 Quantity (kilograms)	1984 Value	1985 Quantity (kilograms)	1985 Value
Cerium chloride:						
Malaysia	--	--	701,092	$754,588	--	--
Netherlands	227	$5,136	--	--	--	--
Total	227	5,136	701,092	754,588	--	--
Cerium compounds:						
France	3,500	13,505	1,000	4,778	1,770	$8,981
Germany, Federal Republic of	25	9,433	42	10,373	206	34,469
Japan	800	1,038	207	9,226	--	--
South Africa, Republic of	2	791	--	--	--	--
Switzerland	2	670	1	266	--	--
United Kingdom	--	--	5	783	10	2,306
Total	4,329	25,437	1,255	25,426	1,986	45,756

Table 4.—U.S. imports for consumption of rare earths, by country —Continued

Country	1983 Quantity (kilograms)	1983 Value	1984 Quantity (kilograms)	1984 Value	1985 Quantity (kilograms)	1985 Value
Cerium oxide:						
Austria	68	$674	68	$738	--	--
Belgium-Luxembourg	18,120	6,504	--	--	--	--
France	6,239	78,136	3,790	53,891	5,327	$81,670
Germany, Federal Republic of	2	381	12	1,457	94	2,283
Japan	835	7,692	3,357	30,522	--	--
Switzerland	3	335	6	1,207	--	--
United Kingdom	50	536	40	287	27	1,707
Total	25,317	94,258	7,273	88,102	5,448	85,660
Cerium salts: France	1,760	6,580	--	--	--	--
Rare-earth oxide excluding cerium oxide:						
Austria	--	--	50	2,646	--	--
Belgium-Luxembourg	55	25,906	16,803	42,856	110	46,342
Brazil	54,999	575,850	--	--	--	--
Canada	100	128,611	83,815	23,264	--	--
China	19,575	450,033	4,058	263,084	3,830	348,923
France	206,345	9,393,632	271,555	13,880,011	170,556	11,132,432
Germany, Federal Republic of	702	191,953	1,078	284,165	811	266,213
India	--	--	199,998	192,500	--	--
Italy	22,640	10,466	--	--	--	--
Japan	10,983	585,262	14,311	1,034,997	7,814	872,783
Korea, Republic of	--	--	68	5,087	--	--
Malaysia	273,597	251,022	274,592	295,907	6,210	186,534
Mexico	--	--	50,499	2,222	--	--
Netherlands	--	--	54	23,459	513	36,372
Norway	7,128	778,743	6,168	659,184	5,996	655,382
Switzerland	5	4,790	--	--	318	111,800
Taiwan	500	31,184	--	--	--	--
U.S.S.R.	12,657	1,237,136	11,984	747,572	6,506	691,201
United Kingdom	31	6,196	225	28,541	197	38,133
Total	609,317	13,670,784	935,258	17,485,495	202,861	14,386,115
Rare-earth alloys:[1]						
Austria	--	--	52,463	444,685	--	--
Brazil	65,147	457,419	79,993	526,031	162,998	817,875
France	--	--	--	--	1,062	9,946
Germany, Federal Republic of	9,870	143,328	11,276	100,653	17,211	167,343
United Kingdom	237	41,038	5	485	5,057	35,535
Total	75,254	641,785	143,737	1,071,854	186,328	1,030,699
Rare-earth metals including scandium and yttrium:						
Austria	--	--	--	--	100	2,968
China	--	--	1,573	59,526	--	--
France	50	1,805	--	--	--	--
Japan	81	12,679	--	--	1,000	76,099
Malaysia	--	--	40	644	--	--
U.S.S.R.	300	70,500	700	164,735	2,061	183,044
United Kingdom	370	97,258	2,003	394,484	24	22,642
Total	801	182,242	4,316	619,389	3,185	284,753
Other rare-earth metals:						
China	--	--	1,000	1,181	--	--
France	--	--	135	3,979	329	9,870
Germany, Federal Republic of	46	5,524	77	7,514	655	15,275
Japan	422	8,237	--	--	--	--
United Kingdom	5	359	--	--	209	9,225
Total	473	14,120	1,212	12,674	1,193	34,370
Ferrocerium and other pyrophoric alloys:						
Austria	953	13,430	937	12,875	1,000	13,240
Brazil	28,839	396,715	47,388	685,088	45,349	632,014
France	54,321	576,549	72,470	695,395	66,771	641,505
German Democratic Republic	--	--	170	1,589	--	--
Germany, Federal Republic of	--	--	459	5,340	--	--
Japan	13,190	176,108	15,537	204,308	20	1,699
Sweden	6,694	7,816	--	--	--	--
Taiwan	91	410	--	--	--	--
United Kingdom	608	14,288	1,167	45,965	245	13,080
Total	104,696	1,185,316	138,128	1,650,560	113,385	1,301,538

[1]Essentially all mischmetal.

Source: Bureau of the Census.

WORLD REVIEW

Bastnasite, the world's principal source of rare earths, was mined as a primary product in the United States and as a byproduct of iron ore mining in China. Significant quantities of rare earths were also recovered from monazite, primarily a byproduct of minerals sands mined for titanium and zirconium minerals or tin in Australia, Brazil, China, India, and Malaysia. Smaller quantities of rare earths, especially yttrium, were obtained from the yttrium-rich minerals sands byproduct xenotime. Xenotime was mined primarily in Malaysia as a byproduct of processing tin ore, but was also produced in Australia, China, and Thailand.

World rare-earth reserves were estimated by the Bureau of Mines at 45 million tons of contained REO, of which 19% is in market economy countries.[8] China, with 80%, had the largest share of world reserves.

Australia.—Renison Goldfields announced its bid to take over control of Allied Eneabba Ltd. Several offers by Renison Goldfields to gain control of Allied through stock purchases had occurred by yearend. The corporate takeover, if successful, would make Renison Goldfields the world's principal minerals sands producer.[9] Renison Goldfields reported in its annual report that all of its minerals sands mines operated at full capacity in 1985. After 52 years of minerals sands mining on the east coast of Australia, Renison Goldfields closed its operations on North Stradbroke Island, Queensland, after depleting its reserves. Legislation by the Australian Government, resulting from environmental concerns, prevented Renison Goldfields, and other companies from mining on Moreton Island, Queensland. Moreton Island is one of the few remaining east coast areas with minerals sands reserves. Renison Goldfields, at Eneabba, Western Australia, obtained a new transportable high-rate thickener and was to install a new plant circuit design to improve recoveries of minerals sands including monazite.

Allied, in a joint venture with Asahi Chemical Industry Co. Ltd. of Japan, was studying the feasibility of building a rare-earth separation plant at Geraldton, Western Australia, to process monazite. Monazite concentrates produced to date have been exported for further processing and separation, with Australian companies reportedly foregoing the added revenues to be gained through secondary refining.[10] Renison Goldfields' takeover bid was not expected to affect the proposed Allied-Asahi separation plant venture.

Consolidated Rutile Ltd. (CRL) reportedly began minerals sands production at the Gordon Lease property on the southern end of North Stradbroke Island, Queensland. The property was acquired by CRL from Associated Minerals Consolidated Ltd. (AMC), a wholly owned subsidiary of Renison Goldfields, in the first quarter of 1985. CRL also completed an agreement with AMC for the acquisition of all of AMC's holdings on the island.[11]

A new company, TiO_2 Corp. NL, owned by Griffiths Bros. Ltd. (80%) and Spunthill Pty. Ltd. (20%), announced plans to mine minerals sands deposits at Jurien Bay and Cooljarloo in Western Australia. These deposits were previously worked by Western Mining Corp. in the mid-1970's. Cooljarloo's reserves were given as 16 million tons of proven and 42 million tons of probable ore grading 3% to 5% heavy minerals, including monazite. Reserves at Jurien Bay were listed at 25 million tons of proven and 1 million tons of probable ore grading 6% to 7% heavy minerals including monazite. Monazite comprises about 0.2% of the mined sand at Cooljarloo and 0.7% at Jurien Bay. Total reserves were equivalent to 64,000 tons of REO at Cooljarloo and 100,000 tons of REO at Jurien Bay.[12] Production from Cooljarloo was planned for 1988. Monazite production capacities for Cooljarloo and Jurien Bay were estimated at 400 tons (220 tons of REO equivalent) and 1,200 tons (660 tons of REO equivalent) per year, respectively.[13]

A joint venture was formed by Strategic Minerals Corp. (SMC) and Rutile & Zircon Mines (Newcastle) Ltd. (RZM) to explore and develop SMC's heavy minerals sands deposits at Byfield, Queensland. Reportedly, RZM can earn an 80% equity in the project by either the expenditure of $2.05 million or by completing a final feasibility study leading to a decision to mine.[14]

Bangladesh.—Reportedly, Bangladesh will spend $7 million on a 5-year plan to extract heavy minerals, including monazite, from the Cox's Bazaar coastal area. The beach sands, located 100 kilometers southeast of Chittagong, along the coast and on nearby islands, contained resources estimated at 5 million tons of heavy minerals.[15]

Brazil.—Minerals sands production at Cumuruxatiba in Bahia State began in

1985. Monazite, along with ilmenite, rutile, and zircon were reportedly recovered at the mine. Concentrates produced at Cumuruxatiba reportedly were shipped to the São Paulo processing plant operated by the state-controlled Nuclebras de Monazita e Associados Ltda., where rare-earth compounds were produced.[16]

Official statistics for Brazil for 1985 were not available, but data for previous years were reported in Anuário Mineral Brasileiro 1985.[17] Production of various rare-earth compounds, in kilograms, was reported as follows:

Year	Carbonate	Chloride	Oxide
1980	5,750	2,071,456	11,716
1981	5,550	1,910,100	21,605
1982	11,500	1,882,700	54,100
1983	8,250	2,002,347	16,160
1984	4,860	1,815,200	82,850

Production of crude monazite ore from the State of Espírito Santo in 1984 was 530 tons, compared with 915 tons in 1983, and was 3,635 tons from the State of Rio de Janeiro, compared with 5,015 tons in 1983.

Measured reserves of monazite in Brazil were 13,705 tons for 1984. Estimated REO equivalent content based on these reserves was 7,500 tons. Monazite reserves were in the States of Espírito Santo, Paraná, and Rio de Janeiro.[18]

Canada.—Iron Ore Co. of Canada decided not to develop its Strange Lake yttrium-beryllium-zirconium deposit northeast of Schefferville, Quebec. The decision was reportedly based on an assessment of the current commodity market, in which a new rare-earth and yttrium recovery plant was planned in Canada, and companies in the United States were considering mine development and recovery of rare earths and yttrium from tailings.

Highwood Resources Ltd. continued feasibility studies at its specialty metals deposit at Thor Lake, 80 miles southeast of Yellowknife, Northwest Territories. The deposit contains rare earths, yttrium, and beryllium. A 490-meter decline driven into the high-grade beryllium T-zone reportedly intersected a high-grade bastnasite zone up to 6 meters thick. Proven reserves of 431,000 tons of ore grading 0.2% yttrium oxide were reported. Samples recovered from the exploration decline were to be tested, with the results forming the basis for a production decision.[19]

Denison Mines, SM Yttrium Canada (a joint venture of the Japanese companies Shin-Etsu Chemical, and Mitsui & Co.), and Unocal Canada (a subsidiary of the U.S. company, Unocal) formed a joint venture to recover yttrium and other rare earths as a byproduct of uranium processing at Denison's existing uranium operations at Elliot Lake, Ontario. The new separation plant, scheduled to open in late 1986, has a planned capacity of 150 tons per year of yttrium oxide in concentrates. Denison reportedly will sell its one-third share of the output to its partners. Union Oil of Canada's share is slated to go to another Unocal subsidiary, Molycorp, in the United States. Molycorp plans to produce high-purity yttrium oxide from the concentrate at its Louviers, CO, processing plant in the United States. Shin-Etsu is expected to refine its part of the concentrate at its plant in Takefu, Fukui, Japan.[20]

An analysis of the rare-earth content of the uranium leach solution at Elliott Lake was reported as follows.[21]

Rare earth	Percent REO
Cerium	3.7
Dysprosium	11.2
Erbium	5.5
Europium	.2
Gadolinium	8.5
Holmium	2.6
Lanthanum	.8
Lutetium	.4
Neodymium	4.1
Praseodymium	1.0
Samarium	4.5
Terbium	1.2
Thulium	.9
Ytterbium	4.0
Yttrium	51.4
Total	100.0

China.—A third rare-earth separation plant was completed at Baotou, Nei Monggol Autonomous Region, in June 1985. Baotou is the site of China's largest rare-earth processing operation and is supplied by the world's largest rare-earth deposit at Baiyunebo, 140 kilometers to the north. The new plant reportedly increased Baotou's production capacity for several separated rare-earth products, including neodymium oxide, the production capacity for which increased from 0.5 ton to 20 tons per year.[22]

France.—Rhône-Poulenc announced it would invest $26.7 million in its two rare-earth plants, one at La Rochelle, France, and the other at Freeport, TX, in the United States. The funds reportedly will be used to increase the existing separation and production capacities, especially for neodymium oxide and dysprosium oxide for use in high-strength permanent magnets.[23]

Germany, Federal Republic of.—Further studies of heavy minerals sands deposits at Cuxhaven, discovered during a drilling program in 1973-76, were concluded in 1985 by the Federal Ministry for Research and Technology. Reserves were estimated at 10 million tons of heavy minerals including ilmenite, rutile, zircon, and possibly monazite. The fossilized beach sands deposits are reportedly similar to those on the east coast of Australia, and were deposited during the late Tertiary era. Additional reserves are thought to occur in the area, and further exploration was scheduled.[24]

India.—Indian Rare Earths Ltd.'s dredge and wet concentrator plant began operation at the Orissa Sands Complex in Orissa. The dry mill was also commissioned and trial runs were being conducted.[25] Production of limited amounts of monazite concentrate associated with an initial production of 30,000 tons of ilmenite was reported.

Japan.—Imports of rare earths in 1985 were reported in the Japan Metal Journal, as follows:

Product	Quantity (kilograms)
Cerium fluoride	391
Cerium oxide	148,525
Ferrocerium and other pyrophoric alloys	30,550
Lanthanum oxide	188,360
Rare-earth chloride	5,889,427
Rare-earth metals including yttrium and scandium	58,966
Yttrium oxide	522,253

Principal sources of imported compounds were China, France, India, and the United States.

Data on Japanese consumption of rare earths in 1984 became available. Consumption was higher than that of 1983, and was reported as follows:[26] catalysts, 300 tons; cerium oxide, 2,100 tons; europium oxide, 8 tons; lanthanum oxide, 300 tons; mischmetal, 290 tons; rare-earth fluoride, 50 tons; samarium oxide, 250 tons; yttrium oxide, 210 tons; and other REO's, 150 tons.

Aimants Ugimag S.A., a subsidiary of the Pechiney Group of France, and Kawasaki Steel Corp., of Japan, formed a joint venture to manufacture rare-earth-cobalt magnets and other permanent magnets in Japan. The joint venture company, Nihon Ugimag Corp., will reportedly use Aimants Ugimag's permanent magnet technology. The plant was scheduled for completion in the fall of 1987.[27]

Thailand.—Monazite and xenotime were produced as byproducts of processing minerals sands for tin. Production data for 1985 were not available; production of xenotime concentrates through 1984 was as follows:[28]

Year	Quantity (metric tons)
1980	52
1981	45
1982	46
1983	38
1984	28

U.S.S.R.—A pilot plant for the recovery of precious metals and rare earths from seawater coolant was reportedly operating at a thermal powerplant in the eastern Soviet Union. Only small amounts of the metals were recovered, but the high value of the precious metals and some of the rare earths reportedly could make the plant economical.[29]

Venezuela.—Preliminary geological studies reportedly delineated economic concentrations of rare earths and niobium at Cerro Impacto, 120 miles southwest of Ciudad Bolivar, Bolivar State. Intense weathering, resulting from the region's tropical climate, has leached the original carbonatite source rock to produce thick lateritic beds with enrichment of rare earths and other elements. Rare-earth contents ranging from 0.1% to 11% were reported. Further investigation of the Cerro Impacto deposit was planned.

Zaire.—Several tin and gold deposits in the Kivu Region reportedly contain monazite. Reserves of monazite in the Obaye mining sector, under the jurisdiction of the Zairian mining company Société Minière et Industrielle de Kivu, occur in two separate deposits. The Kabengelwa deposit contains 2,100 tons of monazite (600 tons of REO equivalent) in ore grading 2.8 kilograms of heavy minerals sands per cubic meter. The Mashabuto deposit was reported to contain 45 tons of monazite (25 tons of REO equivalent) in ore grading 3 kilograms of heavy minerals sands per cubic meter.[30]

Table 5.—Monazite concentrate: World production, by country[1]

(Metric tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Australia	13,282	9,562	15,141	16,702	15,000
Brazil	[r]2,460	[r]1,814	5,256	3,622	6,000
India[e 3]	[4]3,704	4,000	4,000	4,000	4,000
Malaysia[5]	320	[r]546	1,051	4,451	6,000
Mozambique	4	3	4	[e]4	4
Sri Lanka	60	304	[e]300	147	200
Thailand	107	162	277	298	250
United States	W	W	W	W	W
Zaire	35	32	15	2	--
Total	[r]19,972	[r]16,423	26,044	29,226	31,454

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1]Table includes data available through Apr. 29, 1986.

[2]In addition to the countries listed, China, Indonesia, North Korea, the Republic of Korea, Nigeria, and the U.S.S.R. may produce monazite, but output, if any, is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels.

[3]Data are for years beginning Apr. 1 of that stated.

[4]Reported figure.

[5]The 1981-83 figures are exports and the 1984-85 figures are production.

TECHNOLOGY

Researchers in China developed an improved hot-pressed silicon nitride (HPSN) ceramic with rare-earth additives that reportedly has high bend-strength and high fracture-toughness at elevated temperatures. Using rare-earth oxides as sintering aids, bend strengths of 800 to 900 megapascals were maintained up to 1,300° C. At 1,400° C, the ceramic's bend strength was 680 megapascals, reportedly one of the highest values obtained to date. The rare-earth-containing HPSN ceramic was said to represent a major advancement in ceramic material for use in high-temperature applications, such as internal combustion engines.[31]

Kubota and Japan's Agency of Industrial Science & Technology developed an improved silicon nitride ceramic, which reportedly was stronger at 1,000° C than at room temperature. Rare-earth oxides, including praseodymium and lanthanum, were listed as sintering additives.[32]

Rare-earth metals (REM) in continuously cast steels were reportedly responsible for improved ductility, weldability, fatigue resistance, and resistance to hydrogen damage. REM's, which are strong deoxidizers, were reportedly useful because they can be added to and retained in steel in any desired quantity, providing desulfurization and control of sulfide inclusions. Inclusions resulting from this shape control were beneficial in providing nuclei during solidification to promote fine-grained, as-cast structures. In addition to the refinement of as-cast structures, the rare earths reduced segregation and increased hot ductility at temperatures just below solidification.[33]

A high-temperature materials laboratory for research on advanced alloys and ceramic materials, including those containing rare earths, was under construction at Oak Ridge National Laboratory, Oak Ridge, TN, and was scheduled for completion in 1987. The laboratory's work was expected to be directed toward the development of improved alloys and nonbrittle ceramics that can withstand high temperatures and be suitable for use in gasoline and diesel engines, turbine blades, and other energy applications.[34]

A metal-vapor vacuum-arc ion source, developed by scientists at the University of California's Lawrence Berkeley Laboratory, produces heavy ions from a direct current arc generated between two high-melting-point electrodes, such as lanthanum. In the process, metal is vaporized and ionized at small regions of extremely intense current concentration, called cathode spots, on the negative electrode. A dense quasi-neutral plasma of cathode material is generated that diffuses away from the cathode in a plume from which a magnetically confined beam of ions is derived.[35]

A system for producing long pulses of ions from an arc discharge plasma and accelerating them through a series of grids that prevent backstreaming of electrons into the plasma chamber was developed using samarium-cobalt permanent magnets. The rare-earth-cobalt permanent magnets were used to confine the plasma, which generated up to 8.4 megawatts of power for pulsed lengths of 30 seconds. Developed by researchers at Lawrence Berkeley Laboratory, the device was expected to be installed at three major U.S. fusion research centers to serve as the primary energy source for heating reactor plasmas.[36]

A frequency-doubled 532-nanometer neodymium-yttrium-aluminum garnet (Nd: YAG) laser with a green beam was approved for medical use by the Food and Drug Administration. The new laser system was reportedly well received by the medical community and was being studied for applications in dermatology and plastic surgery, gynecology, neurosurgery, ophthalmology, otolaryngology, urology, and other applications. The green Nd:YAG laser's benefits are its generation of visible light; greater electrical efficiency than an argon laser, which emits near the same wavelength; a replaceable arc lamp that costs less than the corresponding large argon laser tube; the unique ability to display the laser energy being delivered to the patient and being measured at the end of the delivery device; an automatic calibration feature that allows the system to remain stable through an entire day's surgery; and the use of currently available optic fibers and probes. In clinical trials, the Nd:YAG laser system showed ease of control, good cutting, coagulating, and vaporizing properties, and less thermal damage than carbon dioxide or 1064-nanometer Nd:YAG lasers.[37]

Rare earths were used by researchers at Los Alamos National Laboratory in New Mexico to develop a cryogenic magnetic refrigerator. Applying the magneto-caloric effect (MCE), where materials held in a magnetic field cool down when the field is removed, gadolinium and gadolinium alloys were cooled from -423° F down to -452° F, using helium gas as the heat transfer fluid. Using fewer moving parts, magnetic refrigerators reportedly are two to four times more energy efficient than conventional refrigeration equipment. Future applications of MCE refrigeration could be in residential heat pumps, low-cost production of liquefied hydrogen, and energy storage devices.[38]

Rare earths were used to trace pollutants back to oil refineries. Highly-temperature-stable rare-earth-containing zeolites, used as fluid cracking catalysts (fcc) in the refining of oil, resist chemical transformation in the refining process and produce a recognizable pollutant signature in emissions. The distinctive ratio of rare-earth elements used in the fcc's reportedly permits identification of air masses originating from areas that have a high density of oil refineries.[39]

Researchers at Battelle Memorial Institute developed a low-cost method to produce zirconia powders, including those stabilized by yttrium oxide (yttria), by a hydrothermal process that eliminates the need for calcination. Battelle further developed the process to prepare powders with a narrow particle size distribution and particles down to 0.1 micrometer in diameter, with minimal agglomeration. Yttria-stabilized zirconia powder was produced that showed uniform distribution of yttria, which eliminated the need for diffusion, through calcination and sintering, to achieve homogeneity. The stabilized powder may be useful in advanced combustion engines because of its excellent wear resistance, fracture toughness, and mechanical strength.[40]

A composite insulation material containing yttria- or calcia-stabilized zirconia fibers was developed at the Oak Ridge National Laboratory. The composite insulation reportedly extends the operating temperature of metal-melting, oxide-fiber-lined furnaces from 1,700° C to 2,000° C. The yttria or calcia stabilizers allow tiny cracks to form in the zirconia fiber structures to release thermal stress.[41]

A research center was set up in Changsah, Hunan Province, China, to study further the use of rare earths in agriculture.[42] According to researchers in China, the addition of rare earths to the soil improves crop yields and raises the sugar content of certain vegetables. A pioneer in the development of rare earths for use in agriculture, China is expected to remain in the forefront of this technology as a result of its abundant reserves and low-cost production.

General Motors reported increased magnetic strengths in its neodymium-iron-boron (Nd-Fe-B) family of permanent magnets using a new process. The process strengthens the magnet by controlling heat and pressure to the die containing the jet-casted Nd-Fe-B alloy, so that the heat-softened ribbon of alloy can flow in a direction transverse to the pressing direction.[43] The new anisotropic permanent magnet material has magnetic strengths (BHmax) from 20 to 40 megagauss-oersteds.

Solid ionic-conducting trivalent beta aluminas containing rare-earth ions were studied for potential applications in optics, phosphors, and lasers, because they can serve as single-crystal or powder hosts. Solid ionic conductors, in which electrical conductivity is the result of ion movement, not electron movement, provide a greater density of electrical energy than aqueous solutions, with as high ionic diffusion rates. A solid-state laser system using trivalent neodymium beta alumina was developed in 1984, while ionic phosphors incorporating europium and terbium were reportedly under development. Currently, ion conductor technology is applied in oxygen sensors in automobiles where yttria-stabilized zirconia measures the partial pressure of oxygen in exhaust gases.[44]

Two Canadian physicians used erbium to filter ineffective but hazardous low-energy X-rays out of X-ray beams used in medical diagnosis. The erbium was reportedly used in foil filters and other shields to minimize X-ray exposure during fluoroscopy.[45]

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Salt

By Dennis S. Kostick[1]

Increased production and sales of rock salt and solar salt failed to offset the decrease in vacuum pan and open pan salt production and in salt brine production and use. This resulted in an overall decrease in total salt production and sales in 1985 compared with the levels recorded in 1984, which had been the best year for salt sales since 1980.

Apparent consumption of salt declined 3% primarily because of the decrease in salt consumption by certain sectors of the chemical industry that used salt as a feedstock. Salt sales reportedly increased for salt used as an ice control for highway deicing, for general industrial purposes, and in food processing. Although salt exports increased 10%, imports for consumption of salt decreased 18%.

Domestic Data Coverage.—Domestic production data for salt are developed by the Bureau of Mines from two voluntary surveys of U.S. operations. Typical of the surveys is the salt company survey. Of the 68 operations to which a survey request was sent, 60 responded, representing 98% of the total production shown in table 1. Production for the eight nonrespondents was estimated using reported 1984 production levels adjusted by trends in employment and other guidelines. Two producers reported no production.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Production[1]	38,899	37,665	32,973	39,181	37,904
Sold or used by producers[1]	38,907	37,894	34,573	39,225	39,484
Value	$637,568	$671,424	$597,081	$675,099	$741,799
Exports	1,046	1,001	517	820	904
Value	$17,429	$16,647	$12,368	$15,299	$15,988
Imports for consumption	4,319	5,451	5,997	7,545	6,207
Value	$44,523	$56,184	$60,194	$74,100	$65,593
Consumption, apparent[2]	42,180	42,344	40,053	45,950	44,787
World: Production	r188,953	r180,320	175,434	p188,699	e187,693

eEstimated. pPreliminary. rRevised.
1Excludes Puerto Rico.
2Sold or used plus imports minus exports.

DOMESTIC PRODUCTION

The total quantities of all types of salt produced by domestic producers decreased 3%. The amount sold or used remained virtually the same. In 1985, 39 companies operated 68 salt-producing plants in 14 States. Nine of the companies and 11 of the plants produced more than 1 million tons each, accounting for 80% and 63%, respectively, of the U.S. total. Many individual companies and plants produced more than one type of salt. By type of salt, the number of companies and operations, respectively, were solar, 11 and 14; vacuum pans and open pans, 8 and 18; rock, 11 and 15; and brine, 24 and 33.

The seven leading States in quantity of salt sold or used were Louisiana, 31%; Texas, 21%; New York, 18%; Ohio, 12%; Kansas, 5%; Utah and Michigan, about 3% each. A significant quantity of the salt produced in Alabama, Louisiana, New York, Texas, and West Virginia was produced as brine, of which the majority was captively consumed to manufacture chlorine, caustic soda, and soda ash. Although the quantity of salt brine used to manufacture chloralkalis decreased 9%, rock salt sales to the chloralkali industry increased 13%.

The percentage of salt sold or used by domestic producers, by type, was as follows:

	1984	1985
Salt in brine	50	46
Mined rock	r34	37
Vacuum pan salt and grainer or open pan salt	9	10
Solar-evaporated salt	r7	7
Total	100	100

rRevised.

International Salt Co. Inc. sold its Detroit salt mine in March to Crystal Mines Inc. Crystal Mines resumed public tours of the 73-year-old, 1,200-foot-deep mine but planned to convert it to a hazardous waste storage facility by 1987.[2] To encourage tourism and discourage possible hazardous waste pollution, local officials passed an ordinance regulating what could be stored in mines down to 200 feet below the Earth's surface.[3]

In April, Diamond Crystal Salt Co. acquired Hardy Salt Co., which had a vacuum pan operation in Michigan and a vacuum pan and brine facility in North Dakota. Morton Thiokol Inc. announced plans to increase rock salt production capacity by 250,000 tons at its Weeks Island, LA, operation. This expansion would partially offset the rock salt production capacity lost in Louisiana because of mine closures and accidents during the past several years. Cargill Inc. intentionally flooded its Belle Isle, LA, rock salt mine in November to eliminate the potential for roof collapse resulting from unsafe mining conditions, which had been the reason cited for the closure of the mine in 1984.

In September, FMC Corp. permanently closed its Bens Run, WV, chlorine and caustic soda facility, which included a salt brine operation. High energy costs and equipment obsolescence were cited as the reasons for the decision. The plant had been in continuous operation since 1915.[4]

A second chloralkali and salt brine facility was closed at yearend. Pennwalt Corp. in Wyandotte, MI, shut down its 100,000-ton-per-year plant as part of a major financial restructuring effort by the company.[5] The company planned to continue operation of its two other chloralkali plants in Oregon and Washington, which primarily used imported salt from Mexico as feedstock.

Table 2.—Salt production in the United States

(Thousand short tons)

Year	Vacuum pans and open pans	Solar	Rock	Brine	Total
1981	3,800	2,393	11,871	20,835	38,899
1982	3,721	2,845	13,264	17,835	37,665
1983	3,697	2,053	9,449	17,774	32,973
1984	3,629	2,705	13,653	19,195	[1]39,181
1985	3,613	2,734	13,819	17,738	37,904

[1]Data do not add to total shown because of independent rounding.

Table 3.—Salt produced in the United States, by product form and type

(Thousand short tons)

Product form	Vacuum pans and open pans	Solar	Rock	Brine	Total
1984					
Bulk	676	1,953	13,032	19,195	34,856
Compressed pellets	824	53	XX	XX	877
Packaged	1,820	466	548	XX	2,834
Pressed blocks	309	233	73	XX	615
Total[1]	3,629	2,705	13,653	19,195	39,181
1985					
Bulk	666	2,006	13,226	17,738	33,636
Compressed pellets	818	60	XX	XX	878
Packaged	1,829	437	524	XX	2,790
Pressed blocks	299	231	69	XX	599
Total[1]	3,613	2,734	13,819	17,738	37,904

XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Table 4.—Salt sold or used in the United States, by type and product form

(Thousand short tons and thousand dollars)

Product form	Vacuum pans and open pans		Solar		Rock		Brine		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1984										
Bulk	653	28,007	1,823	22,831	12,691	151,964	19,669	99,263	34,836	302,065
Compressed pellets	821	80,789	53	3,547	XX	XX	XX	XX	874	84,336
Packaged:										
Less-than-5-pound units	157	NA	116	NA	W	NA	XX	XX	[2]273	NA
More-than-5-pound units	1,684	NA	353	NA	W	NA	XX	XX	[2]2,037	NA
Total[1]	1,841	198,775	468	19,743	593	31,059	XX	XX	2,903	249,577
Pressed blocks:										
For livestock	191	NA	84	NA	71	NA	XX	XX	346	NA
For water treatment	118	NA	149	NA	--	NA	XX	XX	267	NA
Total	309	23,390	233	10,034	71	5,697	XX	XX	613	39,121
Grand total[1]	3,624	330,961	2,578	56,154	13,355	188,720	19,669	99,263	39,225	675,099
1985										
Bulk	676	27,810	2,050	29,336	13,948	202,406	18,127	118,304	34,801	377,856
Compressed pellets	822	75,717	60	4,183	XX	XX	XX	XX	882	79,900
Packaged:										
Less-than-5-pound units	183	NA	--	NA	56	NA	XX	XX	239	NA
More-than-5-pound units	1,902	NA	382	NA	588	NA	XX	XX	2,872	NA
Total	2,085	196,308	382	17,007	644	32,197	XX	XX	3,111	245,512
Pressed blocks:										
For livestock	272	NA	75	NA	78	NA	XX	XX	425	NA
For water treatment	114	NA	159	NA	1	NA	XX	XX	274	NA
Total	386	22,772	234	10,179	79	5,580	XX	XX	699	38,531
Grand total[1]	3,969	322,607	2,725	60,705	14,669	240,183	18,127	118,304	39,484	741,799

NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.
[2]Excludes rock salt; included in "Packaged: Total."

Table 5.—Salt sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1984		1985	
	Quantity	Value	Quantity	Value
Kansas[1]	1,712	71,558	1,790	71,970
Louisiana	13,101	112,142	12,325	138,955
Michigan	1,491	93,860	991	75,030
New York	5,644	123,755	6,928	142,318
Ohio	W	W	4,783	143,949
Texas	8,184	69,672	8,390	80,434
Utah	1,246	28,651	1,189	28,468
West Virginia	1,004	W	895	W
Other[2]	6,844	175,461	2,193	60,675
Total	[3]39,225	675,099	39,484	741,799
Puerto Rico[e]	30	630	35	735

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Quantity and value of brine included with "Other."
[2]Includes Alabama, California, Kansas (brine only), Nevada, New Mexico, North Dakota, Oklahoma, and data indicated by symbol W.
[3]Data do not add to total shown because of independent rounding.

Table 6.—Evaporated salt sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1984		1985	
	Quantity	Value	Quantity	Value
Kansas	906	62,505	876	61,986
Louisiana	203	18,510	205	18,612
Michigan	960	88,048	834	72,349
New York	661	60,631	1,073	64,510
Utah	1,173	27,752	1,129	27,314
Other[1]	2,306	129,789	2,733	152,601
Total	6,209	[2]387,234	6,850	397,372
Puerto Rico[e]	30	630	35	735

[e]Estimated.
[1]Includes California, New Mexico, North Dakota, Ohio, Oklahoma, and Texas.
[2]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Apparent consumption of all types of salt decreased 3% or about 1.2 million tons. Salt sales for highway deicing, general industrial purposes, and food processing were higher in 1985. The chemical industry, which traditionally has been the largest end-use market, required less salt for feedstock in 1985 than in previous years. Production of chlorine gas, sodium hydroxide, and metallic sodium, as reported by the Bureau of the Census, was as follows, in thousand short tons:

	1984[r]	1985
Chlorine gas (100%)	10,700	10,465
Sodium hydroxide, liquid (100%)	10,914	10,959
Sodium, metallic	95	[e]65

[e]Estimated. [r]Revised.

In October, the Wisconsin State Senate passed a bill that restricted the amount of salt used on streets and highways within the State. The legislation stipulated that no more than 300 pounds of salt would be used per lane mile per application, and the salt was to be applied only when the temperature was 10° F and above. The bill was in response to public concern about expensive damage to roads and bridges from salt corrosion and the effect of salt in public water supplies.[6] These factors were also cited by a Michigan State senator who requested a study on whether alternative compounds could be used for winter road deicing instead of rock salt.[7]

Of the 6.2 million tons of salt imports, approximately 2.6 million tons was directly imported and distributed by the domestic salt producers. The reported percent distri-

Table 7.—Distribution of domestic and imported salt by producers in the United States, by end use and type

(Thousand short tons)

End use	SIC	Vacuum pans and open pans		Solar		Rock		Salt in brine	Total[1]		
		Domestic	Imported	Domestic	Imported	Domestic	Imported		Domestic	Imported	Grand
1984											
Chemical:											
Chloralkali producers	2812	24	W	226	438	1,365	W	18,086	19,702	440	20,142
Other chemical	28 (excludes 2812, 2899)	306	W	114	32	684	W	100	1,204	54	1,258
Total[1]		330	W	340	471	2,050	W	18,186	20,906	494	21,400
Food processing industry:											
Meat packers	201	163	W	34	9	254	W	--	451	13	465
Dairy	202	91	--	4	3	9	(2)	--	104	4	107
Canning	2091, 203	125	W	39	25	78	W	(2)	242	25	267
Baking	205	113	W	3	W	8	W	--	124	1	125
Grain mill products	204 (excludes 2047)	54	--	1	W	25	W	--	80	2	81
Other food processing	206-208, 2047, 2099	131	W	14	8	43	W	--	188	9	197
Total[1]		677	3	95	45	417	5	(2)	1,189	54	1,242
General industrial:											
Textiles and dyeing	22	77	W	W	27	47	W	W	135	56	191
Metal processing	33, 34, 35, 37	32	W	W	11	259	W	W	309	17	326
Rubber	2822, 30 (excludes 3079)	4	--	W	W	5	W	W	41	1	42
Oil	13, 29	86	--	273	W	74	W	427	862	10	870
Pulp and paper	26	12	W	170	29	117	W	7	307	30	337
Tanning and/or leather	311	9	W	12	W	64	W	--	85	4	89
Other industrial		64	W	46	29	57	W	--	167	34	201
Total[1]		285	31	528	111	623	9	469	1,904	151	2,055
Agricultural:											
Feed retailers and/or dealers-mixers		371	W	161	36	392	W	--	924	43	967
Feed manufacturers	2048	92	--	66	W	186	W	--	343	25	368
Direct buying end users	02	18	--	15	W	46	W	--	79	1	80
Total[1]		481	W	242	61	624	W	--	1,347	68	1,415

Water treatment:											
Government (Federal, State, local)	2899	8	--	15	W	407	W	(2)	430	18	448
Commercial or other	2899	81	--	269	W	47	W	4	401	12	413
Total		89	--	284	19	454	11	4	831	30	861
Ice control and/or stabilization:											
Government (Federal, State, local)	9621	6	--	481	390	7,090	2,493	--	7,576	2,882	10,458
Commercial or other		6	--	25	19	116	91	1	148	110	258
Total[1]		11	--	506	409	7,210	2,583	1	7,728	2,993	10,721
Distributors:											
Agricultural distribution	5159	84	W	64	W	102	40	--	251	56	307
Grocery wholesalers and/or retailers	514, 54	619	W	88	68	153	W	--	859	74	933
Institutional wholesalers and end users.	58, 70	35	--	W	6	127	1	W	174	6	180
Water conditioning distribution	7399	264	W	121	W	287	219	W	672	408	1,087
U.S. Government resale	9199	W	--	W	--	532	--	W	534	--	534
Other wholesalers and/or retailers	5251	643	W	86	154	737	W	1	1,466	161	1,627
Total[1]		1,645	6	369	431	1,939	268	9	3,962	705	4,667
Other n.e.s.[3]		93	W	156	31	221	W	1,011	1,480	35	1,515
Grand total[1]		3,609	49	2,522	1,578	13,538	2,902	19,680	39,349	[4]4,529	43,878
1985											
Chemical:											
Chloralkali producers	2812	36	W	237	W	1,539	W	16,530	18,342	627	18,969
Other chemical	28 (excludes 2812, 2899)	322	W	119	W	243	W	52	736	32	768
Total		358	17	356	507	1,782	135	16,582	19,078	659	19,737
Food processing industry:											
Meat packers	201	178	W	34	W	202	W	--	414	13	427
Dairy	202	122	W	3	W	4	(2)	--	129	2	131
Canning	2091, 203	145	W	32	W	83	W	1	261	19	280
Baking	205	127	W	3	W	7	W	--	137	1	138
Grain mill products	204 (excludes 2047)	65	--	1	W	25	W	--	91	1	92
Other food processing	206-208, 2047, 2099	150	W	23	W	41	W	--	214	13	227
Total		787	6	96	28	362	15	1	1,246	49	1,295

See footnotes at end of table.

Table 7.—Distribution of domestic and imported salt by producers in the United States, by end use and type —Continued

(Thousand short tons)

End use	SIC	Vacuum pans and open pans		Solar		Rock		Salt in brine	Total[1]		
		Domestic	Imported	Domestic	Imported	Domestic	Imported		Domestic	Imported	Grand
1985 —Continued											
General industrial:											
Textiles and dyeing	22	70	W	7	W	47	(2)	2	126	47	173
Metal processing	33, 34, 35, 37	29	W	11	W	335	1	W	375	5	380
Rubber	2822, 30 (excludes 3079)	4	--	1	W	5	W	32	42	(2)	42
Oil	13, 29	86	--	372	W	73	W	445	976	3	979
Pulp and paper	26	19	W	176	W	77	W	7	279	15	294
Tanning and/or leather	311	10	W	10	W	71	W	--	91	4	95
Other industrial		74	W	49	W	57	5	W	180	8	188
Total		292	33	626	39	665	11	487	2,069	83	2,151
Agricultural:											
Feed retailers and/or dealers-mixers		433	W	127	W	339	W	1	900	22	922
Feed manufacturers	2048	95	W	71	W	226	W	--	392	2	394
Direct buying end users	02	19	--	15	W	19	W	--	53	(2)	53
Total		547	7	213	9	584	7	1	1,345	24	1,369
Water treatment:											
Government (Federal, State, local)	2899	9	W	23	W	215	W	2	249	8	257
Commercial or other	2899	83	--	271	W	53	W	17	424	2	426
Total		92	W	294	7	268	W	19	673	10	683
Ice control and/or stabilization:											
Government (Federal, State, local)	9621	6	W	517	W	8,951	1,383	1	9,475	1,402	10,877
Commercial or other		12	W	11	W	329	66	--	352	69	421
Total		18	W	528	22	9,280	1,449	1	9,827	1,471	11,298

Distributors:											
Agricultural distribution	5159	134	W	59	W	123	W	--	316	59	375
Grocery wholesalers and/or retailers	514, 54	621	W	77	W	151	W	--	849	29	878
Institutional wholesalers and end users.	58, 70	30	W	10	W	135	25	--	175	30	205
Water conditioning distribution	7399	264	W	75	W	253	W	(2)	593	45	638
U.S. Government resale	9199	8	--	1	(2)	5	--	--	14	(2)	14
Other wholesalers and/or retailers	5251	665	W	43	W	678	11	--	1,386	80	1,466
Total		1,722	W	265	W	1,345	52	(2)	3,332	243	3,575
Other n.e.s.[3]		153	W	341	W	383	10	1,037	1,914	29	1,943
Grand total[1]		3,969	86	2,725	799	14,669	1,681	18,127	39,484	[4]2,568	42,052

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Data may not add to totals shown because of independent rounding. Data may differ from totals shown in tables 1, 4, 5, 6, and 8 because of changes in inventory and/or incomplete data reporting.
[2]Less than 1/2 unit.
[3]Includes exports.
[4]Imported for distribution by U.S. producers; included in tables 12, 13, and 14.

Table 8.—Distribution of domestic and imported evaporated and rock salt[1] in the United States, by destination

(Thousand short tons)

Destination	1984 Evaporated: Vacuum pans and open pans	1984 Evaporated: Solar	1984 Rock	1985 Evaporated: Vacuum pans and open pans	1985 Evaporated: Solar	1985 Rock
Alabama	49	W	705	47	(1)	511
Alaska	(1)	22	--	(1)	6	--
Arizona	5	46	8	6	15	6
Arkansas	29	(1)	81	29	(1)	97
California	136	795	7	145	1,026	1
Colorado	18	124	70	19	122	44
Connecticut	11	23	204	15	W	212
Delaware	3	177	8	3	152	9
District of Columbia	1	4	1	1	--	W
Florida	77	55	37	82	W	34
Georgia	64	22	85	59	W	85
Hawaii	2	(1)	W	W	W	(1)
Idaho	5	75	5	6	75	W
Illinois	351	51	1,595	425	45	1,200
Indiana	152	22	856	173	19	872
Iowa	167	43	341	177	25	291
Kansas	95	11	260	98	11	331
Kentucky	35	(1)	428	42	(1)	489
Louisiana	56	W	365	71	3	67
Maine	7	12	219	7	W	175
Maryland	43	229	142	52	W	70
Massachusetts	35	74	442	33	W	536
Michigan	221	26	1,371	257	16	1,225
Minnesota	148	95	439	165	58	346
Mississippi	23	W	125	23	--	123
Missouri	103	17	434	118	17	463
Montana	4	39	5	8	27	W
Nebraska	89	27	115	81	28	144
Nevada	1	167	8	W	166	W
New Hampshire	2	6	86	W	(1)	W
New Jersey	124	131	291	130	31	212
New Mexico	8	124	2	8	127	2
New York	242	63	2,304	245	W	2,376
North Carolina	123	78	86	144	--	46
North Dakota	45	37	3	82	34	2
Ohio	309	11	1,760	321	15	2,368
Oklahoma	55	9	72	47	10	89
Oregon	r11	33	W	11	91	--
Pennsylvania	162	100	r1,191	170	30	1,175
Rhode Island	5	43	39	5	1	77
South Carolina	34	r17	14	38	W	13
South Dakota	42	34	42	42	31	38
Tennessee	63	(1)	547	64	(1)	778
Texas	154	r77	265	162	89	204
Utah	4	368	39	W	367	W
Vermont	5	1	204	5	W	164
Virginia	62	103	105	66	W	79
Washington	18	517	W	W	636	--
West Virginia	16	r5	138	15	(1)	214
Wisconsin	215	35	917	299	30	320
Wyoming	(1)	33	(1)	(1)	30	(1)
Other[2]	r32	r124	r335	56	376	199
Total[3]	r3,661	r4,105	r16,796	4,052	3,709	[4]15,685

[r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]Less than 1/2 unit.

[2]Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and shipments to States indicated by symbol W.

[3]Data may differ from totals shown in tables 1, 4, 5, 6, and 7 because of imports, changes in inventory, and/or incomplete data reporting.

[4]Data do not add to total shown because of independent rounding.

bution of salt by major end use in 1985 was chemicals, 47%; ice control, 27%; distributors, 8%; industrial, 5%; food and agricultural, 3% each; water treatment, 2%; and other, 5%. In table 7, specific sectors of distribution, such as agricultural and water conditioning, can be combined with the primary agricultural and water treatment categories for a complete end-use analysis.

The use of salt in ion exchange water softening units was investigated as part of a study linking water softness with cardiovascular disease. Researchers at the Health Effects and Epidemiology Section of the Oak Ridge National Laboratory concluded that people who drank naturally soft water containing low concentrations of calcium and magnesium—two elements that largely gauge water hardness—had a greater risk of contracting heart disease. However, artificially softened water using salt apparently does not contribute to the risk.[8]

STOCKS AND PURCHASES

Total yearend stocks reported by producers decreased from 2.7 million tons in 1984 to 2.5 million tons in 1985. Most of these stocks were rock salt and solar salt. An unknown quantity of salt for road and highway deicing was usually stored in anticipation of adverse winter conditions by many States, municipalities, distributors, and road deicing contractors.

Intraindustry salt purchases of salt amounted to 3.1 million tons, of which 39% was rock salt; brine, 34%; solar, 23%; and vacuum pans and open pans, 4%.

PRICES

Price quotations are not synonymous with average values reported to the Bureau of Mines. The quotations do not necessarily represent prices at which transactions actually occurred, nor do they represent bid and asked prices. They are quoted here to serve only as a reference to yearend price levels. The following yearend salt prices were quoted in Chemical Marketing Reporter:[9]

Salt, evaporated, common, 80-pound bags, carlots or truckloads, North, works, 80 pounds	$4.02
Salt, chemical-grade, same basis, 80 pounds	4.30
Salt, rock, medium coarse, same basis, 80 pounds	2.70
Bulk, same basis, per ton	25.00

Table 9 represents the average values of different types and product forms of salt, f.o.b. works, based on actual sales by producers.

Table 9.—Average values[1] of salt, by product form and type

(Dollars per short ton)

Product form	Vacuum pans and open pans	Solar	Rock	Brine
1984				
Bulk	42.89	12.52	11.97	5.05
Compressed pellets	98.40	66.92	XX	XX
Packaged	107.97	42.10	52.38	XX
Average[2]	92.78	19.67	13.78	5.05
Pressed blocks	75.70	43.06	80.24	XX
1985				
Bulk	41.14	14.31	14.51	6.53
Compressed pellets	92.11	69.72	XX	XX
Packaged	94.15	44.52	50.00	XX
Average[2]	83.68	20.28	16.08	6.53
Pressed blocks	59.00	43.50	70.63	XX

XX Not applicable.

[1]Net selling value, f.o.b. plant, excluding container costs.

[2]Salt value data previously reported were an aggregate value per ton of bulk, compressed pellets, and packaged salt. For time series continuity, an average of these three types of product forms is presented, which is based on the aggregated values and quantities of the product form for each type of salt shown in table 4.

FOREIGN TRADE

The United States imported nearly seven times the amount of salt it exported. Exports of salt to Canada represented about 98% of the total U.S. export market; the balance was distributed to 47 other countries.

Approximately 99% of total salt imports was bulk rock salt and solar salt. The Bahamas, Canada, and Mexico supplied 78% of the total imports. Imports of salt in bags, sacks, barrels, and brine, primarily from Canada, the Republic of Korea, and Mexico, represented the remainder.

In response to a petition filed by International Salt, the International Trade Administration of the U.S. Department of Commerce preliminarily determined that Canadian rock salt was being sold in the United States at less than fair value, thereby materially injuring domestic rock salt producers. Domtar Inc. and Morton Thiokol, the parent company of Canadian Salt Co., accounted for as much as 70% of the U.S. imports from Canada. The case was submitted to the U.S. International Trade Commission for a final determination by the end of January 1986.[10]

Table 10.—Salt shipped to the Commonwealth of Puerto Rico and the Virgin Islands

Area	1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Puerto Rico	18,000	$2,300	22,990	$5,196
Virgin Islands	1	1	--	--

Source: Annual FT800 U.S. Trade with Puerto Rico and U.S. Possessions, Bureau of the Census.

Table 11.—U.S. exports of salt, by country

(Thousand short tons and thousand dollars)

Country	1984		1985	
	Quantity	Value	Quantity	Value
Australia	(1)	25	(1)	3
Bahamas	2	235	1	86
Canada	792	11,534	883	12,313
Costa Rica	(1)	27	(1)	4
Denmark	3	46	1	35
Honduras	(1)	21	(1)	21
Hong Kong	(1)	3	--	--
Iraq	--	--	1	190
Malaysia	(1)	1	--	--
Mexico	7	382	5	302
Netherlands Antilles	1	98	(1)	105
Saudi Arabia	10	1,970	9	1,930
South Africa, Republic of	(1)	1	(1)	16
Trinidad and Tobago	(1)	66	(1)	17
United Arab Emirates	(1)	49	(1)	54
United Kingdom	1	152	1	216
Venezuela	(1)	10	(1)	2
Other	4	679	3	694
Total	820	15,299	904	15,988

[1]Less than 1/2 unit.

Source: Bureau of the Census as adjusted by the Bureau of Mines.

Table 12.—U.S. imports for consumption of salt

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable)	
	Quantity	Value	Quantity	Value
1982	47	1,613	[1]5,404	[1]54,571
1983	30	1,826	[2]5,967	[2]58,368
1984	71	2,386	[3]7,474	[3]71,714
1985	66	3,794	[4]6,141	[4]61,799

[1]Includes salt brine from Canada through Portland, ME, and St. Albans, VT, customs districts, 26 short tons ($377) and 55 short tons ($2,698), respectively; from Chile through Wilmington, NC, customs district, 100 pounds ($350); and from the United Kingdom through Washington, DC, customs district, 200 pounds ($2,152).

[2]Includes salt brine from Canada through Buffalo, NY, customs district, 400 pounds ($610); from Mexico through Laredo, TX, customs district, 18 short tons ($1,126); from Denmark through Cleveland, OH, customs district, 100 pounds ($269); from the United Kingdom through Baltimore, MD, customs district, 100 pounds ($1,209); from Ireland through New York, NY, customs district, 15 short tons ($300); and from Japan through Seattle, WA, customs district, 1,300 pounds ($392).

[3]Includes salt brine from Iceland, the United Kingdom, and Hong Kong through New York, NY, customs district, 500 pounds ($940); from Norway and the Federal Republic of Germany through Chicago, IL, customs district, 110 short tons ($3,299); from Denmark through Detroit, MI, customs district, 23 short tons ($191); and from Japan through Charleston, SC, customs district, 110 pounds ($527).

[4]Includes salt brine from Spain through New York, NY, customs district, 1,987 short tons ($27,620); from Denmark through Cleveland, OH, customs district, 935 short tons ($76,714); from Japan through Charleston, SC, customs district, 691 short tons ($4,620); from Switzerland through Chicago, IL, customs district, 28 short tons ($2,533); and from the Federal Republic of Germany through Washington, DC, customs district, an undisclosed quantity valued at $5,444.

Source: Bureau of the Census as adjusted by the Bureau of Mines.

Table 13.—U.S. imports for consumption of salt, by country

(Thousand short tons and thousand dollars)

Country	1984		1985	
	Quantity	Value	Quantity	Value
Bahamas	902	9,163	952	10,301
Brazil	304	2,567	70	642
Canada[1]	3,279	27,511	2,670	21,916
Chile	479	4,089	280	2,828
France[2]	114	896	199	1,967
Germany, Federal Republic of[3]	1	70	2	135
Italy[4]	--	--	55	430
Mexico[5]	1,519	22,794	1,230	18,657
Netherlands	236	2,535	90	2,149
Netherlands Antilles	275	2,527	191	2,440
Spain[6]	418	1,503	402	3,188
Other	16	444	67	941
Total[7]	7,545	74,100	6,207	65,593

[1]Includes salt in bags, sacks, and barrels through 10 customs districts, 27,780 short tons ($1,716,050) in 1984; and 11 customs districts, 40,691 short tons ($2,769,497) in 1985.

[2]Includes salt in bags, sacks, and barrels through four customs districts, 567 short tons ($13,263) in 1984; and four customs districts, 128 short tons ($38,356) in 1985.

[3]Includes salt in bags, sacks, and barrels through five customs districts, 562 short tons ($67,446) in 1984; and four customs districts, 2,084 short tons ($120,114) in 1985.

[4]Includes salt in bags, sacks, and barrels through two customs districts, 1 short ton ($5,160) in 1985.

[5]Includes salt in bags, sacks, and barrels through three customs districts, 29,218 tons ($306,502) in 1984; and three customs districts, 14,762 short tons ($148,417) in 1985.

[6]Includes salt in bags, sacks, and barrels through one customs district, 3 short tons, ($3,933) in 1984; and one customs district, 22 short tons ($145,725) in 1985.

[7]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census as adjusted by the Bureau of Mines.

Table 14.—U.S. imports for consumption of salt, by customs district

(Thousand short tons and thousand dollars)

Customs district	1984 Quantity	1984 Value	1985 Quantity	1985 Value
Anchorage, AK	([1])	36	17	272
Baltimore, MD	573	2,587	413	3,686
Boston, MA	167	1,167	73	1,325
Buffalo, NY	66	552	1	67
Chicago, IL	787	5,938	590	4,070
Cleveland, OH	25	298	92	721
Detroit, MI	921	9,219	991	9,766
Duluth, MN	155	1,433	114	887
Los Angeles, CA	121	2,173	127	1,082
Milwaukee, WI	616	4,386	706	3,343
New Orleans, LA	237	1,865	148	1,593
New York, NY	645	6,760	404	6,234
Norfolk, VA	46	501	114	951
Ogdensburg, NY	24	542	5	92
Philadelphia, PA	182	2,567	216	2,505
Portland, ME	571	5,378	461	3,787
Portland, OR	589	7,648	505	7,049
Providence, RI	94	959	13	629
St. Albans, VT	75	841	6	142
San Juan, PR	7	189	10	269
Savannah, GA	467	4,559	400	3,398
Seattle, WA	658	6,165	503	9,580
Tampa, FL	86	902	89	760
Wilmington, NC	165	2,779	207	3,207
Other	268	4,656	2	176
Total	7,545	74,100	6,207	[2]65,593

[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census as adjusted by the Bureau of Mines.

WORLD REVIEW

Canada.—Seleine Mines Inc., wholly owned by Société Québécoise d'Exploration Minière (SOQUEM), which is the Quebec government's mining company, sought a partner to assume a 40% interest or to buy its rock salt mine on the St. Magdalen Islands in the Gulf of the St. Lawrence River. Production problems that affected profitability were cited as the reason SOQUEM needed a partner with the capital necessary to finance mine improvements. Unless a partner or buyer was found, the Government could decide to close the mine that produced 1 million tons of rock salt per year and employed 180 people.[11]

Nigeria.—The Nigerian Mining Corp. and the National Chemical Co. announced plans to coproduce food-grade and industrial salt. The salt would be used for domestic consumption and for export.[12]

[1]Physical scientist, Division of Industrial Minerals.
[2]Edwards, R. Salt Mine Tours Slated: Owner Eyes Dump Setup. The Detroit News, v. 2, No. 10, June 15, 1985, p. 2c.
[3]Michigan Press (Williamston). New Ordinance Governs Use of Underground Mines. Mar. 27, 1985, p. A3.
[4]Virgin, B. Future of FMC's S.C. Plant in Doubt. Daily Mail (Charleston, WV), July 9, 1985, p. A4.
[5]Chemical Week. Pennwalt Closes a Chlorine/Caustic Unit. V. 135, No. 15, 1985, pp. 14-16.
[6]News-Tribune and Herald (Duluth, MN). Wisconsin Senate Passes Bill Restricting Use of Road Salt. V. 110, No. 21, Oct. 18, 1985, p. 10.
[7]The Mining Journal (Marquette, MI). Salt Study Urged. V. 16, No. 25, Dec. 12, 1985, p. 1A.
[8]Science News. Soft Water and Heart Disease. V. 127, No. 25, 1985, p. 189.
[9]Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 228, No. 27, Dec. 30, 1985, p. 43.
[10]———. Rock Salt Dumping Found Against Canada. V. 228, No. 4, July 22, 1985, p. 7.
[11]Toomey, C. Six Salt Producers Eye Soquem Mine. The Gazette (Toronto, Canada), v. 15, No. 10, Nov. 2, 1985, p. H3.
[12]Industrial Minerals (London). Company News and Mineral Notes. No. 218, 1985, p. 81.

Table 15.—Salt: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Afghanistan[e]	7	11	11	11	11
Albania[e]	75	75	80	80	80
Algeria	141	154	[e]165	193	200
Angola[e]	55	65	60	55	11
Argentina:					
Rock salt	1	1	1	1	1
Other salt	1,033	655	746	1,033	880
Australia (marine salt and brine salt)	7,403	5,303	5,699	[e]5,500	5,500
Austria:					
Rock salt	1	1	1	1	1
Evaporated salt	509	478	396	462	460
Salt in brine	291	236	155	263	250
Bahamas	1,069	899	950	[e]960	940
Bangladesh[3]	304	634	268	741	660
Benin	([4])	([4])	([4])	([4])	([4])
Brazil:					
Rock salt	925	922	[5]1,023	1,046	1,050
Marine salt	3,049	3,183	[5]3,592	3,944	4,080
Bulgaria	93	97	95	98	[6]99
Burma[7]	298	297	317	309	310
Cambodia (Kampuchea)	27	42	[e]45	[e]45	45
Canada	7,981	8,752	9,482	11,282	11,070
Chile	320	743	788	690	[6]831
China	20,194	18,060	[e]17,780	[r e]17,950	15,900
Colombia:					
Rock salt	349	331	293	[e]300	280
Marine salt	440	223	321	517	440
Costa Rica (marine salt)[e]	43	[6]121	120	120	120
Cuba	177	218	198	203	200
Cyprus	10	11	--	--	--
Czechoslovakia	343	360	265	268	270
Denmark[5]	439	440	498	576	[6]633
Dominican Republic[e]	70	70	70	70	70
Egypt	748	913	1,012	[e]1,100	1,100
El Salvador[e]	2	2	2	2	3
Ethiopia:[e 3]					
Rock salt[e]	17	17	17	17	17
Marine salt	[6]121	121	121	[r]130	130
France:					
Rock salt	328	421	311	249	250
Brine salt	1,204	1,181	1,184	[e]1,200	1,200
Marine salt	1,517	1,696	1,494	1,522	1,540
Salt in solution	4,266	4,091	4,673	[e]4,740	4,850
German Democratic Republic:					
Rock salt[e]	[6]3,369	[6]3,370	3,380	[r]3,390	3,300
Marine salt	62	61	62	64	60
Germany, Federal Republic of: Marketable:					
Rock salt	9,223	7,754	6,906	[e]7,700	7,200
Marine salt and other salt	4,601	4,348	4,560	[e]4,600	4,400
Ghana[e]	55	55	55	55	55
Greece	145	128	176	[r e]150	180
Guatemala	15	[e]15	17	[r e]18	18
Honduras[e]	35	35	35	35	35
Iceland	([4])	([4])	1	1	[6]1
India:					
Rock salt	[e]4	5	5	[e]6	6
Marine salt	9,841	7,758	7,725	8,514	8,300
Indonesia	[r]295	[r]1,387	681	408	660
Iran[e 8]	660	770	830	830	830
Iraq[e]	[6]88	90	90	90	80
Israel	146	163	[e]160	[e]160	170
Italy:					
Rock salt and brine salt	3,979	3,974	3,807	3,588	[6]3,500
Marine salt[e]	1,060	1,100	1,200	1,100	1,100
Japan[9]	1,105	1,065	1,015	[e]1,300	1,300
Jordan[e]	33	55	90	90	90
Kenya:					
Rock[e]	30	50	70	[6]80	83
Other	[e]23	27	[e]26	31	33
Korea, North[e]	630	630	630	630	630
Korea, Republic of	664	952	530	709	720
Kuwait	21	21	[e]22	23	[6]23
Laos[e]	22	[6]10	11	11	11
Lebanon[e]	17	11	6	6	6
Leeward and Windward Islands[e]	55	55	55	55	55
Libya[e]	11	11	13	13	11
Madagascar[e]	33	33	33	33	33
Mali[e]	5	5	5	5	5
Malta	([4])	([4])	([4])	([4])	([4])
Mauritania[e]	--	[6]8	6	6	6

See footnotes at end of table.

Table 15.—Salt: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Mauritius	7	7	[e]7	[e]7	7
Mexico	8,767	6,130	6,287	6,787	6,600
Mongolia[e]	17	17	18	18	18
Morocco	[r]61	[r]62	77	69	70
Mozambique[e]	30	30	30	30	30
Namibia (marine salt)	213	203	151	97	[6]168
Netherlands	3,944	3,517	3,444	4,050	4,900
Netherlands Antilles[e]	[r]240	[r]300	220	[r]390	390
New Zealand	61	77	89	63	70
Nicaragua[e]	20	20	20	17	17
Niger[e]	3	[6]3	3	3	3
Pakistan:[3]					
Rock salt	[r]564	[r]594	629	659	630
Other salt	[r]202	[r]246	[r] [e]210	[r] [e]200	[6]344
Panama (crude)	35	27	94	[e]100	100
Peru	558	535	[e]540	[e]550	550
Philippines	392	402	421	442	440
Poland:					
Rock salt	1,447	1,475	1,247	1,306	[6]1,321
Other salt	3,261	2,776	[e]2,750	3,887	[6]4,030
Portugal:					
Rock salt	450	448	467	502	510
Marine salt[e]	130	110	120	[r]120	130
Romania	5,548	5,243	5,066	[e]5,000	5,000
Senegal	[e]155	176	190	182	180
Sierra Leone[e]	220	220	220	220	220
Somalia[e]	33	33	33	33	33
South Africa, Republic of	595	646	820	679	[6]797
Spain:					
Rock salt	2,536	2,439	2,214	2,377	2,300
Marine salt and other evaporated salt	1,536	1,187	1,267	1,359	1,300
Sri Lanka	115	194	142	118	120
Sudan	71	31	[e]80	[e]80	80
Switzerland	475	399	349	410	420
Syria	[e]100	112	96	96	100
Taiwan	387	289	87	241	190
Tanzania	[e]41	[e]41	31	24	20
Thailand:					
Rock salt	12	12	6	11	11
Other salt[e]	180	180	180	180	180
Togo[e]	1	([4])	--	--	--
Tunisia	515	464	413	364	[6]446
Turkey	1,539	1,448	[e]1,540	1,432	1,400
Uganda[e]	6	6	6	6	6
U.S.S.R	16,755	17,416	17,857	18,200	18,700
United Kingdom:					
Rock salt	1,488	2,435	1,451	1,730	1,800
Brine salt[10]	1,603	1,713	1,537	1,569	1,700
Other salt[10]	4,317	4,270	3,969	4,557	4,500
United States including Puerto Rico (sold or used by producers):					
Rock salt	11,871	13,503	9,941	13,355	[6]14,669
Other salt:					
United States	27,036	24,391	24,632	25,871	[6]24,815
Puerto Rico[e]	8	16	32	30	35
Venezuela	[e]275	375	342	[r] [e]360	390
Vietnam[e]	445	720	980	880	880
Yemen (Aden)[e]	80	80	80	80	80
Yemen (Sanaa)[e]	[r]70	60	155	160	160
Yugoslavia:					
Rock salt	212	219	212		
Marine salt	40	42	32	419	[6]450
Salt from brine	209	211	215		
Total	[r]188,953	[r]180,320	175,434	188,699	187,693

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Table includes data available through June 24, 1986.

[2]Salt is produced in many other countries, but quantities are relatively insignificant and reliable production data are not available.

[3]Year ending June 30 of that stated.

[4]Less than 1/2 unit.

[5]Data represent sales.

[6]Reported figure.

[7]Brine salt production as reported by the Burmese Government was as follows, in short tons: 1981—92,368; 1982—81,462; 1983—221,502; 1984—89,470; and 1985—49,061.

[8]Year beginning Mar. 21 of that stated.

[9]Fiscal year ending Mar. 31 of that stated.

[10]Data captioned "Brine salt" for the United Kingdom are the quantities of salt obtained from the evaporation of brines; that captioned "Other salt" are the salt content of brines used for purposes other than production of salt by evaporation.

Sand and Gravel

By Valentin V. Tepordei[1]

A total of 800 million short tons of construction sand and gravel valued at $2.4 billion, f.o.b. plant, was estimated to have been produced in the United States in 1985. This tonnage is the highest production reported since 1979, and 17% below the record high production of 1978, but 3% higher than that of 1984, when the last full annual survey was conducted.

Production of industrial sand and gravel in 1985 was unchanged from that of 1984 and totaled 29.4 million tons valued at $374 million, f.o.b. plant, a 12% decrease from the record high production of 1979.

Exports of construction sand and gravel in 1985 decreased 18% to 1.5 million tons valued at $8.9 million, while imports increased 63% to 246,000 tons valued at $1.6 million. Domestic apparent consumption of construction sand and gravel in 1985 was 799 million tons.

Exports of industrial sand decreased 27% in 1985 to 866,000 tons valued at $22.6 million, while imports for consumption increased 212% to 81,000 tons valued at $1.5 million. Domestic apparent consumption of industrial sand and gravel was 28.6 million tons.

Table 1.—Salient U.S. sand and gravel statistics[1]

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
Sold or used:					
Construction sand and gravel:					
Quantity	[e]690,000	594,000	[e]655,100	773,900	[e]800,100
Value	[e]$1,928,000	$1,674,000	[e]$1,935,000	$2,244,000	[e]$2,438,000
Industrial:					
Sand:					
Quantity	29,250	26,350	26,080	28,680	29,070
Value	$326,300	$316,900	$329,500	$370,370	$370,730
Gravel:					
Quantity	728	1,024	537	705	357
Value	$5,997	$6,846	$5,667	$6,844	$3,340
Total industrial:[2]					
Quantity	29,980	27,400	26,620	29,380	29,430
Value	$332,300	$323,800	$335,200	$377,200	$374,070
Exports:					
Quantity	2,397	1,946	2,350	3,038	2,379
Value	$36,736	$34,397	$32,487	$37,981	$31,515
Imports for consumption:					
Quantity	337	275	181	177	327
Value	$2,608	$4,002	$2,666	$2,529	$3,085

[e]Estimated.
[1]Puerto Rico excluded from all sand and gravel statistics.
[2]Data may not add to totals shown because of independent rounding.

Domestic Data Coverage.—Domestic production data for construction and industrial sand and gravel are developed by the Bureau of Mines from voluntary surveys of U.S. producers. Beginning with 1981, full surveys of construction sand and gravel producers are conducted for even-numbered years only. For odd-numbered years, preliminary surveys are conducted that collect production information on a sample basis that is used to generate only annual preliminary estimates at the State level. Industrial sand and gravel producers are surveyed every year. Of the 181 industrial sand and gravel operations surveyed, 139, or 76%, reported to the Bureau of Mines. Of these, 136 operations were active and their total production was 24.5 million tons, or 83% of the U.S. total industrial sand and gravel produced. The nonrespondents' production was estimated using production reports, adjusted prior years' production, and/or employment data. Of the 139 reporting operations, 18 did not indicate a breakdown by end uses. Their total production, as well as that of the 32 estimated operations representing 17% of the U.S. total, was included in "other unspecified uses." In 1985, 13 industrial sand and gravel operations were idle.

Legislation and Government Programs.—On March 5, the U.S. Congress approved an 18-month Interstate Cost Estimate (ICE) legislation that retroactively gave the U.S. Department of Transportation the authority to disburse to the States construction funds collected into the Federal Highway Trust Fund for the period ending September 30, 1985. On September 19, an additional ICE legislation was passed by the U.S. Congress for the period ending September 30, 1986. Most of these funds were to be used for highway construction and repair work, and their late release impacted to some extent the demand for construction sand and gravel.

In August 1985, the Environmental Protection Agency issued its final regulations establishing particulate emission standards of performance for nonmetallic mineral processing plants. The regulations went into effect on August 1, and will be implemented under section 111 of the Clean Air Act. The standards were based on emission levels achievable using well-designed and operated baghouse controls or wet-dust suppression techniques. The standards apply to new, modified, and reconstructed facilities at plants processing 18 industrial minerals including sand and gravel.

CONSTRUCTION SAND AND GRAVEL

DOMESTIC PRODUCTION

Revised production estimates indicate that in 1985 U.S. output of construction sand and gravel increased 3% compared with that of 1984. All regions, except New England and West South Central, registered increases up to 11%. The Pacific region continued to lead the Nation with an estimated 178 million tons, or 22% of the U.S. total, followed by the East North Central region with 132 million tons, or 17% of the total, and the Mountain region with 113 million tons, or 14% of the total.

Among the four major geographic regions, the West again led the Nation in the production of construction sand and gravel with 36% of the total. The North Central region was next with 27%, and the South was third with 25%. Construction sand and gravel was produced in every State, and the 10 leading States, in descending order of volume, were California, Texas, Michigan, Arizona, Ohio, Alaska, New York, Colorado, Illinois, and Minnesota. Their combined estimated production represented 52% of the national total.

Tarmac PLC of Wolverhampton, United Kingdom, purchased the Florida aggregates and ready-mix concrete operations of Lone Star Industries Inc. of Fort Lauderdale, FL. The newly formed company, Tarmac Florida Inc., will be situated in Fort Lauderdale, FL. Pioneer Concrete of Texas Inc., based in Houston, TX, purchased four sand and gravel operations and seven ready-mix concrete plants in south Texas from Lone Star Industries. A Hawaiian affiliate of Lone Star Industries formed a partnership with Adelaide Brighton Cement Holdings Ltd. of Australia and purchased Lone Star's aggregate and ready-mix concrete operations throughout Hawaii.

River Aggregates Co. of Hernando, MS, a subsidiary of River Cement Co. of Orange, TX, is a new major sand and gravel producer in Mississippi. A long-time cement supplier of this area, River Cement decided to diversify by becoming a sand and gravel producer. The new operation, near the Mississippi-Tennessee border, is equipped with a 600-ton-per-hour processing plant.

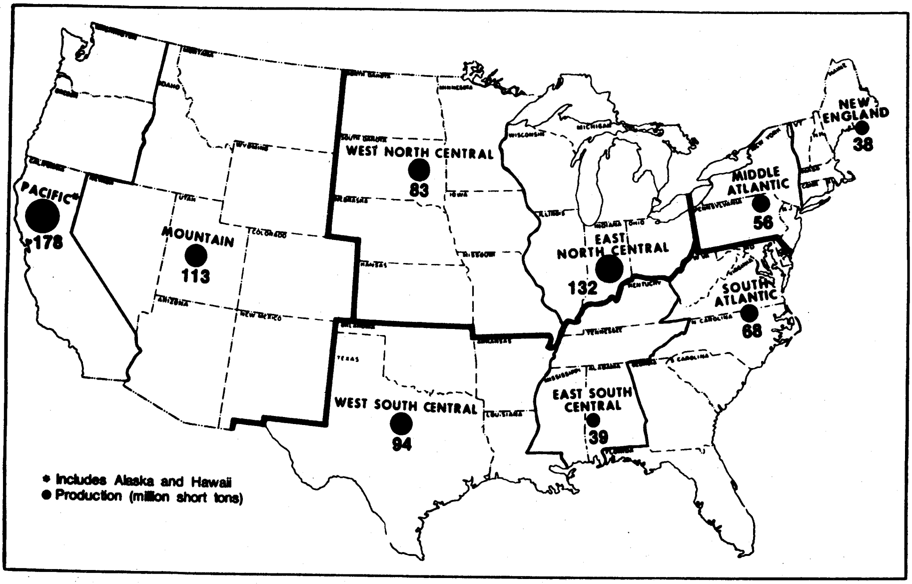

Figure 1.—Production of construction sand and gravel in the United States in 1985, by geographic region.

FOREIGN TRADE

Exports.—Exports of construction sand decreased 18% to 997,000 tons valued at $6.2 million. Canada was the major destination, receiving 90% of the total, while Mexico received 7%. Exports of construction gravel decreased 19% to 516,000 tons valued at $2.7 million, 94% of which went to Canada.

Imports.—Imports for consumption of construction sand and gravel increased 63% to 246,000 tons valued at $1.6 million, 86% of which came from Canada.

TECHNOLOGY

The National Sand and Gravel Association's Annual Plant Operator's Forum, held in Los Angeles, CA, from March 17 to March 20, 1985, covered a broad range of topics related to the use of hydraulic dredging in sand and gravel operations. Automation of sand and gravel plants, computer-controlled sand classifiers, and tips on how to design portable plants for easy relocation within the pit were also discussed.[2] A review of the basics of hydraulic dredging technology and how it can help a sand and gravel operation grow and increase profitability was published by a leading expert in this field.[3]

A computer-controlled sand classifier installed by Eastern Aggregates Inc. of Davidsonville, MD, was instrumental in increasing concrete sand production at the plant. The computerized classifier tracks raw material fed into the system, calculates the optimal settings for different discharge stations, and transmits the parameters to the central control station. Based on the automatic readouts of the sand's fineness modulus made every 6 minutes, the system adjusts the yield from the varying feed stocks to meet preset specifications.[4]

Midwestern Industries of Massillon, OH, introduced a new screening system called Multi-Vib. The system stratifies the material in a shallow fluidized bed on each deck with rapid drop-through of particles. The process reduces the wear of the screens and sizes the material more accurately into the final products.[5]

The chances of success in obtaining mining permits are significantly improved if long-range mining plans of aggregate producing operations are properly presented to the public. Three-dimensional quarry models displaying the present and the future of the operation were successfully used by Cooley Gravel Co. of Denver, CO, and Trap

Rock Industries Inc. of Franklin, NJ.[6]

The decision to automate an aggregate processing plant is usually determined by economic factors. However, the success of such an effort depends on acceptance of the new system by the operating personnel, according to an article that reviewed the human and economic aspects of plant automation.[7]

Table 2.—Construction sand and gravel sold or used in the United States, by geographic region

Geographic region	1984 Quantity (thousand short tons)	1984 Percent of total	1984 Value (thousands)	1984 Percent of total	1985 Quantity[e] (thousand short tons)	1985 Percent of total	1985 Value[e] (thousands)	1985 Percent of total
Northeast:								
New England	39,694	5	$113,590	5	38,300	5	$117,900	5
Middle Atlantic	49,985	6	177,028	8	55,600	7	199,200	8
North Central:								
East North Central	127,643	17	336,715	15	132,200	17	370,800	16
West North Central	80,307	10	183,146	8	82,600	10	196,400	8
South:								
South Atlantic	63,609	8	187,397	8	67,900	8	203,400	8
East South Central	36,697	5	99,225	4	39,200	5	115,000	5
West South Central	98,748	13	304,493	14	93,900	12	302,700	12
West:								
Mountain	107,332	14	314,833	14	112,900	14	338,400	14
Pacific	169,861	22	527,528	24	177,500	22	594,200	24
Total[1]	773,900	100	2,244,000	100	800,100	100	2,438,000	100

[e]Estimated.
[1]Data may not add to totals shown because of independent rounding.

Table 3.—Construction sand and gravel sold or used in the United States, by State

(Thousand short tons and thousand dollars)

State	1984 Quantity	1984 Value	1985[e] Quantity	1985[e] Value
Alabama	10,348	26,188	11,000	32,000
Alaska	30,861	66,883	29,000	63,000
Arizona	30,439	101,959	37,000	118,000
Arkansas	8,334	23,786	8,500	24,400
California	102,420	360,427	112,800	430,000
Colorado	28,024	87,324	27,500	88,000
Connecticut	6,718	22,817	6,000	21,000
Delaware	1,003	2,795	1,300	4,000
Florida	21,032	48,494	22,500	49,500
Georgia	5,347	13,623	5,000	13,400
Hawaii	436	2,031	500	2,100
Idaho	4,725	13,509	4,000	11,400
Illinois	25,969	72,477	26,600	77,000
Indiana	16,071	44,744	18,600	55,800
Iowa	13,882	37,027	12,000	30,500
Kansas	11,796	26,358	13,200	31,800
Kentucky	7,839	18,252	7,600	19,000
Louisiana	17,040	54,664	15,000	48,000
Maine	7,885	19,228	7,200	18,000
Maryland	14,234	46,671	17,000	58,000
Massachusetts	14,168	42,139	14,900	47,500
Michigan	36,071	76,540	38,000	93,000
Minnesota	22,612	49,087	25,000	55,500
Mississippi	12,205	34,955	13,400	42,000
Missouri	7,967	19,364	7,500	20,000
Montana	7,776	21,269	9,000	26,000
Nebraska	11,839	27,791	11,600	28,800
Nevada	8,202	20,505	9,500	24,800
New Hampshire	5,637	16,054	6,300	19,800
New Jersey	9,545	31,878	10,600	36,700
New Mexico	8,363	22,389	8,400	22,800
New York	25,968	80,866	28,000	88,500
North Carolina	6,312	18,159	6,100	19,500
North Dakota	6,426	11,351	6,900	13,800
Ohio	31,748	104,709	33,000	109,000
Oklahoma	10,984	26,582	12,600	32,300
Oregon	12,776	37,117	12,500	36,800
Pennsylvania	14,472	64,285	17,000	74,000

See footnotes at end of table.

Table 3.—Construction sand and gravel sold or used in the United States, by State —Continued

(Thousand short tons and thousand dollars)

State	1984		1985[e]	
	Quantity	Value	Quantity	Value
Rhode Island	1,483	5,282	1,200	4,600
South Carolina	5,845	17,097	4,900	14,000
South Dakota	5,786	12,168	6,400	16,000
Tennessee	6,304	19,830	7,200	22,000
Texas	62,389	199,461	57,800	198,000
Utah	15,217	34,507	14,000	36,400
Vermont	3,802	8,071	2,700	7,000
Virginia	8,860	37,359	10,200	42,000
Washington	23,369	61,070	22,700	62,300
West Virginia	976	3,198	900	3,000
Wisconsin	17,785	38,245	16,000	36,000
Wyoming	4,586	13,372	3,500	11,000
Total[1]	773,900	2,244,000	800,100	2,438,000

[e]Estimated.
[1]Data may not add to totals shown because of independent rounding.

Table 4.—U.S. exports of construction sand and gravel, by country

(Thousand short tons and thousand dollars)

Country	Construction sand		Gravel	
	Quantity	F.a.s. value[1]	Quantity	F.a.s. value[1]
1984				
Bahamas	(2)	3	1	16
Canada	1,006	3,215	616	1,635
Mexico	181	1,534	1	20
Other	23	3,342	17	560
Total	1,210	8,094	635	2,231
1985				
Canada	892	3,061	485	1,430
Germany, Federal Republic of	4	657	--	--
Mexico	74	520	11	238
Netherlands Antilles	1	7	8	131
Saudi Arabia	11	64	(2)	7
Trinidad and Tobago	4	244	1	112
Other	11	1,659	11	806
Total	997	6,212	516	[3]2,723

[1]Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Table 5.—U.S. imports for consumption of construction sand and gravel, by country

(Thousand short tons and thousand dollars)

Country	1984		1985	
	Quantity	C.i.f. value[1]	Quantity	C.i.f. value[1]
Antigua	3	23	9	61
Bahamas	14	110	--	--
British Virgin Islands	4	82	11	155
Canada	121	1,100	212	908
Mexico	--	2	2	20
Spain	--	--	11	297
Other	[r]9	[r]287	1	131
Total	151	[2]1,603	246	1,572

[r]Revised.
[1]Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.
[2]Data do not add to total shown because of independent rounding.

INDUSTRIAL SAND AND GRAVEL

DOMESTIC PRODUCTION

The total output of industrial sand and gravel in 1985 was 29.4 million tons, unchanged from that of 1984. The North Central region continued to lead the Nation with 40% of the U.S. total, followed by the South with 36%, the Northeast with 13%, and the West with 11%. Compared with that of 1984, the output of industrial sand and gravel by region increased 3.6% in the South and slightly in the Northeast, and decreased 3.9% in the West and slightly in the North Central region.

Based on the 1980 census data on population, U.S. per capita industrial sand and gravel production was 0.13 ton. Per capita production by region was 0.20 ton in the North Central, followed by the South with 0.14 ton, and the West and the Northeast with 0.08 ton.

The 10 leading States in the production of industrial sand and gravel in 1985 were, in descending order of volume, Illinois, Michigan, New Jersey, California, Florida, Texas, Ohio, North Carolina, Wisconsin, and Oklahoma. Their combined production represented 73% of the national total. Production increased 38% in Florida, 13% in Wisconsin, 12% in North Carolina, and 4% in New Jersey, but decreased 13% in Ohio and slightly in California and Illinois.

In 1985, 98 producers of industrial sand and gravel with 169 active operations were canvassed by the Bureau of Mines. About 75% of the industrial sand and gravel produced came from 49 operations, each with an annual production of more than 200,000 tons. The 10 leading producers of industrial sand and gravel were, in descending order of tonnage, Unimin Corp., Pennsylvania Glass Sand Corp. (PGS), The Morie Co. Inc., Ottawa Silica Co., Manley Bros. of Indiana Inc., Standard Sand & Silica Co., Oglebay Norton Co., Construction Aggregates Corp., Wedron Silica Co., and Badger Mining Corp. Their combined production, from 54 operations, represented 67% of the U.S. total.

PGS of Berkley Springs, WV, the second largest U.S. producer of industrial sand, was sold in the second half of 1985 by its parent company, International Telephone & Telegraph Corp. of New York, NY, to United States Borax & Chemical Corp. of Los Angeles, CA, a subsidiary of The Rio Tinto-Zinc Corp. PLC of London, United Kingdom. The sale followed expansion plans announced by PGS in 1984 that included the installation of new automated production and quality control equipment, and automated packaging and shipping facilities at four of its operations.

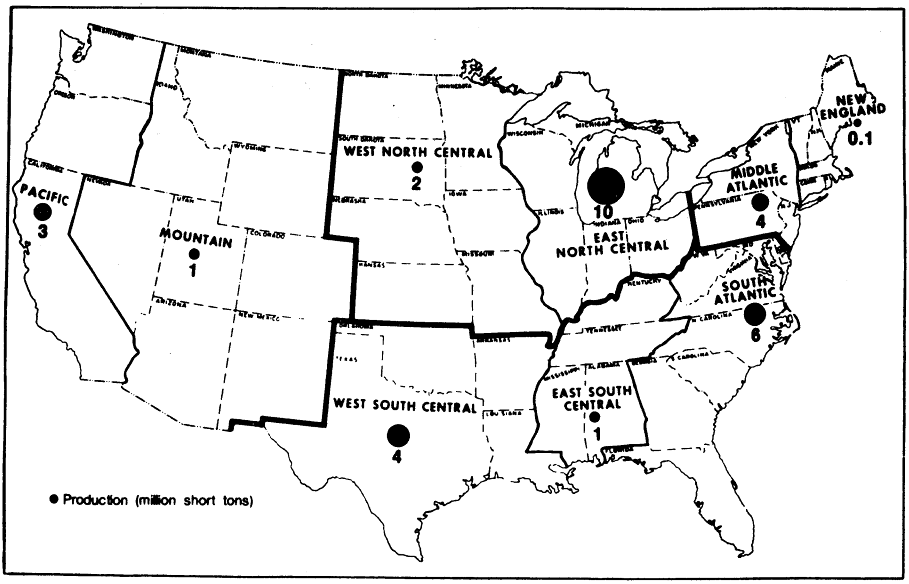

Figure 2.—Production of industrial sand and gravel in the United States in 1985, by geographic region.

CONSUMPTION AND USES

Sand and gravel production reported by producers to the Bureau of Mines is actually material sold or used by the companies. Stockpiled material is not reported until it is consumed.

Of the 29.1 million tons of industrial sand sold or used, 35% was consumed as glassmaking sand and 18% as foundry sand. Other important uses were hydraulic fracturing sand with 7%, and abrasive sand with 6%. Because some companies did not report a breakdown by end use, their total production as well as the estimates for nonrespondents were included in "Other unspecified uses," which represent about 19% of total U.S. output. On a regional level, most of the glassmaking sand was produced in the South, 39%, followed by the North Central, 26%, and the West, 18%; while most of the foundry sand was produced in the North Central, 67%, and the South, 17%. Of the smaller by volume but important uses, most of the hydraulic fracturing sand was produced in the North Central, 66%, and the South, 31%; while most of the abrasive sand was produced in the South, 53%.

PRICES

The average value, f.o.b. plant, of U.S. industrial sand and gravel decreased slightly to $12.71 per ton. Average unit values for industrial sand and industrial gravel were $12.75 and $9.36 per ton, respectively. Nationally, silica sand used as fillers in rubber and paint had the highest value per ton, $53.72; followed by silica sand used in ceramics, $35.30; fiberglass ground, $27.28; and silica flour, $25.81.

TRANSPORTATION

Of the total industrial sand and gravel produced, 80% was transported by truck from the plant to the site of first point of sale or use, 18% by rail, and less than 1% by waterway. Because most of the producers had no records of and/or did not report shipping distances or cost per ton per mile, no transportation cost data were available.

FOREIGN TRADE

Exports.—Exports of industrial sand decreased 27% to 866,000 tons valued at $22.6 million. Of this, 85% went to Canada, and 6% went to Mexico.

Imports.—Imports of for consumption industrial sand increased 212% to 81,000 tons valued at $1.5 million. Of this, 52% came from Australia, 17% from Antigua, and 14% from Japan.

TECHNOLOGY

A consortium of seven companies was established to sponsor research and development in glass technology. The companies involved in this joint venture were ACI International Ltd. of Melbourne, Australia; Brockway Inc. of Brockway, PA; Consumers Glass Co. Ltd. of Toronto, Canada; Emhart Corp. of Farmington, CT; Rockware Glass of Windsor Berks, United Kingdom; Weingand Glass of the Federal Republic of Germany; and Yamamura Glass of Japan. A total of $5 million over a 3-year period will be provided by the group to fund seven research projects. The aim of the research is to develop a strong, lightweight, glass container that could successfully compete with plastic containers. The first phase of the project, conducted at selected research institutes and organizations addressed the development of new glass technology. The second phase of the project will involve the assessment of economic and practical factors of implementing the new technology. Proposed research includes a project at the Massachusetts Institute of Technology that will examine the use of special coatings on glass containers.[8]

Within the next 1 or 2 years, a 16-ounce-capacity super-lightweight nonrefillable soft drink glass container will be manufactured in the United States. The weight of this new container was estimated to be 5 ounces, which is approximately 36% less than the present weight level for this type of container. The weight-to-capacity ratio of about 0.3 for the new container also represents a significant reduction from present levels.[9]

Recent advances in microcomputer hardware and software provided the capability of performing complex batch calculations on inexpensive desk-top models. A microcomputer program was developed at Rutgers University, Department of Ceramic Engineering, which enables optimum glass batch formulation using Linear programming techniques (LP). Previously, such applications required the use of more expensive large mainframe computers. The LP procedure improved the accuracy of glass batch formulation, especially when complex raw materials are used, provided the capability of easily establishing tolerance limits for each oxide level, and controlled many key glass batch parameters in a single integrated computation.[10]

The recent advances achieved in high-intensity wet and dry magnetic separation techniques extended their usefulness for processing industrial minerals. Such new developments included the use of strong rare-earth permanent magnetic separators, large-particle-size electromagnetic separators, and superconducting cryogenic wet and dry systems. Several systems capable of separating minerals on the basis of their magnetic repelling properties rather than their attracting properties also were studied.[11]

The Western Australian government introduced a computerized information system that allowed instant access to the results of mineral exploration performed previously by mining companies. Under the provisions of the Mining Act, companies are required to report all technical details of their exploration activities to the Department of Mines. These reports become eligible for open-file release when the exploration tenements are relinquished. By having access to such reports, companies interested in new exploration will be able to review previous exploration programs and avoid costly duplication.[12]

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[1]Physical scientist, Division of Industrial Minerals.
[2]Robertson, J. L. Dredging Tops NSGA Program. Rock Prod., v. 88, No. 6, June 1985, pp. 36-38.
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[4]Robertson, J. L. Computer Raises Sand Production. Rock Prod., v. 88, No. 9, Sept. 1985, pp. 47-49.
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[6]Rukavina, M. Quarry Model Is Reclamation Aid. Rock Prod., v. 88, No. 5, May 1985, pp. 44-45, 65.
[7]Michard, D. Plant Automation: Human & Economic Aspects. Pit & Quarry, v. 78, No. 5, Nov. 1985, pp. 27-29.
[8]Industrial Minerals (London). International Glass Research. No. 211, Apr. 1985, p. 15.
[9]Southwick, R. D. A Super-Lightweight Container Is Feasible. Glass Ind., v. 66, No. 7, June 10, 1985, pp. 14-17.
[10]Lehman, R. L. Microcomputers Can Be Used To Optimize Batch Formulation. Glass Ind., v. 66, No. 8, July 1985, pp. 14-17.
[11]Clark, G. Magnetic Separation. Ind. Miner. (London), No. 212, May 1985, pp. 21-33.
[12]Industrial Minerals (London). Mines Department Launches First Computerized Database. No. 214, July 1985, p. 9.

Table 6.—Industrial sand and gravel sold or used in the United States, by geographic region

Geographic region	1984				1985			
	Quantity (thousand short tons)	Percent of total	Value (thousands)	Percent of total	Quantity (thousand short tons)	Percent of total	Value (thousands)	Percent of total
Northeast:								
New England	186	1	$3,781	1	164	1	$3,879	1
Middle Atlantic	3,459	12	43,725	12	3,542	12	41,352	11
North Central:								
East North Central	10,260	35	119,035	31	10,092	34	120,162	32
West North Central	1,663	5	25,983	7	1,578	5	25,523	7
South:								
South Atlantic	5,348	18	65,126	17	5,959	20	67,060	18
East South Central	1,128	4	10,939	3	1,121	4	11,113	3
West South Central	3,881	13	52,655	14	3,648	12	52,004	14
West:								
Mountain	819	3	11,595	3	746	3	9,950	3
Pacific	2,638	9	44,377	12	2,576	9	43,022	11
Total[1]	29,380	100	377,200	100	29,430	100	374,070	100

[1]Data may not add to totals shown because of independent rounding.

Table 7.—Industrial sand and gravel sold or used in the United States, by State

(Thousand short tons and thousand dollars)

State	1984		1985	
	Quantity	Value	Quantity	Value
Alabama	442	3,600	524	4,533
Arizona	W	W	W	W
Arkansas	459	6,207	412	5,414
California	2,281	39,176	2,255	37,434
Colorado	149	2,213	W	W
Connecticut	W	W	W	W
Florida	1,533	9,815	2,123	12,642
Georgia	478	6,795	571	6,675

See footnotes at end of table.

Table 7.—Industrial sand and gravel sold or used in the United States, by State —Continued

(Thousand short tons and thousand dollars)

State	1984		1985	
	Quantity	Value	Quantity	Value
Idaho	W	W	W	W
Illinois	4,100	52,197	4,056	56,915
Indiana	194	1,129	182	1,209
Kansas	W	W	134	1,124
Kentucky	W	W	W	W
Louisiana	266	3,757	267	3,838
Maryland	W	W	W	W
Massachusetts	W	W	W	W
Michigan	3,400	33,060	3,345	25,469
Minnesota	W	W	884	16,910
Mississippi	W	W	W	W
Missouri	614	8,129	535	7,330
Montana	W	W	W	W
Nebraska	W	W	W	W
Nevada	489	W	479	5,944
New Jersey	2,712	32,287	2,820	31,119
New York	25	260	W	W
North Carolina	1,158	12,864	1,294	13,086
Ohio	1,506	20,829	1,312	21,945
Oklahoma	W	W	W	W
Pennsylvania	W	W	693	9,846
Rhode Island	W	W	W	W
South Carolina	882	14,889	794	14,092
Tennessee	650	6,903	569	6,156
Texas	2,028	29,282	1,968	29,095
Utah	11	W	8	144
Virginia	W	W	W	W
Washington	356	5,201	322	5,589
West Virginia	W	W	W	W
Wisconsin	1,060	11,821	1,197	14,624
Other	4,587	76,803	2,686	42,934
Total[1]	29,380	377,200	29,430	374,070

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.

Table 8.—Industrial sand and gravel production in the United States in 1985, by size of operation

Size range	Number of operations	Percent of total	Quantity (thousand short tons)	Percent of total
Less than 25,000	35	20.7	288	1.0
25,000 to 49,999	33	19.5	1,166	4.0
50,000 to 99,999	23	13.6	1,796	6.1
100,000 to 199,999	29	17.2	4,038	13.7
200,000 to 299,999	11	6.5	2,753	9.4
300,000 to 399,999	14	8.3	4,764	16.2
400,000 to 499,999	9	5.3	3,991	13.6
500,000 to 599,999	2	1.2	1,041	3.5
600,000 to 699,999	4	2.4	2,572	8.7
700,000 to 799,999	7	4.1	5,132	17.4
800,000 and over	2	1.2	1,885	6.4
Total	169	100.0	[1]29,430	100.0

[1]Data do not add to total shown because of independent rounding.

Table 9.—Number of industrial sand and gravel operations and processing plants in the United States in 1985, by geographic region

Geographic region	Mining operations on land				Dredging operations	Total active operations
	Stationary	Portable	Stationary and portable	No plants or unspecified		
Northeast:						
New England	4	--	--	1	1	5
Middle Atlantic	14	--	--	5	5	19
North Central:						
East North Central	37	1	--	2	2	40
West North Central	10	--	--	--	3	10
South:						
South Atlantic	20	3	1	6	8	30
East South Central	10	2	1	4	3	17
West South Central	21	1	--	3	7	25
West:						
Mountain	7	--	--	2	1	9
Pacific	12	--	--	2	3	14
Total	135	7	2	25	33	169

Table 10.—Industrial sand and gravel sold or used by U.S. producers, by major use

Major use	Northeast Quantity (thousand short tons)	Northeast Value (thousands)	Northeast Value per ton	North Central Quantity (thousand short tons)	North Central Value (thousands)	North Central Value per ton	South Quantity (thousand short tons)	South Value (thousands)	South Value per ton	West Quantity (thousand short tons)	West Value (thousands)	West Value per ton	U.S. total[1] Quantity (thousand short tons)	U.S. total[1] Value (thousands)	U.S. total[1] Value per ton
1984															
Sand:															
Glassmaking:															
Containers	1,365	$17,526	$12.84	1,952	$20,111	$10.30	2,400	$28,358	$11.82	1,856	$31,185	$16.80	7,574	$97,180	$12.83
Flat (plate and window)	W	W	13.02	522	4,818	9.23	1,171	13,745	11.74	W	W	14.29	1,814	20,182	11.13
Specialty	W	W	14.07	414	5,173	12.50	268	3,061	11.42	W	W	26.00	867	10,849	12.51
Fiberglass (unground)	W	W	10.69	237	2,951	12.45	W	W	16.05	W	W	14.70	560	7,619	13.61
Fiberglass (ground)	W	W	40.00	W	W	29.50	492	10,607	21.56	W	W	26.50	526	11,678	22.20
Foundry:															
Molding and core	700	6,506	9.29	4,586	50,583	11.03	1,095	11,272	10.29	145	2,122	14.63	6,526	70,483	10.80
Molding and core facings (ground)	W	W	16.67	492	4,102	8.34	--	--	--	W	W	8.00	502	4,261	8.49
Refractory	W	W	24.29	167	1,640	9.82	W	W	17.93	W	W	13.00	211	2,513	11.91
Metallurgical:															
Silicon carbide	W	W	21.50	132	1,323	10.02	W	W	60.00	(2)	4	--	135	1,430	10.59
Flux for metal smelting	--	--	--	W	W	4.10	--	--	--	W	W	10.83	97	792	8.16
Abrasives:															
Blasting	206	3,824	18.56	389	8,862	22.78	907	14,588	16.08	308	3,826	12.42	1,810	31,099	17.18
Scouring cleansers (ground)	W	W	W	127	2,989	23.54	W	W	23.50	W	W	23.50	194	4,548	23.44
Sawing and sanding	W	W	10.73	W	W	19.67	W	W	W	--	--	--	26	431	16.58
Chemicals (ground and unground)	W	W	12.60	222	2,441	11.00	128	1,901	14.85	W	W	14.00	425	5,303	12.48
Fillers (ground):															
Rubber, paint, putty, etc	W	W	24.00	42	723	17.21	58	1,002	17.28	W	W	13.90	122	2,153	17.65
Ceramic (ground):															
Pottery, brick, tile, etc	W	W	33.05	106	2,768	26.11	W	W	25.98	W	W	30.00	184	4,944	26.87
Filtration	22	969	44.05	75	751	10.01	99	769	7.77	21	240	11.43	217	2,729	12.58
Traction (engine)	26	271	10.42	122	1,171	9.60	55	515	9.36	43	522	12.14	246	2,479	10.08
Coal washing	W	W	11.50	--	--	--	W	W	10.86	--	--	--	25	274	10.96
Roofing granules and fillers	32	648	20.25	30	310	10.33	209	2,652	12.69	18	270	15.00	289	3,881	13.43
Hydraulic fracturing	W	W	11.00	1,246	24,261	19.47	767	12,608	16.44	W	W	22.05	2,057	37,806	18.38
Silica flour	W	W	61.07	W	W	90.06	W	W	78.46	--	--	--	78	5,867	75.22
Other uses, specified	651	10,610	16.30	108	2,385	22.08	536	11,508	21.47	506	9,620	19.01	XX	XX	XX
Other uses, unspecified[3]	597	5,982	10.02	789	6,756	8.56	1,744	12,472	7.15	497	7,072	14.23	3,627	32,283	8.90
Total[1] or average	3,598	46,336	12.88	11,758	144,118	12.26	9,929	125,058	12.60	3,394	54,861	16.16	28,680	370,370	12.92

See footnotes at end of table.

Table 10.—Industrial sand and gravel sold or used by U.S. producers, by major use —Continued

Major use	Northeast			North Central			South			West			U.S. total[1]		
	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton	Quantity (thousand short tons)	Value (thousands)	Value per ton
1984 —Continued															
Gravel: Metallurgical:															
Silicon, ferrosilicon	--	--	--	--	--	--	W	W	$6.55	W	W	$17.28	198	$1,715	$8.66
Filtration	W	W	$23.86	34	$130	$3.82	W	W	10.56	W	W	7.00	W	W	14.60
Grinding	--	--	--	W	W	3.00	--	--	--	(2)	(2)	--	W	W	3.00
Other uses	--	--	--	W	W	5.85	426	$3,662	8.60	W	W	17.65	507	5,129	10.12
Total[1] or average	W	W	23.86	166	902	5.43	426	3,662	8.60	W	W	17.65	705	6,844	9.71
Grand total[1] or average	W	W	13.03	11,923	145,018	12.16	10,357	128,721	12.43	W	W	16.19	29,380	377,200	12.84
1985															
Sand:															
Glassmaking:															
Containers	1,369	$17,538	12.81	1,562	19,663	12.59	2,235	26,996	12.08	1,656	$27,133	16.38	6,822	91,330	13.39
Flat (plate and window)	W	W	12.41	448	4,319	9.64	1,138	12,860	11.30	W	W	14.48	1,777	19,815	11.15
Specialty	W	W	15.23	369	4,279	11.60	W	W	12.56	--	--	--	768	9,790	12.75
Fiberglass (unground)	W	W	10.00	309	3,857	12.48	W	W	15.28	60	861	14.35	587	7,753	13.21
Fiberglass (ground)	W	W	58.00	W	W	30.68	W	W	27.26	W	W	21.71	339	9,247	27.28
Foundry:															
Molding and core	683	5,954	8.72	2,912	30,304	10.41	865	8,740	10.10	108	1,539	14.25	4,568	46,536	10.19
Molding and core facing (ground)	W	W	18.17	W	W	12.62	--	--	--	--	--	--	352	4,475	12.71
Refractory	W	W	24.71	184	1,677	9.11	W	W	17.88	W	W	17.82	223	2,457	11.02
Metallurgical:															
Silicon carbide	W	W	22.67	W	W	10.12	24	124	5.17	1	W	9	121	1,143	9.45
Flux for metal smelting	--	--	--	W	W	7.57	W	W	13.50	51	619	12.14	67	753	11.24
Abrasives:															
Blasting	117	2,054	17.56	221	3,694	16.71	841	14,052	16.71	252	2,961	11.75	1,431	22,762	15.91
Scouring cleansers (ground)	W	W	28.00	W	W	21.94	W	W	26.12	--	--	--	233	5,358	23.00
Sawing and sanding	W	W	13.00	W	W	20.27	W	W	25.00	--	--	--	17	355	20.88
Chemicals (ground and unground)	W	W	12.42	125	1,355	10.84	176	2,613	14.85	W	W	19	378	4,924	13.03
Fillers (ground):															
Rubber, paint, putty, etc	21	1,341	63.86	W	W	95.33	96	4,768	49.67	W	W	13.38	137	7,360	53.72
Silica flour	W	W	26.63	--	--	--	W	W	25.09	--	--	--	21	542	25.81
Ceramic (ground):															
Pottery, brick, tile, etc	W	W	33.93	W	W	38.91	50	1,479	29.58	--	--	--	150	5,295	35.30

Filtration	122	1,661	13.61	39	921	23.62	166	1,215	7.32	18	184	10.22	345	3,981	11.54
Traction (engine)	14	228	16.29	142	1,325	9.33	100	875	8.75	36	335	9.31	292	2,763	9.46
Coal washing	W	W	12.67	--	--	--	W	W	11.57	--	--	--	18	199	11.06
Roofing granules and fillers	36	619	17.19	40	444	11.10	288	3,415	11.86	39	577	14.79	403	5,056	12.55
Hydraulic fracturing	W	W	17.47	1,396	29,853	21.38	W	W	17.47	47	1,045	22.23	2,102	42,417	20.18
Other uses, specified	1,200	14,059	11.72	3,706	41,794	11.28	2,540	39,609	15.59	820	15,902	19.39	XX	XX	XX
Other uses, unspecified[3]	138	1,727	12.51	158	1,451	9.18	1,968	11,817	6.00	182	890	4.89	2,446	15,885	6.49
Total[1] or average	3,701	45,179	12.21	11,609	144,935	12.48	10,489	128,564	12.26	3,270	52,048	15.92	29,070	370,730	12.75
Gravel: Metallurgical:															
Silicon, ferrosilicon	--	--	--	W	W	10.00	W	W	6.44	51	917	17.98	315	2,771	8.80
Filtration	W	W	10.40	W	W	18.75	W	W	24.00	W	W	7	23	383	16.65
Grinding	--	--	--	--	--	--	W	W	8.60	W	W	(2)	5	43	8.60
Other uses	--	--	--	--	--	--	W	W	10.21	W	W	(2)	15	143	9.53
Total[1] or average	W	W	10.40	61	750	12.30	W	W	6.75	53	924	17.43	357	3,340	9.36
Grand total[1] or average	W	W	14.9	11,670	145,685	12.48	W	W	12.13	3,323	52,972	15.94	29,430	374,070	12.71

W Withheld to avoid disclosing company proprietary data; included with "Other uses, specified." XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Mostly estimated total production, plus other uses (small quantities) as reported by the producers.

Table 11.—Transportation of industrial sand and gravel in the United States in 1985 to site of first sale or use

Method of shipment	Quantity (thousand short tons)	Percent of total
Truck	23,620	80
Rail	5,401	18
Waterway	165	1
Not shipped, used at site	245	1
Total	[1]29,430	100

[1]Data do not add to total shown because of independent rounding.

Table 12.—U.S. exports of industrial sand, by country

(Thousand short tons and thousand dollars)

Country	1984		1985	
	Quantity	F.a.s. value[1]	Quantity	F.a.s. value[1]
North America:				
Bahamas	3	115	1	80
Canada	1,045	13,587	739	10,926
Costa Rica	10	151	(2)	68
Dominican Republic	3	231	1	64
Mexico	70	2,245	50	1,516
Panama	5	152	9	239
Other	1	390	4	208
Total[3]	1,138	16,871	805	13,101
South America:				
Argentina	4	238	(2)	12
Chile	(2)	73	(2)	135
Colombia	(2)	102	1	161
Ecuador	(2)	84	6	144
Peru	6	693	7	754
Venezuela	1	171	(2)	114
Other	r (2)	r50	(2)	34
Total[3]	11	1,410	15	1,354
Europe:				
Belgium	1	312	6	327
France	(2)	128	1	203
Germany, Federal Republic of	5	1,381	2	444
Netherlands	3	1,573	6	2,300
Norway	1	86	2	584
United Kingdom	6	441	9	484
Other	4	r453	3	315
Total[3]	20	4,373	28	4,656
Asia:				
Indonesia	2	253	2	142
Japan	4	1,149	4	700
Singapore	4	883	4	780
Other	2	466	2	588
Total[3]	11	2,752	11	2,211
Middle East and Africa:				
Turkey	3	565	--	--
Saudi Arabia	1	73	1	156
United Arab Emirates	2	672	3	585
Other	3	496	1	202
Total	9	1,806	5	943
Oceania	3	444	2	316
Grand total[3]	1,193	27,656	866	22,580

rRevised.
[1]Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 13.—U.S. imports for consumption of industrial sand, by country

(Thousand short tons and thousand dollars)

Country	1984		1985	
	Quantity	C.i.f. value[1]	Quantity	C.i.f. value[1]
Antigua	5	83	14	92
Australia	6	167	42	737
Bahamas	8	15	--	--
British Virgin Islands	1	17	5	89
Canada	5	155	2	115
Japan	([2])	4	11	16
Spain	--	--	3	30
United Kingdom	([2])	1	2	53
Other	[r]1	[r]485	3	382
Total[3]	26	926	81	1,513

[r]Revised.
[1]Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Silicon

By Gerald F. Murphy[1]

Overall demand for silicon materials in the United States in 1985 was slightly lower than that of 1984, a consequence of a decrease in production by the iron and steel and aluminum industries. Production and shipments of silicon ferroalloys and silicon metal declined by significant amounts. Imports of silicon materials overall increased by a little more than 20% while domestic production declined by about 10%. As a result, domestic producers' market share declined. However, silicon metal imports were a little more than double those of 1984. Exports decreased substantially, by more than one-half, and remained small compared with imports. Owing to competition from low-priced imports and a weakening demand by consuming industries, domestic producers lowered the prices for metallurgical-grade silicon metal at the end of the third quarter and for the 50% and 75% ferrosilicon grades toward yearend. World demand for silicon materials increased slightly compared with that of 1984.

Domestic Data Coverage.—Domestic production data for the silicon commodity are developed by the Bureau of Mines by means of monthly and annual voluntary domestic surveys. Typical of these surveys is the monthly "Silicon Alloys" survey. Of the 18 canvassed operations to which a survey collection request was made, all responded, representing 100% of the total production shown in table 1.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in the United States in 1985

(Short tons, gross weight, unless otherwise specified)

Alloy	Silicon content (percent)		Producers' stocks as of Dec. 31, 1984	Gross production	Net shipments	Producers' stocks as of Dec. 31, 1985
	Range	Typical				
Silvery pig iron	5-24	18	W	W	W	W
Ferrosilicon (including briquets)	25-55	48	60,579	349,491	263,152	97,738
Do	56-95	76	29,157	91,045	80,058	24,858
Silicon metal (excluding semiconductor grades)	96-99	98	10,432	122,787	121,640	9,753
Miscellaneous silicon alloys (excluding silicomanganese)	32-65	--	14,300	65,408	61,523	14,670

W Withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—Senate bill 262 and its counterpart, House bill 976 entitled "Fair Trade in Ferroalloys Act," were introduced in the U.S. Senate and the House of Representatives on January 24 and February 6, respectively. The Fair Trade in Ferroalloys Act, aimed at preserving the domestic ferroalloys industry, would establish a "breakpoint" tariff system whereby certain ferroalloys imports entering the United States below an established fair market price would be automatically assessed a tariff. The Senate bill was referred to the Senate Finance Committee and the House bill was referred to the House Ways and Means Committee for consideration. On May 21, the U.S. Senate adopted an amendment (No. 168) to the Department of Defense fiscal year 1986 Authorization Bill (S. 1160), which requires the U.S. Department of Defense to conduct a study to determine what impact the loss of all domestic ferroalloy production capacity would have on the U.S. industrial base and military preparedness.

Senate bill 1533, National Security Trade Act of 1985, was introduced in the U.S. Senate on July 31 to amend section 232 of the 1962 Trade Expansion Act. Final responsibility for decisions on trade relief cases and setting time limits would rest with the U.S. Trade Representative. On October 9, Senate bill 1753 was introduced in the U.S. Senate to amend title II of the Trade Act of 1974, adoption of which would eliminate the discretionary power of the President to grant import relief. The administration outlined a "strike force" consisting of six high-level administration officials that would monitor other countries' export barriers to U.S. goods and unfair subsidies of foreign goods that compete in the U.S. market. The administration also announced an agreement by France, the Federal Republic of Germany, Japan, the United Kingdom, and the United States on a joint action to weaken the U.S. dollar in an attempt to slow the protectionist pressures on Congress to curb imports and to promote U.S. exports.

A report entitled "Can the U.S. Ferroalloy Industry Survive?," released by the Congressional Research Service of the Library of Congress, examined key changes in the structure of the U.S. ferroalloys industry since the early 1970's. The report focused on the changing competitive posture of domestic producers of ferrosilicon, among others.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. The status of silicon carbide was deferred until further detailed studies could be made. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

DOMESTIC PRODUCTION

Production and shipments of silicon ferroalloys and silicon metal overall showed significant decreases in 1985, compared with those of 1984, following comparable declines in the iron and steel and aluminum industries. The 56% to 95% ferrosilicon range declined the most. Both production and shipments declined by about 30%. Magnesium ferrosilicon accounts for the major portion of the miscellaneous silicon alloys category, the remainder in this class being calcium-silicon, silicon-manganese-zirconium, and rare-earth silicides. Data for silvery pig iron are withheld because there was only one producer.

Producer stocks of 25% to 55% ferrosilicon increased by about two-thirds, while those of 56% to 95% ferrosilicon showed a decrease of about 15%. Stocks of miscellaneous silicon alloys were relatively unchanged.

Foote Mineral Co., Exton, PA, announced in September plans to sell its specialty products lines including proprietary technology, trade names, and patents to SKW Alloys Inc., Niagara Falls, NY, effective January 3, 1986. As compensation, Foote will participate in the profits generated by SKW Alloys in the manufacture and sales of the product lines over the next 6 years. As a result of this transaction, Foote closed its Graham, WV, ferroalloys plant on December 31, 1985. In February 1985, Ohio Ferro-Alloys Corp. (OFA), Dayton, OH, closed its Powhatan Point silicon metal plant for the balance of the year. The company subsequently concentrated all of its silicon metal production in its Montgomery, AL, facility. OFA's third plant in Philo, OH, which produced ferrosilicon, had been shut down in September 1984. The company also secured a 5-year agreement to sell silicon metal to General Electric Co.'s (GE) Silicones Product Div. and concluded a $3 million loan agreement with GE's Credit Corp. The Bonneville Power Administration approved M. A. Hanna Co.'s request for a 5-year extension of its current offpeak power rate for Hanna's smelter at Riddle, OR. Additionally, a new 5-year labor contract was finalized between Hanna and unionized workers at Riddle.

International Minerals & Chemical Corp. (IMC), Northbrook, IL, completed an expansion that tripled production of high-purity quartz at its feldspar beneficiation complex in Spruce Pine, NC. Markets for IMC quartz include fused quartz producers, semiconductor manufacturers, and the refractory and fiber-optic components industries.

Estimated ferrous scrap consumption by the domestic silicon ferroalloys industry to produce silicon ferroalloys was 280,000 tons in 1985, compared with 310,000 tons in 1984.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1985

Producer	Plant location	Product
Aluminum Co. of America, Northwest Alloys Inc	Addy, WA	FeSi and Si.
Dow Corning Corp	Springfield, OR	Si.
Elkem Metals Co	Alloy, WV	FeSi and Si.
Do	Ashtabula, OH	FeSi.
Foote Mineral Co., Ferroalloys Div	Graham, WV	Do.
Do	Keokuk, IA	Silvery pig iron.
M. A. Hanna Co.:		
Hanna Nickel Smelting Co	Riddle, OR	FeSi.
Silicon Div	Wenatchee, WA	FeSi and Si.
International Minerals & Chemical Corp., Industry Group, TAC Alloys Div	Bridgeport, AL	FeSi.
Do	Kimball, TN	Do.
Moore McCormack Resources Inc., Globe Metallurgical Inc	Beverly, OH	FeSi and Si.
Do	Selma, AL	Si.
Ohio Ferro-Alloys Corp	Montgomery, AL	FeSi and Si.
Do	Powhatan Point, OH	Si.
Reactive Metals & Alloys Corp	West Pittsburgh, PA	FeSi.
Reynolds Metals Co	Sheffield, AL	Si.
SKW Alloys Inc	Calvert City, KY	FeSi.
Do	Niagara Falls, NY	Do.

CONSUMPTION AND USES

Overall reported consumption of silicon materials in 1985 decreased by about 5%, based on silicon content, compared with that of 1984. The more pronounced decreases occurred for the 56% to 70% and 81% to 95% ferrosilicon ranges, but these grades remained a small part of the total ferrosilicon used. Moderate declines were observed for the 50% and 75% ferrosilicon grades and silicon carbide. The largest demand was for silicon metal and the 50% ferrosilicon grade, followed, on the basis of silicon content, by 75% ferrosilicon, miscellaneous silicon alloys, silicon carbide, and silvery pig iron. The decreasing order of end uses for silicon materials was steel, cast iron, silicones and silanes, and nonferrous alloys, with about 60% of consumption being accounted for by ferrous applications. Cast-iron production consumed the greatest amounts of silicon carbide, miscellaneous silicon alloys, and silvery pig iron, while steelmaking was the biggest user of 75% and 85% ferrosilicon. Iron foundries and steel plants together accounted for 95% of 50% ferrosilicon usage; 90% of silicon metal went into nonferrous alloys and silicones and silanes.

Decreases in consumption paralleled declines in major markets for silicon alloys. Iron foundries and the steel industry each experienced production losses of a little more than 5%. The aluminum industry, which uses silicon metal to make wrought and cast products, suffered from an excess of supply over demand and reduced production by about 15%. The decrease was attributed to overproduction in 1984. Consumption of silicon metal for silicones and silanes increased slightly in 1985, compared with that of 1984.

Silicon metal produced by tonnage methods is used as raw material for the manufacture of the relatively small quantity of ultrahigh-purity polycrystalline silicon for semiconductors, solar cells (photovoltaic cells), and other highly specialized applications. The Bureau of Mines does not collect data on these specialty grades of silicon, which have a high unit value. In 1985, domestic production of polycrystalline silicon was estimated at 1,800 tons.

Overall, consumer stocks of silicon material declined 15%. The largest decreases occurred for the 56% to 70% and 81% to 95% ferrosilicon ranges and for silicon carbide.

Union Carbide Corp. began a project to

double its production capacity to 2,400 tons per year at its new Moses Lake, WA, polycrystalline silicon plant. The additional capacity was expected to meet anticipated demand from the semiconductor industry for polycrystalline silicon. Some of the additional capacity was expected to become available in late 1986.

Monsanto Electronic Materials Co. (MEMC), St. Louis, MO, formed a 50-50 partnership with Dongbu Industrial Inc. to produce silicon wafers for the semiconductor industry. The new facility, Korsil Inc., will be in Gumi Industrial Park, Republic of Korea. The plant was expected to be completed in 1986. MEMC also began construction of a silicon wafer manufacturing and research plant in Utsunomiya, Tochigi, Japan. The project's first phase was expected to be completed by mid-1986. Nippon Kokan K.K. purchased GE's Great Western Silicon polycrystalline silicon plant in Arizona. The plant has the capacity to produce about 200 tons per year of high-purity silicon. Polycrystalline Silicon Technology Inc., Arizona, developed a laboratory version of polycrystalline silicon plants. The self-contained units can be used to investigate the Siemens process for production of high-purity silicon.

Dynamit Nobel A.G., through its subsidiary Kay-Fries Inc., purchased Petrarch Systems Inc., Bristol, PA. Petrarch specializes in high-technology silicon. Markets for its products include optical fiber cable jacketing, medical implants, electronics, and catalysts. The company began an expansion program to increase its capacity for silanes and silicone compounds by doubling the size of its facilities in Bristol.

Table 3.—Consumption, by major end use, and stocks of silicon alloys and metal in the United States in 1985

(Short tons, gross weight, unless otherwise specified)

End use	Silicon content (percent)	Silvery pig iron	Ferrosilicon[1]				Silicon metal	Miscellaneous silicon alloys[2]	Silicon carbide[3]
	Range	5-24	25-55	56-70	71-80	81-95	96-99	--	63-70
	Typical	18	48	65	76	85	98	48	64
Steel:									
Carbon		(4)	48,864	--	19,402	(4)	(4)	1,969	(4)
Stainless and heat-resisting		--	33,848	--	27,315	(4)	123	(4)	--
Full alloy		(4)	15,417	--	6,543	(4)	(4)	562	--
High-strength, low-alloy		--	6,526	--	573	(4)	35	125	(4)
Electric		--	(4)	(5)	(4)	--	--	(4)	--
Tool		--	(4)	--	1,683	--	(4)	(4)	--
Unspecified		44	6,466	--	18,742	800	1,903	172	223
Total		44	111,121	(5)	74,258	800	2,061	2,828	223
Cast irons		11,288	110,741	(5)	19,043	314	51	37,995	28,309
Superalloys		7	367	--	74	59	60	3	--
Aluminum alloys		--	(5)	--	--	(5)	48,479	(5)	--
Other alloys		11	2,897	--	107	4	7,376	11	--
Silicones and silanes		--	--	--	--	--	63,235	--	--
Miscellaneous and unspecified		--	7,653	2,750	30	228	[6]11,167	54	--
Total		11,350	232,779	2,750	93,512	1,405	132,429	40,891	28,532
Percent of 1984		119	88	66	91	59	116	133	88
Total silicon content[7]		2,043	111,734	1,788	71,069	1,194	129,780	19,628	18,260
Consumers' stocks, Dec. 31		881	10,013	116	6,559	118	5,029	1,743	940

[1]Includes briquets.
[2]Primarily magnesium-ferrosilicon but also includes other silicon alloys. Average silicon content estimated as 48%, based on 1985 production survey.
[3]Does not include silicon carbide for abrasive or refractory uses.
[4]Included with "Steel: Unspecified."
[5]Included with "Miscellaneous and unspecified."
[6]Includes an estimated 11,000 tons consumed for unspecified chemicals.
[7]Estimated based on typical percent content.

PRICES

Published prices for domestic silicon materials remained unchanged for much of 1985. However, domestic producers lowered their prices for metallurgical-grade silicon metal at the end of the third quarter and for the 50% and 75% ferrosilicon grades toward yearend. The price reductions were attributed to competition from low-priced imports, a falloff in demand for silicon metal by the aluminum industry in the second half of the year, and weaker demand by the steel and ferrous foundry industries. Despite these decreases, the average price per year for major silicon materials increased in 1985 compared with that of 1984. For example, on a contained-silicon basis, ferrosilicon increased from 42.9 cents per pound in 1984 to 44.6 in 1985, 75% ferrosilicon increased from 44.3 to 46.1, and silicon metal containing 1% maximum iron increased from 62.9 to 63.3.

Published prices of imported silicon ferroalloys showed a downward trend throughout the year, while the price of imported silicon metal showed an upward trend for the first half of 1985, followed by a steady decline for the remainder of the year. Most imported silicon materials were priced significantly lower than comparable domestically produced materials. For example, the average price per year for imported 50% ferrosilicon, 75% ferrosilicon, and silicon metal containing 1% iron was lower than domestically produced material by 18%, 24%, and 9%, respectively.

Although posted prices for domestically produced silicon materials were, in general, much higher than those of imports, discounting by domestic producers was reported throughout the industry.

FOREIGN TRADE

Exports of ferrosilicon declined by more than one-half in quantity and by 40% in value, compared with that of 1984. The largest quantity went to Canada, 9,425 tons, which accounted for about 70% and 60% of total quantity and value, respectively. Exports went to 27 countries. Silicon metal exports also showed a comparable decline, about one-half in quantity and 30% in value. Most of the metal was exported to Mexico (625 tons), Japan (583 tons), and Canada (413 tons), making up about 75% in terms of total quantity and about 50% of total value. A relatively small quantity, 118 tons, was shipped to Malaysia. Combined exports to Japan and Malaysia accounted for about one-third of total quantity but about 85% of total value. Exports went to 31 countries.

Compared with those of 1984, imports of ferrosilicon increased about 8% in volume but were little changed in value. Silicon metal imports increased a little more than 100% in quantity and about 50% in value. Imports of 75% ferrosilicon were the most significant on a volume basis. Overall total imports of ferrosilicon and silicon metal increased a little more than 20%.

The 75% grade (60% and 80% silicon) accounted for a little more than 60% of ferrosilicon imports. Norway shipped one-fourth of the total in this range, while Brazil and Venezuela, each with a little more than one-fifth of the total, were the next largest sources. Imports in this range from Canada increased notably compared with those of 1984. The next largest import class was regular-grade 50% ferrosilicon (30% to 60% silicon), which amounted to about one-fourth of all ferrosilicon imports. The main sources of this material were, in decreasing order, the U.S.S.R., Canada, and Venezuela, which accounted for about 80% of the total in this class. Average silicon content of all imported ferrosilicon in 1985 decreased to 66% from 67% in 1984.

Imports of silicon metal in the 96% to 99% range showed an increase of 40%, compared with those of 1984. The main sources of this material were Canada and Yugoslavia, which accounted for about 75% of the total. However, imports of silicon metal in the 99% to 99.7% range increased about 140%, compared with those of 1984. Total imports of silicon metal increased by a little more than 100% in terms of gross weight, compared with those of 1984. Brazil, Canada, and Portugal were the dominant sources of commercial-purity silicon metal. The Federal Republic of Germany, Italy, and Japan supplied over 90% of the imported high-purity semiconductor-grade silicon, which is included in the over 99.7% silicon import class.

Imports of silicon materials, on a gross-weight basis, represented a larger share of the domestic market, increasing from about one-fifth in 1984 to a little more than one-quarter in 1985.

The very large increase in silicon metal imports and a small increase in ferrosilicon imports combined with a marked decline in ferrosilicon and silicon metal exports left the United States a net importer of silicon materials. Net imports of silicon materials amounted to about 189,000 tons and a trade deficit of about $83 million. The administration also announced an agreement by the United States with four other leading industrial nations on a joint action to weaken the U.S. dollar in an attempt to slow the protectionist pressures on Congress to curb imports and to promote U.S. exports.

Table 4.—U.S. exports of ferrosilicon and silicon metal

Year	Quantity (short tons)	Value (thousands)
FERROSILICON		
1981	15,768	$12,136
1982	14,932	11,996
1983	13,338	10,712
1984	29,364	21,135
1985	12,969	12,671
SILICON METAL		
1981	8,673	57,001
1982	2,411	34,335
1983	2,767	47,826
1984	4,420	88,543
1985	2,120	61,647

Source: Bureau of the Census

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country

Grade and country	1984			1985		
	Quantity (short tons)		Value (thousands)	Quantity (short tons)		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content	
Ferrosilicon:						
Over 8% but not over 30% silicon:						
Canada	42	6	$3	152	23	$9
Germany, Federal Republic of	--	--	--	171	17	5
United Kingdom	5	1	10	23	4	27
Total[1]	46	7	13	345	43	41
Over 30% but not over 60% silicon, with over 2% magnesium:						
Brazil	5,564	2,530	2,845	3,973	1,822	2,462
Canada	351	178	151	774	365	223
France	964	446	662	727	340	519
Germany, Federal Republic of	256	143	321	212	106	289
Italy	273	122	201	99	45	71
Japan	182	82	311	127	57	215
Norway	3,244	1,488	2,688	1,662	743	1,186
Spain	78	41	73	12	5	17
Total[1]	10,912	5,030	7,252	7,586	3,484	4,981
Over 30% but not over 60% silicon, not elsewhere classified:						
Argentina	--	--	--	66	40	60
Brazil	7,160	3,473	2,428	3,135	1,532	977
Canada	7,221	3,627	2,113	11,547	5,568	3,697
France	2,703	1,578	2,694	2,628	1,497	2,209
Germany, Federal Republic of	868	480	948	261	145	270
Italy	76	41	72	--	--	--
Japan	18	8	31	36	16	60
Netherlands	18	11	16	--	--	--
Norway	1,090	437	408	--	--	--
Spain	939	589	1,019	1,111	644	1,103
U.S.S.R	11,514	5,424	3,151	16,132	7,518	4,542
Venezuela	--	--	--	6,969	3,828	1,672
Total[1]	31,607	15,668	12,880	41,887	20,788	14,590
Over 60% but not over 80% silicon, with over 3% calcium:						
Argentina	--	--	--	357	222	368
Brazil	4,436	2,802	3,841	6,134	3,860	5,377
Canada	--	--	--	31	24	15
France	1,118	691	1,209	1,080	653	1,052
Germany, Federal Republic of	1,054	678	999	602	367	576

See footnotes at end of table.

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country —Continued

Grade and country	1984 Quantity (short tons) Gross weight	1984 Quantity (short tons) Silicon content	1984 Value (thousands)	1985 Quantity (short tons) Gross weight	1985 Quantity (short tons) Silicon content	1985 Value (thousands)
Ferrosilicon —Continued						
Over 60% but not over 80% silicon, with over 3% calcium —Continued						
Italy	146	104	$148	37	24	$35
Mexico	44	26	10	--	--	--
Spain	--	--	--	312	191	291
Total[1]	6,798	4,301	6,207	8,554	5,340	7,714
Over 60% but not over 80% silicon, not elsewhere classified:						
Argentina	1,743	1,319	759	5,741	4,416	2,817
Belgium-Luxembourg	17	13	53	--	--	--
Brazil	17,793	13,311	9,209	21,120	15,918	10,411
Canada	8,652	6,564	5,096	12,877	9,812	6,590
Chile	1,068	822	598	--	--	--
France	575	440	492	413	317	393
Germany, Federal Republic of	968	727	1,401	1,079	802	1,575
Iceland	2,582	1,937	1,259	5,295	4,011	2,229
Israel	4,327	3,245	1,919	--	--	--
Norway	23,710	17,746	11,619	23,598	17,632	10,293
Poland	799	589	372	--	--	--
Portugal	4,021	3,056	2,099	--	--	--
South Africa, Republic of	1,382	1,079	796	4,144	3,168	2,076
Sweden	111	83	111	--	--	--
United Kingdom	--	--	--	19	14	11
Venezuela	25,377	19,074	10,046	20,768	15,302	9,297
Yugoslavia	--	--	--	1,101	835	529
Total[1]	93,125	70,005	45,829	96,154	72,228	46,222
Over 80% but not over 90% silicon:						
Belgium-Luxembourg	76	69	59	19	17	16
Brazil	220	187	158	498	422	312
Canada	55	45	19	--	--	--
France	38	32	23	--	--	--
Norway	441	383	203	358	315	132
Spain	231	206	156	--	--	--
Total[1]	1,063	923	619	875	754	460
Over 90% but not over 96% silicon:						
Belgium-Luxembourg	38	36	33	--	--	--
Canada	20	20	11	--	--	--
Germany, Federal Republic of	--	--	--	20	19	11
Italy	41	38	32	--	--	--
South Africa, Republic of	([2])	([2])	([2])	--	--	--
Total[1]	100	94	76	20	19	11
Total ferrosilicon[1]	143,651	96,027	72,874	155,421	102,656	74,019
Silicon metal:						
Over 96% but not over 99% silicon:						
Argentina	--	NA	--	440	NA	475
Brazil	--	NA	--	55	NA	48
Canada	3,101	NA	3,425	4,257	NA	4,898
France	114	NA	106	65	NA	79
Italy	--	NA	--	1,134	NA	1,020
Portugal	22	NA	15	--	NA	--
South Africa, Republic of	244	NA	247	--	NA	--
Spain	105	NA	71	116	NA	115
Sweden	--	NA	--	551	NA	585
Switzerland	37	NA	29	19	NA	15
United Kingdom	--	NA	--	36	NA	37
Yugoslavia	3,130	NA	3,219	2,680	NA	2,412
Total[1]	6,753	NA	7,113	9,353	NA	9,684
Over 99% but not over 99.7% silicon:						
Argentina	1,203	1,181	1,322	1,520	1,508	1,482
Belgium-Luxembourg	115	107	103	18	18	18
Brazil	2,665	2,640	2,792	13,283	13,122	13,071
Canada	5,123	5,076	6,196	6,027	5,959	7,231
China	441	434	411	165	162	157
Denmark	([2])	([2])	1	--	--	--
France	3,988	3,956	4,354	3,869	3,837	4,012

See footnotes at end of table.

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country —Continued

Grade and country	1984 Quantity (short tons) Gross weight	1984 Quantity (short tons) Silicon content	1984 Value (thousands)	1985 Quantity (short tons) Gross weight	1985 Quantity (short tons) Silicon content	1985 Value (thousands)
Silicon metal —Continued						
Over 99% but not over 99.7% silicon —Continued						
Germany, Federal Republic of	(2)	(2)	$1	--	--	--
Italy	337	335	347	1,093	1,087	$1,105
Netherlands	--	--	--	136	134	137
Norway	660	655	693	1,081	1,072	1,100
Portugal	887	880	930	6,386	6,322	6,737
South Africa, Republic of	1,745	1,729	1,840	3,932	3,900	4,128
Spain	252	250	259	1,280	1,267	1,111
Sweden	--	--	--	1,111	1,101	1,098
Switzerland	--	--	--	757	749	765
Venezuela	--	--	--	20	20	21
Yugoslavia	172	166	113	884	869	780
Total[1]	17,588	17,408	19,361	41,563	41,128	42,954
Over 99.7% silicon:						
Belgium-Luxembourg	--		--	19		16
Canada	49		121	--		--
China	35		398	1		50
Denmark	21		502	21		639
Dominican Republic	--		--	4		172
Finland	(2)		6	--		--
France	22		370	5		591
German Democratic Republic	(2)		2	1		52
Germany, Federal Republic of	618		21,608	598		21,565
Hong Kong	5	NA	289	--	NA	--
Israel	(2)		3	--		--
Italy	93		3,547	80		3,353
Japan	34		1,952	144		3,623
Korea, Republic of	(2)		6	--		--
Malaysia	(2)		9	(2)		1
Netherlands	--		--	(2)		22
Sweden	4		37	--		--
Switzerland	(2)		57	13		640
United Kingdom	--		--	(2)		5
Total[1]	880	NA	28,907	885	NA	30,729
Total silicon metal	25,221	XX	55,381	51,801	XX	83,367

NA Not available. XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

World demand for silicon materials increased slightly compared with that of 1984, owing to only a small increase in production by the world iron and steel industry, the major consumer of ferrosilicon. Worldwide overcapacity made it difficult for producers to maintain profitability. European Economic Community (EEC) ferrosilicon producers met with EEC commission officials to discuss an increase in the low level of prices, set in 1983, of ferrosilicon delivered to the EEC border. Subsequently, the Commission began to monitor the ferrosilicon market and asked producers from countries accused of dumping in 1983 to provide details of all transactions in the EEC market since April 1985. If the non-EEC producers do not agree to an increase of the minimum price set in 1983, the EEC would be expected to use other ways to seek a firming in prices, such as the EEC antidumping legislation. The EEC Council of Ministers also agreed to maintain the duty-free quota for imports of ferrosilicon for 1986 at about 14,000 tons, of which the Federal Republic of Germany will be the main beneficiary.

Argentina.—A shipment amounting to about 4,400 tons of ferrosilicon produced by Industrias Siderurgicas Grassi S.A. was delivered to Japan in 1985, the largest shipment ever of Argentine ferrosilicon to that country. The company owns a ferroalloy plant with an annual capacity of 11,000 tons.[2]

Australia.—Pioneer Concrete Ltd. and French metals producer Pechiney agreed to set up a joint venture to build a silicon plant near Hobart, Tasmania. The new plant, estimated to cost $34 million, would be 60% owned by Pioneer with Pechiney holding the remainder and was expected to be completed by June 1987. The joint venture intends initially to build a single 18.5-megawatt submerged arc furnace, which will produce about 13,000 tons per year of salable alloy or chemical-grade silicon metal, based on technology of Pechiney's subsidiary Pechiney Electrometallurgie.[3]

Brazil.—Brazil announced that it planned to triple its output of silicon ferroalloys by 1990 including ferrosilicon and silicon metal. Brazil's aggressive expansion program coincides with diminishing capacity in the United States and Japan. However, worldwide overcapacity is still the main problem facing the world ferroalloy industry.[4]

Italmagnesio S.A. Indústria e Comércio planned to start silicon metal production by March 1986 by converting its 24-megavolt-ampere (MV•A) submerged arc furnace from ferrosilicon production. The furnace was scheduled for operation in January 1986. Its monthly capacity for silicon metal production is rated at about 1,100 tons. Italmagnesio also planned to build a new 13-MV•A furnace for silicon metal production. The unit was expected to be completed by June 1986. Ferro-Ligas Assofun S.A. began installation of an electric furnace for ferrosilicon production at its ferroalloy plant in São Joas da Boa Vista, doubling capacity to about 15,000 tons per year. The company negotiated with Nippon Kokan and Mitsui Co. Ltd., with the aim of establishing a joint venture to raise a part of the financing required for the construction. Cia. Brasileria Carbureto de Calcio (CBCC) converted one of its old 30-MV•A ferrosilicon furnaces to silicon metal production. CBCC brought a new 30-MV•A furnace on-stream about midyear for ferrosilicon production. Production for the new unit was expected to be about 20,000 tons per year. CBCC also signed a contract to supply Toyo Denka Kogyo Co. Ltd. with 5,000 tons per year of ferrosilicon. Eletrovale, a joint venture 60% owned by Cia. Vale do Rio Doce and Eletrometalur S.A. Indústria e Comérico and 20% each by Kawasaki Steel Corp. and Mitsubishi Corp., began construction of its 27,000-ton-per-year ferrosilicon plant. The facility was scheduled to come on-stream toward the end of 1986. Kawasaki Steel will take one-third of the plant's output.

Eletrometalur and Ila og Lilleby Smelteverker A/S of Norway formed a joint venture to produce silicon metal in Brazil. Two 14,000-kilowatt furnaces will be erected at Captain Eneas, Minas Gerais. The 20,000-ton-per-year operation was expected to come on-stream in mid-1987. Plant output will be for export. Alcan Alumínio do Brasil S.A. agreed to sell its ferroalloys division to Cia. Paulista de Ferro-Ligas. Alcan's properties included two single-furnace operations with a total capacity of about 19,000 tons per year of 75% ferrosilicon. A third facility produces silicomanganese. All plants are in Minas Gerais. Cia. de Ferro-Ligas Minas Gerais brought on-stream a 15-M•VA furnace in August, increasing its ferrosilicon capacity from 26,000 tons per year to 40,000 tons of 75% material. Cia. de Ferro-Ligas da Bahia S.A. planned to resume ferrosilicon production by building three 13,000-ton-per-year furnaces in Salvador, Brazil. The first furnace was scheduled for completion in December.

Minerações Brasileiras Reunidas S.A.'s (a Brazilian iron ore producer) plans to build two 15,000-kilovolt-ampere (kV•A) electric furnaces in Pirapora were approved by Conselho de Nao-Ferrosos e de Siderurgia (CONSIDER). The $23 million ferrosilicon plant was to have a capacity to produce about 26,000 tons of ferrosilicon per year. Brazil's Interior Minister approved new investment in the Inoculantes e Ferro-Ligas Nipo Brasileiros S.A. (INONIBRAS) ferrosilicon project. INONIBRAS planned to increase capacity from 7,000 tons per year to 29,000 tons. Osaka Special Alloy Ltd. holds a 30% share in the company, whose smelter is in Mato Grosso State.

France.—Pechiney Electrometallurgie, a subsidiary of Pechiney, planned to increase silicon metal capacity by about 14,000 tons per year by switching a ferrosilicon alloy unit to silicon metal production at its Anglefort plant. The new capacity was expected to come on-line in early 1986. Pechiney, the parent company, already has about 83,000 tons of silicon metal capacity. The conversion was made because the market outlook was more promising for silicon metal than for ferrosilicon. In the fourth quarter, Pechiney announced cutbacks in ferrosilicon production, owing to world overcapacity and low prices, and in silicon metal production, owing to some weakening in demand.[5]

Iceland.—Icelandic Alloys Ltd.'s production of ferrosilicon dropped below 1984 levels owing to a 7-week shutdown of one of its 35,000-kV•A electric furnaces. The plant operated at full capacity in 1984. Financial restructuring of the company to reduce long-term debt was also completed in 1984. Icelandic Alloys also obtained long-term sales guarantees from Elkem A/S, Norway, and Sumitomo Corp., Japan, which will provide good plant utilization in years of poor demand for ferrosilicon. Construction of the 25,000-ton-per-year silicon metal plant at Reydarsjordur has been delayed until 1986.[6]

India.—A letter of intent to produce 2,700 tons per year of silicon metal was issued by the Indian Government to Ispat Alloys Ltd., Balasore, Orissa State. Indian Metals and Ferro Alloys Ltd., Rupali, Orissa, is the only other current producer of silicon metal, with a capacity of 5,500 tons per year. The plant output will go to the semiconductor industry and to the aluminum industry as an additive in aluminum alloys.[7]

Italy.—Industria Elettrica (INDEL) planned to install a new 24-MV•A electric furnace for silicon metal production at its Ospitale di Cadore facility by yearend. The expansion will raise INDEL'S capacity to about 31,000 tons per year from a current level of about 19,000 tons. All of the new output was destined for export. INDEL was also producing 22,000 tons per year of 75% ferrosilicon at its Domodossala plant.[8]

Japan.—Japan's cabinet approved a plan drafted by its Ministry of International Trade and Industry (MITI) to offer domestic ferrosilicon, ferrochromium, and ferronickel producers financial support in exchange for scrapping or mothballing plant capacity by March 31, 1987. MITI expected most ferrosilicon producers to accept this offer. MITI promised producers who comply with the law on "Extraordinary Measures for Depressed Industries" that they will be exempted from having to pay any or most of their fixed property taxes. MITI said these measures were necessary to offset major inroads by foreign ferroalloys producers whose power costs are much below that of Japanese producers. Japan's ferrosilicon industry has operated at below 50% of its rated capacity owing to the effect of foreign imports. The ferrosilicon companies participating in the plan include Denki Kagaku Kogyo Kabushiki Co. Ltd., Ibiden Co. Ltd., Japan Metals and Chemical Co. Ltd., Toyo Denka, and Ube Denki Kagaku Co. Ltd. Some plants are expected to be mothballed totally, while others would eliminate one or more furnaces.[9]

Japan imported about 113,000 tons of metallurgical-grade silicon metal in 1985, an increase of about 20%, compared with that of 1984. Ferrosilicon imports amounted to approximately 338,000 tons, about a 10% decrease, compared with those of 1984. Production of polycrystalline silicon for the Japanese semiconductor industry was about 1,600 tons, an increase of slightly over 60%, compared with that of 1984.[10]

Showa Denko K.K. planned to begin production of silicon wafers in 1986. A new $91 million facility was to be built in Chichibu City, Saitama Prefecture, north of Tokyo. The company will use a new magnetic crystallization process developed by Sony Corp. to produce 6-inch wafers. Nippon Kokan, Japan's second largest steelmaker, planned to go into the manufacture of silicon wafers in Japan. The company purchased technology for production of polycrystalline silicon from GE. Toyo Soda Manufacturing Co. signed an agreement with Siltec Corp., United States, for a joint venture to produce silicon wafers for the Japanese semiconductor market. Wacker-Chemie GmbH planned to build a silicon rubber compound resin plant at the site of its technical laboratories in Daito Town, Shizuoka.

Norway.—Loss of ferrosilicon production owing to furnace breakdowns was experienced by Finnfjord Smelteverk A/S, Orkla Metal A/S, and Hafslund A/S early in 1985. Loss of silicon metal production was reported by Elkem A/S, owing to a furnace breakdown in October at its Fiskaa works.

Hafslund began construction of an 11,000-ton-per-year metal powder plant at its Sarpsborg ferrosilicon facility. The plant, scheduled to come on-line early in 1986, would produce high-quality metal powders by water atomization. Products would include fine-grained 15% ferrosilicon for heavy-medium separation of ores and scrap.

Elkem became sole owner of Elkem Metals Co., United States, and Elkem Metals Canada Inc. Elkem also acquired a 20% share in Officine Elettrochimiche Trentine S.p.A. (OET), Italy, a ferroalloys producer. Additionally, Elkem undertook to market all of OET's products outside Italy. OET makes various specialized, highly refined alloys such as magnesium ferrosilicon, high-purity ferrosilicon, and calcium silicon, among others. Orkla Industrier A/S acquired a 51% interest in Bjoelvefossen A/S, a ferrosilicon producer. Tinfoss Jernverk A/S planned to convert its two 12,000-kV•A ferrosilicon furnaces to silicon metal production, one by July and the other by February 1986.

In December, Elkem announced plans to buy Orkla Industrier's 50% share of Orkla Metal's ferrosilicon plant in Thamshavn and its 51% share in Bjoelvefossen. Elkem also began negotiating with a third Norwegian ferroalloy producer, Tinfoss Jernverk, with the aim to establish a close working agreement in the areas of technology and marketing. With this consolidation of the Norwegian ferrosilicon industry, Elkem would effectively control about 386,000 tons per year of Norwegian ferroalloy capacity and about 110,000 tons per year of U.S. production through its U.S. subsidiary Elkem Metals. Additionally, Elkem holds a 30% interest in and an exclusive marketing agreement with Icelandic Alloys.[11]

In October, Norway's Finance Minister proposed an increase in the electricity tax to be applied to all consumers at a uniform rate, from 0.37 cent to 0.39 cent per kilowatt hour, effective in 1986. Norwegian ferrosilicon producers had sought some reduction in the electricity tax because of the depressed state of the ferrosilicon market.

Pakistan.—Saadi Ferroalloys Inc. planned to set up a plant to produce about 16,000 tons per year of 75% ferrosilicon. The new facility will be built in the North-West Frontier Province in the Hazera District.[12]

South Africa, Republic of.—Silicon Smelters Ltd., a subsidiary of South African Manganese Amcor Ltd., planned to expand silicon metal production by about 26,000 tons at its Witkop plant in Transvaal, over a period of 4 years. A new 13,000-ton-per-year furnace was expected to come on-line in 1987, with a second furnace scheduled for installation 2 years later. The company's expansion plans were based on forecasts of high growth in demand for silicon metal by the chemical industry and a more moderate increase in consumption by the secondary aluminum sector.[13]

Electricity costs for ferroalloys producers in the Republic of South Africa were raised by 10% on September 1, bringing the total increase for the year to 15%.

Spain.—Sociedad Española de Carburos Metálicos S.A. planned to invest about $19 million in the construction of a hydroelectric project at Santa Eugenia in Galicia. The company expected to improve its power consumption efficiency by this undertaking. Carburos Metálicos produces 75% ferrosilicon and other ferroalloys.[14] The Asociación Técnica Española de Fundición requested that a special quota be set up for the duty-free import of about 2,600 tons of magnesium ferrosilicon.

Sweden.—Uddevalla Kiselmetalverk AB, a joint venture formed by HB-Consult and Skanska Cement, planned to build a 33,000-ton-per-year silicon metal plant in Uddevalla. The plant was scheduled to come on-stream in early 1988. The facility's overall production costs were expected to be low since waste heat from the furnaces will be purchased by the Uddevalla'a district heating system.[15]

Malmo Industrikombinat AB, also jointly owned by HB-Consult and Skanska Cement, planned to build a 55,000-ton-per-year ferrosilicon plant at Swede Harbour, Malmo. Construction was scheduled to begin in April 1986, with startup of the plant planned for 1988. Power costs for the facility will be partially offset by the sale of waste heat from the furnaces to the Malmo municipality.[16]

Venezuela.—C.V.G. Ferrosilicio de Venezuela C.A.'s (FESILVEN) output of ferrosilicon reportedly was expected to be about 54,000 tons in 1985, compared with about 42,000 tons in 1984. FESILVEN's production fell to a very low level in the first half of 1984 owing to an explosion in one of the company's two furnaces, which put the plant out of operation for several weeks. The company has a nominal capacity of about 60,000 tons of ferrosilicon per year, most of which is exported to Europe, Japan, and the United States.[17]

TECHNOLOGY

Advanced ceramics, such as silicon carbide, silicon nitride, and sialon (a mixture of alumina and silicon nitride) are attractive because of their unusual resistance to heat, corrosion, and abrasion and wear. These high-performance materials have great potential, provided researchers can learn to design and manufacture ceramic parts in intricate shapes that are less brittle than the materials available now. Advanced ceramic materials are unreliable under stress.

U.S. companies such as Air Products & Chemicals Inc., ARCO Chemical Co., Dow Chemical Co., Dow Corning Corp., E. I. duPont de Nemours & Co. Inc., GE, W. R. Grace & Co., Koppers Inc., and Sohio Engineered Materials among others are all expanding the scope of their ceramic programs. Norton Co. and TRW Inc. formed a joint venture, Norton/TRW Ceramics Inc., in October 1985. The new company was formed to develop wear-resistant and hot-section parts for aerospace gas-turbine, rotary, and reciprocating engines that can run at much higher temperatures than metal engine parts can withstand. Heat engines with ceramic parts would be expected to offer substantial energy savings while also reducing automobile emissions.

Sohio Engineered Materials, a division of Sohio Inc., makes a variety of silicon carbide parts including mechanical seals, blast nozzles, fluid control nozzles, semiconductor hardware, and tubing for heat exchangers. General Motors' Allison Turbine Div., under a contract signed with the National Aeronautics and Space Administration's (NASA) Lewis Research Center, Cleveland, OH, is developing a nondestructive, photoacoustic spectroscopy technique to distinguish surface and near-surface ceramic flaws in the 50- to 100-micrometer range. Oak Ridge National Laboratory (ORNL) planned to build a $9.3 million laboratory for high-temperature-materials research. The facility's mission will be to develop ceramics that allow transportation and energy generating equipment to run more efficiently at high temperatures. AiResearch Casting Co. and Garrett Turbine Engine Co., units of Garrett Corp., received a $1.7 million ceramic materials research and development contract by NASA's Lewis Research Center. The NASA contract is the result of AiResearch's past and current fabrication of experimental high-technology ceramics of silicon nitride. Cabot Corp., Boston, MA, signed a letter of intent to purchase the ceramics unit of Augat Inc., Attleboro, MA. Augat produces ceramic packages for integrated circuit computer chips.[18]

Composite materials are coming under intense investigation in response to material requirements for advanced aerospace systems. For high-temperature applications, research efforts include work on ceramic matrix composites (CMC) and metal matrix composites (MMC). The main purpose of fiber reinforcement for MMC is to achieve high-temperature strength-to-density properties greater than those for superalloys. For the CMC, the fibers are introduced mainly to yield lightweight ceramic materials with greater toughness and reliability than conventional monolithic structural ceramics. A wide variety of silicon carbide reinforcements are available. However, evaluation studies by scientists at NASA's Lewis Research Center indicate that available commercial fibers do not meet all the necessary property requirements for providing MMC and CMC with high strength and toughness. Fiber research and development efforts are expected to overcome these limitations. Silicon carbide is available in the form of continuous fibers, short fibers, whiskers, and particles. Silicon carbide in the form of whiskers, short fibers, and particles is being used as a reinforcement of mainly aluminum and its alloys.

Two primary obstacles to achieving CMC with optimum microstructures are the development of high-strength, high-modulus, small-diameter continuous fibers whose mechanical properties are not drastically degraded by CMC processing or use conditions and net shape composite processing methods, that result in uniform microstructure of nondegraded aligned fibers surrounded by low porosity matrices. Major emphasis is being placed on silicon-carbide-based fibers. A recently developed CMC approach that shows promise for yielding high-temperature composites with good toughness and strength is the formation of reaction-bonded silicon nitride matrices reinforced by silicon carbide fibers produced by chemical vapor deposition.

Dow Corning is the prime contractor in a $22 million Defense Advanced Project Research Agency aimed at developing high-temperature ceramic fibers made of silicon carbide and ceramic composites that can withstand temperatures in the range of from 1,200° C to 1,400° C. Several years of research conducted by the U.S. Air Force Aeronautical Systems Division's Flight Dynamics Laboratory, Wright-Patterson Air Force Base, and LTV Corp.'s Aerospace and Defense Division resulted in a successful test firing of a solid rocket motor with a case made of the metal matrix materials, silicon carbide and aluminum. The Air Force is interested in the possibility of replacing the typical aluminum rocket motor casing with another material, mainly to achieve weight savings. Large ceramic composite panels of silicon carbide reinforced with silicon carbide fibers will be used for the heat shield on France's aerospace shuttle. The composite is able to withstand rapid temperature changes far in excess of what either component can tolerate separately.[19]

Photovoltaic systems (solar cells) have not reached the stage of development where they are cost competitive with fossil-fuel electric generating plants. Single-crystal silicon, a costly material, is the dominant material from which solar cells are made. Scientists are showing increased interest in amorphous silicon, which can be produced at a much lower price than single-crystal silicon, as an alternative in the manufacture of solar cells. To make amorphous silicon solar cells, very thin films of amorphous silicon are deposited on stainless steel or glass substrates. Although amorphous silicon solar cells are less efficient than single-crystal cells, they are much less expensive and easier to mass produce.

Sovonics Solar Systems, a joint venture partnership of Energy Conversion Devices (ECD), Troy, MI, and Standard Oil Co. of Ohio, reported having achieved an energy conversion efficiency of 12.2% in the laboratory for its amorphous silicon cells. Sovonics' cells consist of three extremely thin, vertically stacked subcells, each of which is sensitive to a different color in the spectrum.[20] Sandia Base Laboratories, Albuquerque, NM, developed a process that increases the electrical efficiency of polycrystalline silicon to 14.5% by exposing the material to a beam of hydrogen ions in a vacuum chamber. Mobil Solar Energy Corp., Waltham, MA, and Solavolt-Motorola Inc., Phoenix, AZ, are currently developing prototype solar cells using the hydrogen-treated polycrystalline material. Southern Co., an electric utilities company based in Atlanta, GA, invested $6.1 million for an 85% share in a new solar cell manufacturing plant in Birmingham, AL. The plant will be jointly owned with Chronar Corp., Lawrenceville, NJ, a maker of amorphous silicon cells.[21]

Union Carbide's new technology to make polycrystalline silicon employs silane (SiH_4) as an intermediate product instead of trichlorosilane ($HSiCl_3$), which is used in the conventional process. In Union Carbide's process, silicon tetrachloride ($SiCl_4$) is hydrogenated to trichlorosilane in a fluidized bed of metallurgical silicon at 932° F and 515 pounds per square inch, followed by catalytic conversion into silane. The silane is then pyrolyzed, yielding very-high-purity polycrystalline silicon.[22]

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Silver

By Robert G. Reese, Jr.[1]

Domestic mine production of silver declined in 1985 as the silver price continued the downward trend begun in 1983, and mining companies emphasized financial results improvement. Exploration declined except at those prospects that contained gold as the main product. Correspondingly, most new silver production was from new gold mines with byproduct silver. World mine output of silver was unchanged, owing in part to production from new mines, to enhanced mining profits brought about by currency devaluations relative to the U.S. dollar, and to the need by some silver exporting countries to earn foreign exchange.

U.S. silver consumption remained at about the same level as in 1984 and 1983. Silver consumption by all market economy countries was estimated to have increased by 11 million ounces.[2]

Domestic Data Coverage.—Domestic mine production data for silver are developed by the Bureau of Mines from four separate voluntary surveys of U.S. operations. Typical of these surveys was the lode-mine production survey of gold, silver, copper, lead, and zinc. Of the 140 lode silver operations to which a survey form was sent, 87% responded, representing 97% of the

Table 1.—Salient silver statistics

	1981	1982	1983	1984	1985
United States:					
Mine production thousand troy ounces	40,683	40,248	r43,431	r44,592	39,357
Value thousands	$427,922	$319,975	r$496,850	r$362,976	$241,653
Percentage derived from:					
Precious metals ores	54	68	76	80	70
Base metal ores	46	32	24	20	30
Placers	(1)	(1)	(1)	(1)	(1)
Refinery production:					
Domestic and foreign ores and concentrates thousand troy ounces	47,007	44,170	50,450	r50,019	45,609
Secondary (old scrap) do	39,067	27,171	25,549	24,070	24,285
Exports:					
Refined do	15,131	12,876	13,658	10,340	12,611
Other do	12,772	12,594	18,294	14,108	12,145
Imports for consumption:					
Refined do	75,921	96,917	161,199	93,546	137,398
Other do	18,194	20,541	18,692	21,420	15,204
Stocks, Dec. 31:					
Industry do	20,875	20,467	17,536	21,173	17,136
Futures exchanges do	96,511	106,182	151,232	137,631	173,144
Consumption:					
Industry and the arts do	116,670	118,840	116,464	114,841	118,559
Coinage do	179	1,846	2,128	2,665	355
Price, average per troy ounce[2]	$10.52	$7.95	$11.44	$8.14	$6.14
Employment[3]	3,600	2,900	2,400	2,600	p3,000
World:					
Mine production thousand troy ounces	r361,617	r382,969	392,054	p415,239	e412,273
Consumption:[4]					
Industry and the arts do	r344,000	r351,800	r349,600	r362,900	373,900
Coinage do	9,000	12,800	r19,600	r8,700	8,700

eEstimated. pPreliminary. rRevised.
1Less than 1/2 unit.
2Handy & Harman.
3Mine Safety and Health Administration.
4Market economy countries only. Source: Handy & Harman.

total U.S. mine production shown in tables 1, 2, 3, 5, 6, and 7. Production for the remaining 18 firms was estimated using prior reported production levels adjusted for economic trends and for information from other sources, such as company annual reports, news or journal articles, or State agency reports.

Legislation and Government Programs.—On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, silver would be categorized in tier II, and the goal would be 87.5 million ounces. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

On July 9, the President signed Public Law 99-61, the Statue of Liberty-Ellis Island Commemorative Coin Act, authorizing the U.S. Mint to produce 500,000 gold, 10 million silver, and 25 million cupronickel coins commemorating the centennial of the Statue of Liberty. Each silver coin would contain 0.77 ounce of silver. Title III of Public Law 99-61 authorized the production of a silver bullion coin upon completion of the Statue of Liberty coin program. The bullion coin would have a $1.00 face value, contain 1 ounce of 999 fine silver, and be produced in quantities sufficient to meet demand. Silver for both the Statue of Liberty coin program and the bullion coin program was to be obtained from the silver held in the National Defense Stockpile.

DOMESTIC PRODUCTION

Silver production was reported at 113 mines, including 12 placer operations. Silver was produced from precious metal ores at 71 mines while 30 mines produced silver as a byproduct of the processing of copper, lead, and zinc ores. The 25 largest mines accounted for 95% of total domestic mine output. In 1985, 10 mines each produced more than 1 million ounces of silver, which when aggregated equaled 76% of the total domestic production.

For the past several years, the mining industry's emphasis regarding silver has been on the discovery and development of new deposits, owing in part to the historic high silver price in 1979-80, and to the relative strength of the silver price when compared with the prices of base metals such as copper, lead, and zinc. However, 1985 was a year of change for the domestic silver mining industry. As the silver price continued the decline begun in 1983, and the silver market remained oversupplied, return-on-investment became the main concern at many silver producing operations. Many companies reduced their exploration activities during 1985, especially at those byproduct silver projects that did not have gold as the main product. Labor concessions, both in terms of wages and job content, along with operational and organizational changes to improve productivity were used at a number of mines to reduce operating costs and improve profitability. Other companies reduced or eliminated the book value of unprofitable mining assets, or temporarily closed mines, or gave the ownership of mining assets to their shareholders through the creation of new companies in order to improve their operating results.

Battle Mountain Gold Co. was created in 1985 by Pennzoil Co. as a means of transferring ownership of Pennzoil's mining activities to its shareholders, who could if desired use the stock market to dispose of their interest in these mining assets while maintaining their interest in Pennzoil's other assets. Included in Battle Mountain were substantially all of the domestic gold and silver mining and milling operations of Pennzoil's Duval Corp. subsidiary, and Pennzoil's interest in various domestic and Australian exploration and development activities. Pennzoil's Board of Directors approved the tax-free distribution of Battle Mountain's stock to Pennzoil shareholders on June 11. On August 2, each Pennzoil shareholder received one share of Battle Mountain common stock for each Pennzoil share held, at which time Battle Mountain became a separate publicly held corporation.

Similarly, Amoco Corp. gave the ownership of its mining subsidiary, Amoco Minerals Co., to its shareholders on July 1. Each Amoco Corp. shareholder of record on June 19 received 1 share of the new company, Cyprus Minerals Co., for each 10 shares of Amoco Corp. stock held. In 1985, Cyprus Minerals produced 625,000 ounces of silver, primarily from its Bagdad and Thompson Creek Mines.[3]

St. Joe Minerals Corp., a subsidiary of Fluor Corp., transferred all of its domestic, Chilean, and Canadian precious metal assets to a new subsidiary, St. Joe Gold Corp., in November. St. Joe Minerals planned an initial public offering equivalent to 6% to 10% of the common stock in St. Joe Gold near yearend. In mid-1985, Freeport-McMoRan Inc. publicly sold common stock equivalent to about 11% of the ownership of its Freeport-McMoRan Gold Co. subsidiary.

Alaska.—Commercial production began at the Grant Mine in November. Joint developers of the gold-silver operation were Silverado Mines Ltd., Aurex Inc., and Tri-Con Mining Inc. with holdings of 55%, 40%, and 5%, respectively. A 230-short-ton-per-day mill at the mine recovered precious metals using flotation and cyanidation. Reserves were estimated at 591,000 short tons grading 0.61 ounce of gold per ton. In late December, the mine temporarily closed, reportedly because of lower than expected operating results.

The Alaska State Legislature passed a measure allowing the Alaska Industrial Development Authority to issue up to $175 million worth of bonds to provide funds for construction of port facilities on the Chukchi Sea and a road from the port to the Red Dog lead-zinc-silver deposit. Federal legislation was enacted in October allowing the road to be constructed through the Cape Krusenstern National Monument.

An informal survey of Alaskan silver producers by the Alaska State Division of Geological Geophysical Survey indicated that 28,500 ounces of silver was produced in Alaska during the year, compared with about 5,000 ounces reported to the Bureau of Mines on a voluntary basis by producers.

Arizona.—Cyprus Minerals reduced the book value of the Bagdad Mine, a copper-molybdenum-silver-gold operation, by $194.8 million to $189.2 million. Low metal prices and an unfavorable finding in a study of Cyprus Minerals' ability to recover the carried value of its Bagdad investment were cited as the reasons for writing-down Bagdad's book value. The Bagdad Mine achieved full production in January 1985 following a 9-month closure in 1984 during which operating costs at the mine were reduced.

In September, ASARCO Incorporated acquired the Pima Mine, a copper-silver producer, from Cyprus Pima Mining Co., for $12.5 million payable over a 10-year period. The Pima Mine operated in the same pit as Asarco's Mission, Eisenhower, and San Xavier Mines. Acquisition of Pima resulted in a near 30-million-ton reserve increase at the Mission complex, to over 286 million tons with an average grade of 0.62% copper and 0.13 ounce of silver per ton. The acquisition was expected to allow more efficient operations in the pit. Asarco reported that its 1985 share of silver production from the Mission complex was 1.07 million ounces contained in concentrates.[4]

In November, all remaining operations at the Twin Buttes Mine were terminated. About 160 employees were affected. Anamax Mining Co., operator of the copper-silver-molybdenum mine, had halted mining operations in January 1983, but had continued to operate a copper oxide leach plant on the property. The last reported silver production for Twin Buttes was 392,000 ounces in 1983.[5]

Colorado.—Homestake Mining Co. temporarily closed the Bulldog Mine on January 29, 1985, owing to depressed silver prices. In 1984, the silver-lead mine was Colorado's largest silver producer. Although mine operations remained suspended throughout the remainder of the year, the carbon-in-pulp plant continued to operate, recovering gold and silver from loaded carbon from the Homestake Mine in South Dakota. It was estimated that 90 employees were affected by the closure.

Standard Metals Corp. closed the Sunnyside Mine during the first quarter of 1985. Low gold and silver prices were cited as the primary reasons for the closure. Sunnyside was the second largest silver producing operation in Colorado in 1984. Standard Metals, operating under Chapter 11 of the Federal Bankruptcy Code, agreed to sell the Sunnyside Mine to Echo Bay Mines Ltd. for $20 million plus other interests. Following approval of the sale by the U.S. Bankruptcy Court for the District of Colorado in late October, Echo Bay acquired the mine in November. Echo Bay subsequently began to refurbish the mine for a planned mid-1986 reopening.

Leadville Corp. assumed the costs of

maintaining the Sherman Mine on February 1, 1985, as stipulated in the 1984 agreement between Hecla Mining Co. and Leadville, which allows Leadville to purchase Hecla's 50-year operating lease of the mine for $1.5 million. Hecla subsequently extended the deadline for payment of the $1.5 million from December 31, 1985, to June 30, 1986. The Sherman Mine remained closed throughout 1985.

Asarco reported that 344,000 ounces of silver in concentrate was produced at its Leadville Unit.[6] In 1984, 363,000 ounces was produced.

Idaho.—In July 1985, NERCO DeLamar Co., a subsidiary of NERCO Inc., acquired Superior Oil Co.'s 47.5% interest in the DeLamar Mine, giving NERCO total ownership. Mine production at DeLamar was 1,557,000 ounces of silver and 28,000 ounces of gold.[7] Reserves at DeLamar were increased through exploration to 11.09 million tons grading 1.84 ounces of silver and 0.23 ounce of gold per ton.

At the Lucky Friday Mine, a record high 276,817 tons of ore was milled during 1985, compared with 257,315 tons in 1984.[8] Silver production was 4,740,971 ounces in 1985, a decrease of nearly 55,000 ounces from production in 1984. Despite the drop in silver output, productivity increased by 20%, owing in part to reduced employment and to mine and mill improvements. Hecla began testing a new mechanized mining method at Lucky Friday, which, if successful, should result in improved mine efficiency and safety.

Sunshine Mining Co. announced in January the closure of some low-grade stopes at the Sunshine Mine. An estimated 35 employees were affected by the decision. Production at the Sunshine Mine was 4,714,403 ounces of silver from 218,496 tons of ore, compared with 4,808,072 ounces in 1984.[9] Exploration and development activities continued in 1985, although at a lower rate than in previous years, owing in part to the lower silver price.

At Sunshine's refinery, 3,034,256 ounces of silver and 21,384 ounces of gold were produced from concentrates from the Sunshine and Sixteen-to-One Mines.[10] On December 13, Sunshine acquired the refining and minting equipment of Tentex Inc., a California-based precious metals reclamation and custom minting operation. Sunshine planned to move this equipment to Idaho. With this purchase, Sunshine completed the vertical integration of its precious metals operations, and thus could control its silver production from the mining of ore to the minting of bullion coins. Sunshine Bullion Co., a Sunshine subsidiary, reported sales of 4 million ounces of silver to the public in the form of bullion coins, bullion bars, and jewelry.

Bunker Limited Partnership closed some marginal underground workings at the Crescent Mine during the first quarter of 1985. At the Coeur Mine, Asarco reported the production of 2.6 million ounces of silver in concentrate, compared with 2.5 million ounces in 1984. At the Clayton Mine, 261,931 ounces of silver was recovered from 102,258 tons of ore in 1985, an increase of over 42,000 ounces from that of 1984. Silver production at the Galena Mine, operated by Asarco, declined in 1985 to 4.1 million ounces in concentrate from 4.2 million ounces in 1984.

Missouri.—Ore production at the Buick lead-zinc-silver mine improved from 1.5 million tons to about 2.3 million tons mined and milled in 1985. The production increase was the result of an agreement that ended a strike lasting from May 31 to December 29, 1984, by the mine's unionized workers. A significant reduction in Buick's reserves followed a decision by AMAX Inc., the mine operator, to revise Buick's mining plans. Reserves were reduced to 20 million tons, grading 8.0% lead and 2.2% zinc, from 36.1 million tons, grading 5.6% lead and 1.4% zinc.[11]

A record high 1.15 million tons of ore was produced at the Magmont Mine, a lead-zinc-silver operation, during 1985.[12] Productivity improved to 26.9 tons per worker shift owing to increased mining efficiency and increased mill throughput following replacement of the original flotation cells with large-volume cells.

Production began at Asarco's West Fork lead-zinc-silver mine in September. The mine was operating at about 40% of capacity by yearend. Reported production for the year was 2,000 ounces of silver, 3,900 tons of lead, and 100 tons of zinc, in concentrate.[13]

Montana.—Pegasus Gold Inc. acquired Wharf Resources Ltd.'s interest in the Landusky Mine for cash and warrants to purchase common shares in Pegasus. The transaction gave Pegasus total ownership of the gold-silver mine, which prior to the acquisition Pegasus had operated under a lease from Wharf. There was no production at Landusky in 1985 because of extensive planning required following the discovery and acquisition of substantial new reserves in 1984.

At the Zortman Mine, Pegasus produced 157,500 ounces of silver and 60,400 ounces of gold.[14] On March 20, Pegasus reached an agreement, subject to Gold Reserve Corp. shareholder approval, to acquire Gold Reserve's interest in the Zortman Mine in exchange for Pegasus' common shares. The agreement, if approved by Gold Reserve shareholders in 1986, would give Pegasus total ownership and control of the property.

Asarco reported that 3.6 million ounces of silver in concentrate was produced at the Troy Mine compared with 4.3 million ounces in 1984.

Nevada.—Production resumed at the Buckhorn Mine in March following a 4-month shutdown to modernize the ore handling and crushing facilities. The project increased capacity by 30%. In 1985, 600,000 tons of ore was milled to produce over 100,000 ounces of silver, compared with 10,000 ounces of silver from 194,000 tons of ore in 1984. Employment at the mine increased from 36 at yearend 1984 to 66 at yearend 1985.[15]

At the Fortitude Mine, 222,000 ounces of gold and 647,000 ounces of silver were produced.[16] The drilling program on the property resulted in an 18% increase in reserves. Reserves at Fortitude contain an estimated 1.6 million and 2.2 million ounces of recoverable gold and silver, respectively. The Surprise deposit, which Battle Mountain plans to develop as a satellite operation to the Fortitude Mine, was discovered by the Fortitude drilling program. Production from the Surprise deposit was expected to begin in 1987.

In February 1985, operations at the Gooseberry Mine were reduced from 10,000 tons per month to 1,200 tons per month owing to low precious metals prices. Production was maintained at the reduced level until November, when production was halted because of continued low prices and disappointing exploration results. During the year, 25,000 tons of ore was milled yielding an average of 0.182 ounce of gold and 7.87 ounces of silver per ton.[17]

Echo Bay acquired a 50% interest in the Round Mountain Mine on January 1, through the purchase of Copper Range Co. from The Louisiana Land and Exploration Co. Echo Bay subsequently reduced operating costs at the gold-silver heap-leach operation by lengthening the leach cycle, using higher leaching piles, using heated leaching solution in winter, and by pressure stripping of loaded carbon.

AMAX began construction at the Sleeper deposit, in northwestern Nevada. Production from a central high-grade zone containing 1.4 million tons of ore grading 0.324 ounce of gold and 0.903 ounce of silver per ton was expected in mid-1986.

Limited production resumed at the Victor Mine in the second half of 1985. Testing of the mine's facilities following renovations and expansion projects, completed since the mine's closure in 1984, was conducted during this period of production.

At the Candelaria Mine, 2.5 million ounces of silver was produced in 1985.[18] United Mining Corp. closed its New Savage Mine in April because of low gold and silver prices. The New Savage Mine is on the famous Comstock Lode. The Taylor Mine, one of Nevada's largest silver producers, remained closed throughout the year.

Utah.—Kennecott closed the Bingham Canyon Mine, a copper-gold-silver operation, in March reportedly because of low prices. During the third quarter, Kennecott announced the purchase of the Carr Fork Mine's reserves from Atlantic Richfield Co.'s Anaconda Minerals Co. subsidiary. The Carr Fork Mine is on property adjacent to Bingham Canyon. Near yearend, Kennecott's parent company, Standard Oil Co., announced a $400 million program to modernize Bingham Canyon. The projects were expected to be completed in 1988.

At the Escalante Mine, nearly 2.4 million ounces of silver was produced in 1985, an increase of over 203,000 ounces from that of 1984.[19] Operating costs at the mine were reduced through an 8% labor force reduction. Additional ore was developed on the southernly extension of the vein, and the possible presence of another vein north of the present mine boundary was indicated in drilling results.

Texaco Inc. sold its Getty Gold Co. subsidiary to Barrick Resources Corp. near midyear. Getty operated the Mercur Mine, a gold-silver operation in southern Utah.

Washington.—Asamera Minerals (U.S.) Inc. and Breakwater Resources Ltd. began commercial production at the Cannon Mine in 1985. The mine began operations on January 1, and the mill officially began production on July 15. Nearly 150,000 tons of gold-silver ore was processed. By yearend, mill throughput was averaging 1,600 tons per day. Tenneco Minerals Co. and United Mining sold their properties adjacent to the

Cannon Mine to Asamera and Breakwater for $12.5 million plus royalty and/or net profit interests. The properties sold by Tenneco and United Mining were estimated to contain 600,000 and 1,500,000 ounces of recoverable gold and silver, respectively.

Silver production at the Republic Mine increased to 101,521 ounces from 80,967 ounces in 1984.[20] Development work at the mine encountered two veins, which may contain 300,000 tons of ore, and could extend the mine's life by nearly 5 years at 1985 production rates.

Other States.—Handy & Harman opened a new secondary refinery in South Windsor, CT. The plant will process low-grade precious metal-bearing electronic scrap.

Production began at the Ropes gold mine, in Michigan, near yearend. Commercial production was lower than anticipated in part because of unstable wall conditions and localized faulting. A renovated iron ore mill treated 154,000 tons of ore, including 87,000 tons of development ore, during 1985. Average ore grade was 0.067 ounce of gold and 0.179 ounce of silver per ton.[21]

Echo Bay sold the White Pine copper-silver mine to Northern Copper Co., an investment group consisting predominantly of former White Pine employees and management, in the fourth quarter. Echo Bay acquired the Michigan mine, as part of the assets of Copper Range, which Echo Bay purchased from Louisiana Land and Exploration earlier in the year. The White Pine Mine, closed in 1982, was reopened by Northern Copper on November 1, 1985.

In October, AMAX announced that it would phase out smelting and refining operations at its Carteret, NJ, facility, owing to continuing losses and a poor outlook for secondary smelting and refining activities in the United States. Approximately 9.7 million ounces of silver was produced at Carteret from either purchased or toll-refined material during 1985.

Workers struck St. Joe Minerals' Balmat and Pierrepont Mines, in New York, on July 22. Although the strike continued through yearend, the mines were operated at partial capacity by salaried and some nonunion personnel.

Production at Asarco's Amarillo, TX, refinery was reported as 42.3 million ounces of silver, a decrease of about 4.1 million ounces from the 1984 output.[22]

CONSUMPTION AND USES

Overall silver consumption remained at about the same level as in 1984 and 1983. Silver consumption for photographic materials and in electrical and electronic products increased somewhat, reflecting the continued growth of the U.S. economy and lower silver prices. Stagnant consumption in most end uses may have been due to the continued use of more efficient manufacturing processes and substitutes developed during periods of higher prices, or to changes in consumer tastes, or to the availability of more financially liquid lower premium alternatives to holding silver as an investment.

STOCKS

Refiner, fabricator, and dealer stocks declined from 21.2 million ounces at yearend 1984 to 15.6 million ounces at the end of the 1985 third quarter. The decline in industrial stocks was probably due in part to the combination of a weak silver price and expectations of future price declines, which prompted stockholders to delay purchases, and to the increase in industrial consumption. In the fourth quarter, as the silver price declined to less than $6.00 per ounce, industrial stocks increased slightly, to 17.1 million ounces at yearend.

Silver depository stocks held by Commodity Exchange Inc. (COMEX) declined to 104.2 million ounces by the end of May, a 14.3-million-ounce decrease from yearend 1984 levels. By the end of June, however, COMEX stocks increased significantly to 132.4 million ounces, and continued to increase thereafter, ending the year significantly higher than in 1984. The depository stocks held by the Chicago Board of Trade (CBT) declined from yearend 1984 levels to 13.9 million ounces at the end of April 1985. CBT stocks increased later in the year, but at yearend 1985 were 17.8 million ounces, compared with 19.1 million ounces at yearend 1984.

PRICES

Although the domestic silver price, as quoted by Handy & Harman, remained in a relatively narrow range when compared with the volatile prices of the past several years, it continued along the downward trend begun in mid-1983. The most significant price movement occurred from mid-February 1985 through the end of March. The price began the year at $6.14 per ounce, was $5.83 at yearend, and averaged $6.14 for the year. U.S. currency exchange rates, crude oil prices, the U.S. economic outlook, and the potential returns on alternative investments were the major factors in silver price movements, according to analysts.

As with the Handy & Harman silver price, movement of the London spot price occurred within a relatively narrow range, and in general continued along the downward trend begun in mid-1983. The London spot price as quoted by Metals Week began 1985 at $6.25 per ounce. The low for the year of $5.45 occurred on February 25, after which the price increased, reaching the peak of $6.75 on April 15. During the remainder of 1985, the price gradually declined, ending the year at $5.80. The average price for the year was $6.13.

The Union Bank of Switzerland, the Swiss Bank Corp., and Credit Suisse, the three major banks of Switzerland, began publication of a silver price in December to compete with the price established by the London Metal Exchange. The yearend price established by these banks was $5.80.

Futures contracts representing 24.1 billion ounces of silver were traded on COMEX, a decrease of 9.6 billion ounces from the volume traded in 1984. The silver trading volume at the CBT declined by nearly 900 million ounces to 1 billion ounces in 1985. During the year, the CBT received permission from the Commodity Futures Trading Commission to trade options on its silver futures contract. Options trading began on March 29. Each option entitled the holder to either buy or sell one CBT futures contract representing 1,000 ounces of silver at a given price for a specified period of time. Silver futures trading on the Mid-America Commodity Exchange increased to 62 million ounces from 32 million ounces in 1984.

On October 3, 1985, an article in the Wall Street Journal reported that the Hunt brothers had disposed of most of their silver holdings. It was estimated that most of the sales took place over a 9-month period, and may have amounted to 54 million ounces of silver.[23]

FOREIGN TRADE

U.S. silver exports remained essentially unchanged in 1985, probably owing in part to the continued strength of the U.S. dollar throughout most of the year. A strong dollar, depending upon currency exchange rates, tended to cause silver purchased in the United States to be relatively more expensive than silver from other sources. Canada and Japan remained the largest recipient countries for U.S. silver, most of which was in the form of refined bullion. Exports of refined bullion to Canada increased by 1.1 million ounces; the increase may have been related to the increased participation of Canadian companies in the U.S. mining industry. Exports of refined bullion to Japan declined by nearly 600,000 ounces.

U.S. silver imports for consumption increased by one-third, in part owing to increased industrial consumption and the strong U.S. dollar. The most significant increases in silver imports into the United States came from the United Kingdom, with an increase of 18.8 million ounces; Belgium-Luxembourg, with an increase of 11.0 million; Switzerland, with an increase of 9.8 million; and Canada, with an increase of 9.2 million. Most of the increased imports from these countries consisted of refined bullion: the United Kingdom, 18.9 million ounces; Belgium-Luxembourg, 9.5 million ounces; Switzerland, 9.8 million ounces; and Canada, 8.7 million ounces. U.S. silver imports from Peru declined substantially.

Imports for consumption of ore and concentrates declined significantly. Peru, with a decrease of 7.3 million ounces, and Mexico, with a decrease of 1.7 million ounces, were the countries with the largest decreases in ore and concentrate shipments to the United States.

The United States was a net importer of silver. Net import reliance calculated as a percentage of apparent consumption was approximately 60%.

WORLD REVIEW

Despite the decline in U.S. silver production, world mine production of silver was essentially unchanged, owing in part to production from new mines, especially gold mines that produce byproduct silver, to the continued need by some developing countries to earn foreign exchange for debt repayment, and to the strong U.S. dollar, which moderated the impact of the declining silver price on foreign earnings. Exploration continued to be very active for gold deposits; however, exploration for other sources of byproduct silver, such as copper, lead, or zinc deposits, or for primary silver deposits was limited. Australia, Canada, Mexico, and Peru continued to be the countries where most of the silver-bearing discoveries were reported, although there appeared to be increasing interest in exploring the islands of the Pacific Basin for precious metals deposits.

Total consumption of silver by market economy countries was estimated at 382.6 million ounces, an increase of 11 million ounces over the revised figures for 1984. Of the 382.6 million ounces consumed, 373.9 million was used in industrial applications, an increase of 11 million ounces over the 1984 level. The quantity of silver used for coinage, 8.7 million ounces in 1985, was the same as the revised estimate for 1984.[24]

The total silver required by all market economy countries including the United States for industrial use and coinage, for bullion stocks, and for net exports to centrally planned economy countries exceeded their primary production by 106.3 million ounces. The shortfall was met with silver obtained from the following sources: old scrap, 72.2 million ounces; outflow from stocks held in India, 25.7 million ounces; demonetized coin, 3.0 million ounces; and withdrawals from government stocks, 5.4 million ounces. Estimated net exports to centrally planned economy countries was 1 million ounces.[25]

Australia.—Aberfoyle Ltd. reported that over 260,000 tons of ore was produced at the Que River Mine in Tasmania, a 19% increase from that of 1984.[26] Ore grades at the zinc-lead-copper-silver-gold mine were 14.2% zinc, 8.1% lead, 0.4% copper, 7.4 ounces of silver, and 0.1 ounce of gold per ton. During 1985, additional equipment was purchased to expand the mine's capacity to over 330,000 tons per year. Employment at the mine increased to 333 from 315 at yearend 1984.

Development work at Aberfoyle's Hellyer deposit continued. Construction of a 4,000-foot adit for underground exploration of the ore body reached the midpoint by yearend and was expected to reach the ore body in mid-1986. Laboratory testing on drill core samples indicated that flotation would probably be the most practical and economic process for treating the fine-grained polymetallic ore even though achieving any significant gold recovery from the ore would be difficult given the refractory nature of the gold content. Conversion of the nearby Cleveland tin mill to a trial milling facility for Hellyer ore continued and was expected to be completed by mid-1986. The mill was to have a nominal capacity of 11 tons per hour.

The British Petroleum Co. PLC reported that the Teutonic Bore Mine was closed owing to exhaustion of reserves. Silver production increased to nearly 1.14 million ounces from 1.06 million ounces in 1984.

At its Zinc Corporation Mine and New Broken Hill Consolidated Mine, CRA Ltd. reported that 2.46 million tons of ore was produced in 1985, compared with 2.06 million tons in 1984. Both mines were at Broken Hill in New South Wales. CRA decided to close the 47-year-old Zinc Corporation concentrator, and to upgrade the New Broken Hill concentrator so that it could treat the ore from both mines. An agreement was reached with the New South Wales government that would allow the mines to be connected to the New South Wales electricity grid, subsequently allowing the closure of CRA's oil-fired power generating station. The closure of the concentrator and the power station were expected to significantly reduce future operating costs.

Following agreements near yearend 1984, which allowed CRA to buy the interests of its two partners in the Woodlawn Mine, CRA completed the acquisition in early 1985. An exploration program to test the feasibility of extending the mine's life as an underground operation following exhaustion of strippable reserves was begun during 1985. Ore production was 1.03 million tons in 1985.[27]

Production began at the Kidston Mine, a gold operation with byproduct silver, on March 1. The Kidston Mine was operated by Kidston Gold Mines Ltd., a 70%-owned subsidiary of Placer Development Ltd. The mine was operating at design capacity by midyear, and at yearend, mill throughput was averaging 15,300 tons per day. During the first 10 months of operation, 4.16 million tons of ore was milled.[28]

During the fiscal year ended June 30, 1985, about 10.3 million tons of ore was treated at the Mount Isa Mine in Queensland.[29] Increased hoisting capacities and the use of the Jubilee mill heavy-medium plant in the silver-lead-zinc processing stream to increase the rejection of barren material prior to concentrator processing were cited as the major factors in allowing a record-high tonnage of ore to be processed.

M.I.M. Holdings Ltd. agreed to sell its 50% interest in the Lady Loretta deposit to Pancontinental Mining Ltd. on August 22. The deposit, in Queensland, contained silver, lead, and zinc.

Canada.—Silver production at Brunswick Mining and Smelting Corp. Ltd.'s No. 12 Mine increased to about 6.8 million ounces in concentrate from about 6.2 million ounces in 1984.[30] Construction of an in-mine crusher and a footwall backfill system was completed in 1985. Both projects were expected to reduce future operating costs. The No. 12 Mine was closed for 2 weeks at yearend owing to a zinc concentrate surplus. At its Smelting Div., Brunswick produced nearly 2,659,000 ounces of doré from 213,000 tons of concentrate, dust, and residues. Smelting Div. output was lower than in prior years owing in part to a January acid plant shutdown for catalyst screening.

At the Sullivan Mine, Cominco Ltd. milled 2,397,000 tons of ore with an average silver content of 1.5 ounces per ton. The mill throughput was less than the 2.73 million tons processed in 1984 because of a decision to reduce metal production at the Trail smelter-refinery complex. Employment at Sullivan declined from 1,125 to 986 at yearend 1985.

The Trail smelter refinery produced about 9.8 million ounces of refined silver, compared with 10.6 million ounces in 1984. Cominco attributed the lower refined silver production to a drop in quantity of lead concentrates with a high silver content that could be purchased by the company. Employment at Trail was reduced to 2,562 from 3,164, through rationalization and reorganization of the work force.

Production costs at the Silvana Mine were reduced following a conversion from diesel to hydropower, according to Dickenson Mines Ltd. The mine produced 470,000 ounces of silver from 25,418 tons of ore.[31]

Newmont Mining Corp. reported that 266,666 ounces of silver was produced from the treatment of 7,585,000 tons of ore at the Similkameen copper mine in British Columbia.[32] The increased mill throughput was attributed to the installation of an intermediate crusher in the grinding circuit during 1985. Silver production at the Fox copper-zinc-silver-gold and Ruttan copper-zinc-silver-gold mines, in which Newmont has a 34% interest, was 165,727 ounces and 304,196 ounces, respectively.

Noranda Inc. reopened the Bell copper-gold-silver and Brenda copper-molybdenum-gold-silver mines. Negotiations with the mines' labor unions and the British Columbia government prior to the reopenings obtained concessions that reduced the mines' operating costs. Silver production at the Bell Mine was 32,000 ounces, and the Brenda Mine produced 80,000 ounces.[33]

Noranda reported that the Geco Mine produced 1,325,000 ounces of contained silver, Mattabi Mines produced 555,000 ounces, and the Lyon Lake Mine produced 1,430,000 ounces. In 1984, these mines produced 1.4 million ounces, 1.2 million ounces, and about 1.9 million ounces of contained silver, respectively. Overall, mines in which Noranda had an interest in 1985 produced 9.8 million ounces of silver, 2.4 million ounces less than in 1984. Noranda reduced employment at its Horne smelter and CCR refinery through a combination of early retirements, layoffs, and attrition.

The Copper Rand mill produced 76,918 ounces of silver from the treatment of 402,922 tons of ore from the Copper Rand Mine, and 54,338 ounces of silver from the treatment of 285,335 tons of ore mined at the Portage Mine.[34] A 4-year expansion program at the Portage Mine was completed, and the mine returned to full capacity in the fourth quarter. Gold recovery at the mill was improved through the addition of a jig and two sluice boxes to the gravity circuit. However, a cyanidation plant installed in 1984-85 remained inoperative, owing to metallurgical problems. Operating costs at the mine and mill were reduced through improved operating efficiencies, mining lower tonnages, elimination of the summer vacation shutdown, and a reduction in employment from 651 to 525.

In October, a project was begun that would increase the mill capacity of the Equity silver mine from 5,800 tons per day to 8,500 tons per day. The project included construction of a second rod mill, construction of a third ball mill, and increased flotation and pumping capacities. Production for 1985 was 4.57 million ounces of silver in concentrate.[35] The mill processed about 2.3 million tons of ore.

At the Beaverdell Mine, Teck Corp. reported that 336,426 ounces of silver was produced, compared with 375,709 ounces in 1984.[36] Average mill throughput was 41,105 tons per day in 1985.

United Keno Hill Mines Ltd. reported the production of 1.3 million ounces of silver contained in lead concentrate.[37] A total of 74,609 tons of ore was milled during 1985. The Elsa Mine was reopened in May, and produced 1,980 tons of ore grading 48.2 ounces of silver per ton. Underground mining was also conducted at the Husky, Husky Central, Husky S.W., and Ruby Mines. Mining was halted at the Ruby Mine in May after production of 600 tons of ore, owing to the exhaustion of all known ore reserves. Average silver grade of the Ruby Mine ore was 25.7 ounces per ton. At the Calumet Pit, 221,200 tons of ore containing an average of 21.5 ounces of silver per ton was mined in 1985.

Mexico.—México, Desarrollo Industrial Minero S.A. (MEDIMSA) completed development of its new Rosario silver-zinc-copper-lead mine. At the Charcas Mine, MEDIMSA completed a capacity expansion project, which increased the silver-zinc-copper-lead operation's capacity from 1,400 to 3,800 tons per day. From its 11 mines and 5 metallurgical plants, MEDIMSA produced 22.87 million ounces of silver during 1985, compared with 21.23 million ounces in 1984.[38]

At the Real de Ángeles Mine, silver production increased by 23%, while lead and zinc output increased by 25% and 38%, respectively. Higher mill throughput and better recoveries were cited as the major factors for the increased output. Additional mining equipment was purchased and placed in service so that the increased milling rates could be maintained. Silver output was reported as 11.17 million ounces in concentrate in 1985 compared with 9.04 million ounces in 1984.[39] Ore reserves were increased substantially when it was discovered that mineralization extended below earlier pit designs.

AMAX reported that the mines of Compania Fresnillo S.A. de C.V., Zimapán S.A. de C.V., and Rosario Mexico S.A. de C.V. produced 10.4 million ounces of silver.[40] In 1984, these mines produced 10.3 million ounces. At the Bolanos Mine, 49% owned by Kennecott, 1.6 million ounces of silver was produced in 1985, an increase of 600,000 ounces from that of 1984.[41] Lacana Mining Corp. reported that its 30%-owned Torres mining complex in Guanajuato produced nearly 3.8 million ounces of silver in 1985, and that its 40%-owned Encantada Mining Group in Coahuila produced almost 1.2 million ounces of silver.[42] In 1984, Torres produced 4.2 million ounces, and Encantada, 1.8 million ounces. The reduced production by the Encantada Group was attributed to operational problems.

In May 1985, the Mexican Government granted tax and fiscal aid to Mexican mine operators owing to the peso devaluation and the declining silver price. Under the measure, mine operators would receive tax relief ranging from 10% to 45% on any tax assessed.

Peru.—Cía. de Minas Buenaventura S.A. remained Peru's largest privately owned silver producing company with an output of nearly 8.6 million ounces. At the Uchucchacua Mine, a project to increase capacity to 1,000 from 700 tons per day was completed. Production at Uchucchacua consisted of 18,515 tons of lead concentrates containing an average of 206.5 ounces of silver per ton. At the Julcani Mine, 7,801 tons of lead concentrates averaging 238.9 ounces of silver per ton was produced. Buenaventura's subsidiary, Cía. de Minas Orcopampa S.A., produced 6,614 tons of concentrates averaging 426.7 ounces of silver per ton. In December, the International Finance Corp. agreed to provide $10 million of the $30 million estimated cost to expand Orcopampa's capacity to 1,000 tons of ore per day, to construct a hydroelectric plant and other facilities, and for exploration and mine development.

At Empresa Minera del Centro del Perú (Centromín Perú), silver production increased to 14.2 from 13.2 million ounces in 1984. Record-high production of silver contained in concentrate was reported for the Casapalca Mine (4.5 million ounces), the Yauricocha Mine (1.3 million ounces), the Cerro-San Expedito Mine (1.1 million ounces), and the Cobriza Mine (948,000 ounces). In 1984, these mines produced 4.0 million, 1.2 million, 1.1 million, and 843,000 ounces, respectively. Centromín Perú's Cerro-Paragsha and Morococha Mines produced 3.1 million ounces and 2.0 million ounces of silver contained in concentrate in 1985, respectively. At the La Oroya Complex, production of refined silver decreased slightly to 23.2 million from 23.6 million ounces. Feed for La Oroya was provided by Centromín Perú and numerous independent mines during 1984.

Cía. Minera Arcata S.A., Peru's second largest private silver producer, produced 3.5 million ounces of silver at the Arcata Mine, compared with 3.3 million ounces in 1984. At the Caylloma Mine, Cía. Minera Caylloma S.A. produced 2.5 million ounces of silver in 1985, and reduced operating costs by 14%. Cía. Minera Milpo S.A. was able to increase output through production from new mine workings, adoption of new beneficiation techniques, and more efficient complementary services. The increased production at Milpo occurred despite several partial work stoppages due to terrorist attacks and a 26-day strike. The company produced nearly 30,000 tons of lead concentrates and 65,000 tons of zinc concentrates containing 79.6 and 4.2 ounces of silver per ton, respectively. Cía. Minera del Madrigal S.A. produced 357,750 ounces of silver in concentrate by milling 344,744 tons of ore grading 1.4 ounces of silver per ton. The Quiruvilca Mine, operated by Corporacíon Minera Nor Peru S.A. produced 2.0 million ounces of silver in 1985 compared with 1.8 million ounces in 1984. Southern Peru Copper Corp. (SPCC) milled 31.2 million tons of ore from its Toquepala and Cuajone Mines to produce 2.8 million ounces of silver contained in its blister copper. In 1984, SPCC milled 30.3 million tons of ore and produced 2.5 million ounces of silver.

Other Countries.—For the year ended October 31, 1985, Cía. Minera Aguilar S.A. milled 636,160 tons of ore to produce 1.4 million ounces of silver contained in lead concentrates at its Aguilar Mine in Argentina. The production was essentially the same as that of 1984. At the Quioma Mine in Bolivia, 131,000 ounces of silver was produced, compared with 52,000 ounces in 1984. St. Joe Gold announced that it would expand the capacity of its El Indio Mine, in Chile, to 2,100 tons per day from 1,800 tons per day. For the year ended October 31, 1985, El Indio produced nearly 1 million ounces of silver contained in either its direct smelting ore or its mill products.

The El Mochito Mine in Honduras produced 2.7 million ounces of silver in concentrate in 1985. Production at the mine was increased to offset declining ore grades and to reduce unit costs. In 1984, 2.6 million ounces of silver was produced.

Depressed copper and silver prices and national economic conditions were cited by Atlas Consolidated Mining and Development Corp. for operating reductions made at some of its properties in the Philippines. On July 5, the Biga concentrator was closed, and operations at the Biga and Carmen Pits reduced. Subsequently, the Carmen concentrator was closed on October 1 for general overhaul and for installation of transportation facilities to bring ore from the Lutopan Mine to the concentrator. At this time, the Biga and Carmen Pits were closed. In December, the Carmen concentrator resumed operation, along with some mining activities at the pits to supplement ore production from Lutopan. With the resumption of processing at the Carmen concentrator, the DAS concentrator was closed. Ore production for 1985 was 17.7 million tons from the Biga and Carmen Pits and 11.3 million tons from the Lutopan Mine. Silver content of the concentrates produced was 311,862 ounces, compared with 452,201 ounces in 1984.[43] At its Masbate Pit, Atlas produced 50,579 ounces of silver, a decrease of over 20,000 ounces from that of 1984. The heap-leaching plant at Masbate, in its first full year of operation, produced 6,146 ounces of silver.

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Ounce as used throughout this chapter refers to the troy ounce.
[3]Cyprus Minerals Co. 1985 Annual Report. 33 pp.
[4]ASARCO Incorporated. 1985 Annual Report. 33 pp.
[5]AMAX Inc. 1985 Annual Report. 37 pp.
[6]Work cited in footnote 4.
[7]NERCO Inc. 1985 10K Report. 32 pp.
[8]Hecla Mining Co. 1985 Annual Report. 33 pp.
[9]Sunshine Mining Co. 1985 Annual Report. 38 pp.
[10]Work cited in footnote 9.
[11]AMAX Inc. 1985 10K Report. 62 pp.
[12]Cominco Ltd. 1985 Annual Report. 37 pp.
[13]Work cited in footnote 4.
[14]Pegasus Gold Inc. 1985 Annual Report. 37 pp.
[15]Work cited in footnote 12.
[16]Battle Mountain Gold Co. 1985 Annual Report. 24 pp.
[17]Asamera Inc. 1985 Annual Report. 55 pp.
[18]Work cited in footnote 7.
[19]Work cited in footnote 8.
[20]Work cited in footnote 8.
[21]Callahan Mining Corp. 1985 10K Report. 27 pp.
[22]Work cited in footnote 4.
[23]Wall Street Journal. Hunts Sold Most of Silver Hoard, Taking Estimated $1 Billion Loss. Oct. 3, 1985, p. 3
[24]Handy & Harman. The Silver Market, 1985. 70th. Annual Report. 26 pp.
[25]Work cited in footnote 24.
[26]Aberfoyle Ltd. 1985 Annual Report. 25 pp.
[27]CRA Ltd. 1985 Annual Report. 60 pp.
[28]Placer Development Ltd. 1985 Annual Report. 43 pp.
[29]M.I.M. Holdings Ltd. 1985 Annual Report. 32 pp.
[30]Brunswick Mining and Smelting Corp. Ltd. 1985 Annual Report. 21 pp.
[31]Dickenson Mines Ltd. 1985 Annual Report. 32 pp.
[32]Newmont Mining Corp. 1985 Annual Report. 54 pp.
[33]Noranda Inc. 1985 Annual Report. 46 pp.
[34]Northgate Exploration Ltd. 1985 Annual Report. 29 pp.
[35]Work cited in footnote 27.
[36]Teck Corp. 1985 Annual Report. 33 pp.
[37]United Keno Hill Mines Ltd. 1985 Annual Report. 20 pp.
[38]Work cited in footnote 4.
[39]Work cited in footnote 27.
[40]Work cited in footnote 5.
[41]The British Petroleum Co. PLC 1985 Annual Report. 64 pp.
[42]Lacana Mining Corp. 1985 Annual Report. 33 pp.
[43]Atlas Consolidated Mining and Development Corp. 1985 Annual Report. 21 pp.

Table 2.—Mine production of recoverable silver in the United States, by State

(Troy ounces)

State	1981	1982	1983	1984	1985
Alaska	2,372	2,080	4,123	W	W
Arizona	8,055,231	6,309,327	4,491,532	r4,246,616	4,885,310
California	53,286	34,048	26,899	W	115,478
Colorado	3,008,994	1,934,312	2,145,616	2,199,888	548,696
Idaho	16,545,648	14,830,351	17,684,278	18,869,186	18,827,948
Illinois	W	W	W	W	W
Michigan	W	W	--	--	W
Missouri	1,837,011	2,241,159	2,021,343	1,401,070	1,635,301
Montana	2,988,810	6,168,711	5,707,963	5,652,847	4,009,979
Nevada	3,039,480	3,142,263	r5,179,394	6,477,032	4,946,523
New Mexico	1,632,346	804,594	W	W	W
New York	28,829	27,212	33,137	W	W
Oregon	7,487	--	856	W	--
South Carolina	W	--	--	--	W
South Dakota	55,792	26,241	62,314	50,036	63,156
Tennessee	W	W	W	W	W
Utah	2,882,671	4,342,333	4,566,610	W	W
Washington	67,390	W	W	W	W
Total	40,683,173	40,248,409	r43,430,937	r44,591,671	39,357,197

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 3.—Mine production of recoverable silver in the United States, by month

(Thousand troy ounces)

Month	1981	1982	1983r	1984r	1985
January	3,062	3,643	3,101	3,774	3,425
February	3,404	3,283	3,051	3,897	3,045
March	3,408	4,039	3,776	4,202	3,385
April	3,314	3,733	3,681	4,027	3,207
May	3,151	3,713	3,675	3,892	3,351
June	3,315	3,568	3,767	3,780	3,231
July	3,577	3,090	3,588	3,576	3,234
August	3,408	2,987	3,755	3,719	3,355
September	3,503	3,014	3,563	3,245	2,925
October	3,795	2,889	3,408	3,662	3,847
November	3,354	3,241	3,414	3,323	3,124
December	3,392	3,048	4,652	3,495	3,228
Total	40,683	40,248	43,431	44,592	39,357

rRevised.

Table 4.—Twenty-five leading silver producing mines in the United States in 1985, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Lucky Friday	Shoshone, ID	Hecla Mining Co	Silver ore.
2	Sunshine	do	Sunshine Mining Co	Do.
3	Galena	do	ASARCO Incorporated	Do.
4	Troy	Lincoln, MT	do	Silver-copper ore.
5	Coeur	Shoshone, ID	do	Silver ore.
6	Escalante	Iron, UT	Helca Mining Co	Do.
7	Candelaria	Mineral, NV	NERCO Metals Inc	Do.
8	DeLamar	Owyhee, ID	NERCO DeLamar Co	Gold-silver ore.
9	Sixteen-to-One	Esmeralda, NV	Sunshine Mining Co	Silver ore.
10	Tyrone	Grant, NM	Phelps Dodge Corp	Copper ore.
11	Sierrita	Pima, AZ	Duval Corp	Do.
12	Eisenhower	do	Eisenhower Mining Co	Do.
13	Morenci	Greenlee, AZ	Phelps Dodge Corp	Do.
14	Buick	Iron, MO	AMAX Lead Co. of Missouri	Lead ore.
15	Battle Mountain	Lander, NV	Battle Mountain Gold Co	Gold ore.
16	Bagdad	Yavapai, AZ	Cyprus Bagdad Copper Co	Copper ore.
17	Ray	Pinal, AZ	Kennecott	Do.
18	Crescent	Shoshone, ID	Bunker Limited Partnership	Silver ore.
19	San Manuel	Pinal, AZ	Magma Copper Co	Copper ore.
20	Magmont	Iron, MO	Cominco American Incorporated	Lead ore.
21	Leadville	Lake, CO	ASARCO Incorporated	Lead-zinc ore.
22	Reymert	Pinal, AZ	Nichols Development Corp	Silver ore.
23	Pinto Valley	Gila, AZ	Pinto Valley Copper Co	Copper ore.
24	Clayton	Custer, ID	Clayton Silver Mines	Silver ore.
25	Viburnum 29	Washington, MO	St. Joe Minerals Corp	Lead ore.

Table 5.—Silver produced in the United States, by State, type of mine, and class of ore

Year and State	Placer (troy ounces of silver)	Lode: Gold ore: Short tons	Lode: Gold ore: Troy ounces of silver	Lode: Gold-silver ore: Short tons	Lode: Gold-silver ore: Troy ounces of silver	Lode: Silver ore: Short tons	Lode: Silver ore: Troy ounces of silver
1981	1,839	8,758,364	754,037	1,040,878	2,263,535	4,538,322	19,095,412
1982	2,012	13,087,462	852,500	1,213,247	2,769,495	5,422,706	23,577,319
1983	4,035	18,329,722	1,146,835	1,129,756	1,794,753	[r]7,528,125	[r]30,079,569
1984	[r]1,503	24,581,032	1,333,227	1,587,850	2,890,407	7,804,144	31,328,954
1985:							
Alaska	W	--	--	--	--	--	--
Arizona	--	--	--	W	W	W	W
California	W	W	W	W	W	--	--
Colorado	--	811,529	69,317	--	--	W	W
Idaho	--	50,637	6,574	W	W	W	W
Illinois	--	--	--	--	--	--	--
Michigan	--	W	W	--	--	--	--
Missouri	--	--	--	--	--	--	--
Montana	W	W	W	W	W	40,832	231,894
Nevada	W	12,355,594	982,180	W	W	2,861,995	3,833,760
New Mexico	--	914,946	7,606	2,527	14,926	W	W
New York	--	--	--	--	--	--	--
South Carolina	--	W	W	--	--	--	--
South Dakota	--	2,345,704	63,156	--	--	--	--
Tennessee	--	--	--	--	--	--	--
Utah	--	W	W	--	--	292,000	2,430,000
Washington	--	W	W	--	--	--	--
Total	6,434	26,887,964	1,571,730	1,043,854	2,039,797	4,302,681	24,012,856
Percent of total silver	([1])	XX	4	XX	5	XX	61

Year and State	Lode: Copper ore: Short tons	Lode: Copper ore: Troy ounces of silver	Lode: Lead ore: Short tons	Lode: Lead ore: Troy ounces of silver	Lode: Zinc ore: Short tons	Lode: Zinc ore: Troy ounces of silver
1981	281,939,595	13,952,838	8,524,045	1,839,198	561,970	28,863
1982	190,713,274	9,420,220	9,407,482	2,244,737	713,228	27,212
1983	[2]171,614,767	[2]7,344,180	8,050,251	2,021,346	753,044	33,137
1984	[r 2]166,255,710	[r 2]6,526,427	5,272,047	1,723,368	923,843	61,505
1985:						
Alaska	--	--	--	--	--	--
Arizona	129,545,286	4,382,734	--	--	--	--
California	--	--	--	--	--	--
Colorado	--	--	--	--	--	--
Idaho	--	--	--	--	--	--
Illinois	--	--	--	--	--	--
Michigan	W	W	--	--	--	--
Missouri	--	--	7,091,945	1,635,301	--	--
Montana	2,842,971	3,565,927	--	--	--	--
Nevada	--	--	--	--	--	--
New Mexico	W	W	--	--	--	--
New York	--	--	--	--	W	W
South Carolina	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--
Tennessee	W	W	--	--	W	W
Utah	W	W	--	--	--	--
Washington	--	--	--	--	--	--
Total	154,658,676	9,659,224	7,091,945	1,635,301	949,988	28,285
Percent of total silver	XX	25	XX	4	XX	([1])

See footnotes at end of table.

Table 5.—Silver produced in the United States, by State, type of mine, and class of ore—Continued

Year and State	Lode				Total	
	Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Old tailings, etc.			
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
1981	3,186,988	2,369,785	286,419	[3]377,666	308,836,581	40,683,173
1982	2,125,147	919,329	433,446	[3] [4]435,585	223,115,992	40,248,409
1983	([5])	([5])	[6]856,550	[3] [7]1,007,082	[r]208,262,215	[r]43,430,937
1984	([5])	([5])	[6]15,377,223	[3] [7]726,280	[r]221,801,849	[r]44,591,671
1985:						
Alaska	--	--	--	--	--	W
Arizona	--	--	W	W	129,738,370	4,885,310
California	--	--	--	--	2,364,363	115,478
Colorado	W	W	--	--	1,041,194	548,696
Idaho	W	W	W	W	5,655,699	18,827,948
Illinois	--	--	W	W	W	W
Michigan	--	--	--	--	W	W
Missouri	--	--	--	--	7,091,945	1,635,301
Montana	--	--	W	W	10,412,113	4,009,979
Nevada	--	--	W	W	15,402,843	4,946,523
New Mexico	--	--	35	43	W	W
New York	--	--	--	--	W	W
South Carolina	--	--	--	--	W	W
South Dakota	--	--	--	--	2,345,704	63,156
Tennessee	--	--	--	--	W	W
Utah	--	--	12,385	367	W	W
Washington	--	--	--	--	W	W
Total	([5])	([5])	[6]4,271,240	[3] [7]403,570	199,206,348	39,357,197
Percent of total silver	XX	([5])	XX	1	XX	100

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Less than 1/2 unit.
[2]Includes copper-zinc ore and silver recovered from copper-zinc ore in Tennessee to avoid disclosing company proprietary data.
[3]Includes silver recovered from tungsten ore in California and silver recovered from fluorspar ore in Illinois.
[4]Includes silver recovered from molybdenum ore in Nevada.
[5]In order to avoid disclosing company proprietary data, copper-zinc ore and silver recovered from copper-zinc ore in Tennessee are included in totals for copper ore; and lead-zinc ore and silver recovered from lead-zinc ore in Colorado and Idaho are included in total "Old tailings, etc."
[6]Includes lead-zinc ore in Colorado and Idaho to avoid disclosing company proprietary data.
[7]Includes silver recovered from lead-zinc ore in Colorado and Idaho to avoid disclosing company proprietary data, and includes silver recovered from molybdenum ore in Nevada.

Table 6.—Silver produced in the United States by cyanidation[1]

Year	Leaching in vats, tanks, and closed containers[2] [3]		Leaching in open heaps or dumps[4]	
	Ore treated (thousand short tons)	Silver recovered (troy ounces)	Ore treated (thousand short tons)	Silver recovered (troy ounces)
1981	4,434,835	2,579,957	7,413,219	2,047,709
1982	[r]7,875,468	[r]5,460,897	12,295,132	1,384,326
1983[r]	9,733,730	7,058,108	12,727,412	2,201,221
1984[r]	11,172,695	7,752,063	18,222,366	2,986,172
1985	15,421,903	6,819,904	14,875,133	2,701,360

[r]Revised.
[1]May include small quantities recovered by leaching with thiourea, by bioextraction, and by proprietary processes.
[2]Including autoclaves.
[3]May include small quantities recovered by gravity methods.
[4]May include tailings and waste ore dumps.

Table 7.—Lode silver produced in the United States, by State

Year and State	Amalgamation		Cyanidation		Smelting of concentrates			Smelting of ore		Total ore processed[1] (short tons)	Total silver recovered (troy ounces)
	Ore treated (short tons)	Silver recovered (troy ounces)	Ore treated (short tons)	Silver recovered (troy ounces)	Ore concentrated (short tons)	Concentrates smelted (short tons)	Silver recovered (troy ounces)	Ore smelted (short tons)	Silver recovered (troy ounces)		
1981	790	6	11,848,054	4,627,666	296,500,821	7,157,354	34,815,156	486,916	1,238,506	308,836,581	40,681,334
1982	--	--	[r]20,170,600	[r]6,845,223	[r]202,592,304	[r]5,256,331	[r]32,719,805	353,088	681,369	223,115,992	40,246,397
1983	3,400	50	[r]22,461,142	[r]9,259,329	[r]185,513,477	[r]4,939,007	[r]33,338,651	284,196	[r] [2]829,030	[r]208,262,215	[r] [2]43,427,060
1984	--	--	[r]29,395,061	[r]10,738,235	[r]192,253,620	[r]4,108,133	[r]33,373,850	153,168	478,083	[r]221,801,849	[r]44,590,168
1985:											
Arizona	--	--	--	--	129,508,286	3,024,066	4,382,491	230,084	502,819	129,738,370	4,885,310
California	--	--	W	W	W	W	W	--	--	W	W
Colorado	--	--	W	W	257,967	38,490	506,154	W	W	1,041,194	548,696
Idaho	--	--	W	W	4,785,159	78,202	17,058,959	W	W	5,655,699	18,827,948
Illinois	--	--	--	--	W	W	W	--	--	W	W
Michigan	--	--	W	W	W	W	W	--	--	W	W
Missouri	--	--	--	--	7,091,945	660,069	1,635,301	--	--	7,091,945	1,635,301
Montana	--	--	W	W	2,883,803	39,293	3,797,821	610	2,869	10,412,113	W
Nevada	--	--	14,803,688	4,853,312	599,080	1,577	92,086	W	W	W	W
New Mexico	--	--	914,946	7,606	W	W	W	W	W	W	W
New York	--	--	--	--	W	W	W	--	--	W	W
South Carolina	--	--	W	W	--	--	--	--	--	W	W
South Dakota	--	--	2,345,704	63,156	--	--	--	--	--	2,345,704	63,156
Tennessee	--	--	--	--	W	W	W	--	--	W	W
Utah	--	--	292,000	2,430,000	W	W	W	W	W	W	W
Washington	--	--	W	W	W	W	W	--	--	W	W
Total	--	--	30,297,036	9,521,264	168,650,998	4,540,641	29,238,043	258,314	591,456	199,206,348	39,350,763

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes old tailings and some nonsilver-bearing ores not separable, in amounts ranging from 0.04% to 0.12% of the totals for the years listed. Excludes fluorspar, molybdenum, and tungsten ores from which silver was recovered as a byproduct and excludes ores leached for recovery of copper.
[2]Includes some placer production to avoid disclosing company proprietary data.

Table 8.—U.S. refinery production of silver

(Thousand troy ounces)

Raw material	1981	1982	1983	1984	1985
Concentrates and ores:					
Domestic	44,487	43,825	50,281	r49,892	45,609
Foreign	2,520	344	169	126	--
Total[1]	47,007	44,170	50,450	r50,019	45,609
Old scrap	39,067	27,171	25,549	24,070	24,285
New scrap	44,738	37,812	41,839	r45,503	48,036
Grand total[1]	130,812	109,153	117,838	r119,592	117,931

rRevised.
[1]Data may not add to totals shown because of independent rounding.

Table 9.—U.S. consumption of silver, by end use

(Thousand troy ounces)

End use[1]	1981	1982	1983	1984	1985
Electroplated ware	3,904	3,254	3,154	3,542	3,660
Sterlingware	4,407	6,579	7,022	3,638	3,527
Jewelry	5,368	6,260	6,885	5,773	5,779
Photographic materials	51,025	51,769	51,827	55,322	57,895
Dental and medical supplies	1,709	1,688	1,532	1,569	1,485
Mirrors	581	970	970	970	970
Brazing alloys and solders	7,718	7,384	5,837	5,889	5,590
Electrical and electronic products:					
Batteries	3,803	4,167	2,800	2,671	2,470
Contacts and conductors	26,411	27,730	26,298	25,633	27,517
Bearings	297	228	170	260	183
Catalysts	3,830	2,418	2,424	2,448	2,409
Coins, medallions, commemorative objects	2,622	1,832	2,979	2,564	2,514
Miscellaneous[2]	4,995	4,562	4,567	4,562	4,559
Total net industrial consumption[3]	116,670	118,840	116,464	114,841	118,559
Coinage	179	1,846	2,128	2,665	355
Total consumption[3]	116,849	120,686	118,592	117,506	118,914

[1]End use as reported by converters of refined silver.
[2]Includes silver-bearing copper, silver-bearing lead anodes, ceramics, paints, etc.
[3]Data may not add to totals shown because of independent rounding.

Table 10.—Yearend stocks of silver in the United States

(Thousand troy ounces)

	1981	1982	1983	1984	1985
Industry	20,875	20,467	17,536	21,173	17,136
Futures exchanges	96,511	106,182	151,232	137,631	173,144
U.S. Department of the Treasury	38,732	36,768	34,565	31,889	32,621
U.S. Department of Defense	3,810	1,750	100	342	460
National Defense Stockpile	137,500	137,500	137,500	137,500	137,500

Table 11.—U.S. silver prices

(Dollars per troy ounce)

Period	Low	(date)	High	(date)	Average
1981	7.95	(Dec. 29)	16.45	(Jan. 6)	10.52
1982	4.88	(June 21)	11.21	(Dec. 29)	7.95
1983	8.34	(Nov. 17)	14.74	(Feb. 16)	11.44
1984	6.26	(Dec. 20)	10.04	(March 5)	8.14
1985:					
January	5.60	(Jan. 7)	6.37	(Jan. 31)	6.10
February	5.60	(Feb. 25)	6.32	(Feb. 14)	6.07
March	5.57	(Mar. 12)	6.74	(Mar. 27)	6.01
April	6.16	(Apr. 24)	6.72	(Apr. 11)	6.46
May	6.02	(May 28)	6.65	(May 14)	6.28
June	6.07	(June 3)	6.39	(June 18)	6.17
July	5.90	(July 3)	6.36	(July 29)	6.10
August	6.11	(Aug. 6)	6.38	(Aug. 16)	6.25
September	5.88	(Sept. 18)	6.16	(Sept. 24, 25)	6.05
October	6.03	(Oct. 1)	6.33	(Oct. 3)	6.19
November	6.00	(Nov. 8)	6.28	(Nov. 25)	6.13
December	5.71	(Dec. 11)	6.08	(Dec. 3)	5.89
Average	XX		XX		6.14

XX Not applicable.

Source: Handy & Harman daily quotation.

Table 12.—U.S. exports of silver, by country

(Thousand troy ounces and thousand dollars)

Year and country	Ore and concentrates		Waste and sweepings		Doré and precipitates		Refined bullion		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1981	213	1,510	9,746	115,106	2,813	34,474	15,131	181,380	27,903	332,470
1982	47	368	10,937	87,644	1,610	14,756	12,876	105,977	25,470	208,748
1983	67	554	17,231	197,996	996	9,516	13,658	169,383	31,952	377,449
1984	1,048	8,335	12,059	102,452	1,001	9,178	10,340	86,339	24,447	206,306
1985:										
Belgium-Luxembourg	265	1,604	2,148	15,161	1	12	1	18	2,415	16,794
Brazil	--	--	10	81	22	192	901	6,547	933	6,820
Canada	4	35	2,734	17,845	242	1,577	5,702	37,450	8,682	56,907
France	--	--	1,727	10,778	78	610	--	--	1,805	11,388
Japan	--	--	21	116	204	1,624	3,578	22,475	3,803	24,215
Spain	--	--	704	4,795	147	869	467	2,900	1,318	8,564
Sweden	--	--	1,335	8,136	--	--	55	358	1,390	8,493
United Kingdom	--	--	1,075	7,311	521	1,551	1	5	1,597	8,867
Uruguay	--	--	16	102	--	--	1,752	11,056	1,769	11,158
Other	1	11	556	3,560	336	3,115	153	936	1,046	7,622
Total[1]	270	1,651	10,325	67,884	1,550	9,551	12,611	81,746	24,756	160,832

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 13.—U.S. imports for consumption of silver, by country

(Thousand troy ounces and thousand dollars)

Year and country	Ore and concentrates		Waste and scrap		Doré and precipitates		Refined bullion		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1981	9,769	100,422	2,051	16,414	6,374	74,439	75,921	837,174	94,115	1,028,450
1982	12,530	91,638	2,837	11,979	5,173	37,308	96,917	786,154	117,458	927,079
1983	13,911	145,419	1,241	13,010	3,540	39,038	161,199	1,926,102	179,891	2,123,569
1984	13,018	105,587	903	7,871	7,499	64,901	93,546	784,838	114,966	963,198
1985:										
Belgium-Luxembourg	37	200	1	5	1,541	11,624	9,477	62,715	11,055	74,545
Brazil	419	2,242	110	715	17	92	42	258	588	3,307
Canada	518	3,365	607	3,695	847	5,446	43,903	275,189	45,875	287,696
Chile	155	223	464	2,842	4,356	28,554	388	2,411	5,363	34,029
Dominican Republic	--	--	--	--	1,521	9,395	110	673	1,631	10,068
Germany, Federal Republic of	--	--	2	13	375	2,561	160	1,009	537	3,582
Mexico	1,157	7,424	37	302	539	3,055	39,874	240,281	41,608	251,062
Netherlands	--	--	26	172	--	--	1,823	11,174	1,849	11,345
Peru	8	50	424	2,520	384	2,494	11,252	71,164	12,068	76,228
Switzerland	--	--	--	--	109	847	10,157	64,352	10,267	65,199
United Kingdom	602	3,114	9	62	53	365	18,990	118,635	19,654	122,175
Other	637	3,563	90	525	158	930	1,221	7,689	2,106	12,709
Total[1]	3,533	20,180	1,771	10,854	9,900	65,364	137,398	855,550	152,601	951,947

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 14.—Silver: World mine production, by country[1]

(Thousand troy ounces)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	110	110	120	120	120
Argentina	2,518	2,684	2,500	1,662	1,600
Australia	23,906	29,156	33,208	31,183	35,000
Bolivia	6,394	5,472	6,025	4,560	4,000
Brazil[3]	765	760	486	829	850
Bulgaria[e]	930	930	930	930	930
Burma	450	526	558	455	[4]568
Canada	36,298	42,246	35,559	42,655	[4]38,889
Chile	11,610	12,288	15,055	15,766	[4]16,633
China[e]	2,500	2,500	2,500	2,500	3,000
Colombia[5]	143	136	99	130	200
Costa Rica[e]	2	2	2	2	2
Czechoslovakia[e]	1,125	1,061	964	1,029	1,000
Dominican Republic	2,034	[r]2,198	1,329	1,207	[4]1,560
Ecuador	32	10	3	2	2
El Salvador	137	86	22	22	20
Fiji	8	19	13	15	[4]15
Finland	[r]1,215	[r]1,188	980	1,123	1,100
France	[r]1,707	[r]983	696	770	700
German Democratic Republic	1,450	1,450	1,380	1,290	1,400
Germany, Federal Republic of	1,126	1,279	1,167	1,225	1,225
Ghana[e]	17	[4]17	14	14	14
Greece	1,945	1,582	1,797	[e]1,800	1,700
Greenland[e]	700	[r]700	[r]600	[r]500	500
Guatemala[e]	8	[r]3	([6])	([6])	--
Honduras	1,823	2,100	2,587	[e]2,650	[4]2,678
India[5]	555	463	469	862	[4]778
Indonesia	830	1,134	1,135	1,121	1,170
Ireland	596	352	309	279	250
Italy[5 7]	1,768	1,791	2,361	1,554	[4]2,301
Japan	9,010	9,843	9,877	10,403	[4]10,899
Korea, North[e]	1,600	1,600	1,600	1,600	1,600
Korea, Republic of	3,061	3,237	3,366	3,759	[4]3,990
Malaysia (Sabah)	465	502	481	470	500
Mexico	52,916	59,175	63,607	75,340	69,000
Morocco[e]	2,120	2,640	2,850	[r]2,410	[4]2,733
Namibia	3,456	2,812	3,535	3,255	[4]3,400
New Zealand	--	--	([8])	([6])	--
Nicaragua	140	76	63	[e]50	[4]30
Papua New Guinea	1,363	1,387	1,524	1,427	1,483
Peru	46,940	53,479	55,878	56,523	[4]60,395
Philippines	2,024	1,984	1,823	1,574	[4]1,743
Poland	20,576	21,123	21,798	23,920	24,000
Portugal	39	24	32	29	30
Romania[e]	850	850	820	810	810
Solomon Islands	([8])	([8])	([8])	--	--
South Africa, Republic of	7,568	6,943	6,513	6,997	[4]6,721
Spain	5,347	3,787	1,496	4,999	5,000
Sweden	5,170	5,395	5,491	5,793	[4]6,102
Taiwan	215	504	345	364	[4]366
Tunisia	84	115	90	[r e]85	[4]26
Turkey[e]	200	220	220	220	220
U.S.S.R.[e 5]	46,500	46,900	47,200	47,400	47,900
United States	40,683	40,248	43,431	44,592	[4]39,357
Yugoslavia[5]	4,437	3,343	3,987	4,051	[4]5,015
Zaire	2,580	1,751	1,288	1,225	1,200
Zambia	714	887	933	795	648
Zimbabwe	857	918	938	893	900
Total	[r]361,617	[r]382,969	392,054	415,239	412,273

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Recoverable content of ores and concentrates produced unless otherwise specified. Table includes data available through July 1, 1986.

[2]In addition to the countries listed, Austria and Thailand may produce silver, but information is inadequate to make reliable estimates of output levels.

[3]Of total production, the following quantities, in thousand troy ounces, are identified as placer silver (the balance being silver content of other ores and concentrates): 1981—144; 1982—123; 1983—247; 1984—250 (estimated); and 1985—250 (estimated).

[4]Reported figure.

[5]Smelter and/or refinery production.

[6]Revised to zero.

[7]Includes production from imported ores.

[8]Less than 1/2 unit.

Slag—Iron and Steel

By Donald P. Mickelsen[1]

Domestic production of iron and steel slag decreased slightly during 1985. A significant decrease in sales and use of iron slag was partially offset by a strong increase in sales and use of steel slag. Air-cooled iron-blast-furnace slag continued to comprise the largest portion of total blast furnace slag sold or used.

The construction industry was the major user of iron and steel slag products. Air-cooled iron-blast-furnace slag was used mainly for road base, concrete aggregate, asphaltic concrete aggregate, fill, and railroad ballast. The use of air-cooled slag as a road base dropped considerably below that of 1984. Growth areas for iron slag include replacement for cement in concrete construction, use as a concrete aggregate, and as an aggregate in bituminous mixtures. Steel slag was typically used as road base and fill. The average unit value of blast furnace slag increased 13%, and steel slag decreased 11% in unit value from that of 1984.

Domestic Data Coverage.—Sales, use, and transportation data for iron and steel slag are developed by the Bureau of Mines from a voluntary annual survey of U.S. processors. Of the 93 operations canvassed, all responded, representing 100% of the total sales or use data shown in table 1. Of the 93 respondents, 87 shipped processed slag, 4 reported their operations as idle, and 2 reported operations as permanently closed.

DOMESTIC PRODUCTION

Domestic iron and steel slag production, which is not reported to the Bureau of Mines, apparently decreased owing to a slight decline in U.S. iron and steel production. Sales and use of iron and steel slag, when combined, decreased only slightly from that of 1984. Blast furnace slag consumption, however, decreased significantly but was offset by strong increases in the sales and use of steel slag. Sales of all kinds of iron and steel slag were still above the levels of 1982 and 1983, reflecting continued increases in the construction industry which uses most of the slag produced by iron and steel plants. According to the U.S. Department of Commerce, private nonresidential, public, and highway and bridge construction increased 10%, 9%, and 12%, respectively, in 1985.[2] In general, most blast furnace slag processors reported decreases in sales, in some cases owing to a lack of availability of iron slag to process. Most steel slag processors, on the other hand, either reported increases in sales or their sales remained relatively stable. Steel slag sales data also increased because of the addition of 17 operations to the survey.

Blast furnace slag sold or used decreased 10% in quantity yet increased slightly in value compared with that of 1984, totaling 15.1 million short tons valued at $86.9 million. Sixty-six percent of this, in decreasing order, was marketed in Pennsylvania, Ohio, Indiana, and Michigan. Of the blast furnace slag sold or used, 89% was air cooled. During 1985, 38 plants processed iron slag, 1 plant was inactive, and 1 plant closed. Steel slag sold or used totaled 6.0 million tons valued at $17.5 million, up 13% in quantity and only slightly in value com-

Table 1.—Iron and steel slags sold or used[1] in the United States

(Thousand short tons and thousand dollars)

Year	Iron-blast-furnace slag: Air-cooled		Granulated		Expanded		Total iron slag[2]		Steel slag		Total slag[2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1981	14,461	60,164	456	1,823	800	4,953	15,717	66,941	5,770	17,494	21,487	84,435
1982	13,617	56,816	597	3,237	539	4,800	14,752	64,854	4,764	14,641	19,516	79,495
1983	12,380	50,999	(3)	(3)	1,175	13,736	13,554	64,735	4,832	14,546	18,386	79,280
1984	15,325	66,289	(3)	(3)	1,452	19,142	16,776	85,432	5,287	17,327	22,063	102,758
1985	13,363	62,588	(3)	(3)	1,742	24,290	15,106	86,878	5,972	17,472	21,078	104,351

[1]Value based on selling price at plant.
[2]Data may not add to totals shown because of independent rounding.
[3]Included with "Expanded" to avoid disclosing company proprietary data.

pared with that of 1984. Sixty plants processed steel slag including 17 operations added to the 1985 survey. Of all iron and steel slag products shipped, 86% traveled by truck with an average marketing range of 30 miles; 8% traveled by waterway with an average marketing range of 394 miles; and 5% traveled by rail with an average marketing range of 153 miles. The remaining 1% was used at the plantsite.

Blue Circle Industries PLC, the largest cement manufacturer in the United Kingdom, purchased the Atlantic Cement Co., a U.S. subsidiary of Newmont Mining Corp., in May. Atlantic's slag cement plant in Sparrows Point, MD, with a capacity of 800,000 tons per year was included in the purchase.[3]

The National Slag Association conducted a survey of physical and chemical characteristics of blast furnace and steel furnace slags produced at U.S. operations by association members. Average chemical analysis of 18 blast furnace slag producers surveyed was as follows: silica (SiO_2), 36%; alumina (Al_2O_3), 10%; lime (CaO), 39%; magnesia (MgO), 12%; ferric oxide (Fe_2O_3), 0.5%; manganese oxide (MnO), 0.44%; and sulfur (S), 1.4%. Average blast furnace slag unit weight was 78 pounds per cubic foot, and absorption was 4.3%. Average analysis of slag from 17 electric arc furnaces (EAF) was as follows: SiO_2, 16.9%; Al_2O_3, 8.1%; CaO, 41.2%; MgO, 10.2%; MnO, 3.6%; S, 0.23%; ferrous oxide (FeO), 18.1%; iron (Fe), 13.6%; phosphorus pentoxide (P_2O_5), 0.63%; and phosphorus (P), 0.43%. Average analysis of slag from 12 basic oxygen furnaces (BOF) was as follows: SiO_2, 14.1%; Al_2O_3, 1.9%; CaO, 44.4%; MgO, 7.4%; MnO, 5.7%; S, 0.17%; FeO, 22.4%; Fe, 20.7%; P_2O_5, 0.75%; and P, 0.28%. Iron analyses shown are averages for iron data reported separately by some producers. The average unit weight and absorption for EAF slags were 106 pounds per cubic foot and 2.5%, and for BOF slags, 126 pounds per cubic foot and 2.4%, respectively.[4]

CONSUMPTION AND USES

Iron and steel slags, byproducts of ironmaking and steelmaking, were utilized mainly by the construction industry as substitutes for natural aggregates and other construction materials. Historically, iron and steel slags have been used as replacement materials because of economic benefits, better characteristics for some applications, and shortages of natural aggregates in some areas.

Essentially all iron-blast-furnace slag produced is eventually utilized. Of the air-cooled iron-blast-furnace slag sold or used in 1985, 44% was used as road base, 12% as concrete aggregate, 11% as asphaltic concrete aggregate, 10% as fill, and 8% as railroad ballast. The remaining 15% was used for producing mineral wool and in concrete products, roofing, sewage treatment, soil conditioning, glass manufacture, ice control, and other miscellaneous uses. Usage as a road base, while by far the largest end use for air-cooled iron-blast-furnace slag, dropped significantly in 1985, decreasing 27% from that of 1984. Expanded blast furnace slag was mainly used as lightweight concrete aggregate. Concrete products and all other end uses for expanded slag and for granulated blast furnace slag are combined under "Other" to avoid disclosing company proprietary data. Currently, growth areas for iron slag include replacement for cement in concrete construction, use as an aggregate in bituminous mixtures, and use as an aggregate in concrete. As a replacement for cement, ground granulated blast furnace slag offers a savings in natural resources and in energy required to manufacture cement clinker.

Approximately 3.0 million tons of steel slag was recycled to blast furnaces in 1985. The bulk of steel slag produced, however, was used in aggregate applications. Steel slag processed and sold primarily as road base comprised 52%; as fill, 24%; as asphaltic concrete aggregate, 7%; and as railroad ballast, 6%. The remaining 11% was used for ice control and miscellaneous uses. The major growth areas for iron and steel slag usage were as fill and road base.

PRICES

The average unit price, f.o.b. plant, for all iron-blast-furnace slag sold increased 13% over that of 1984 to $5.75 per ton. Air-cooled slag increased 8% to $4.68 per ton, and expanded slag decreased slightly to $11.00 per ton. Price information for granulated slag was withheld to avoid disclosing company proprietary data. Steel slag unit value was $2.93 per ton, down 11% from that of 1984. Higher prices in some use categories indicate that additional processing was required to meet some users' specifications.

FOREIGN TRADE

U.S. export and import information for iron and steel slag cannot be determined because slag is classified in nonseparable combined categories. U.S. exports of slag are classified under the schedule heading "Mineral Substances and Articles of Mineral Substances Not Specifically Provided For" and "Waste and Scrap Not Specifically Provided For," while U.S. imports of slag are classified as either "Metal Bearing Ores and Metal Bearing Materials" or "Waste and Scrap Not Specifically Provided For." Blast furnace slag is exported to and imported from Canada periodically.

Basic slag, a byproduct of basic steelmaking processes, is both exported and imported by the United States for use as an artificial fertilizer because of its high lime and phosphorus content. Statistics developed by the U.S. Department of Commerce, Bureau of the Census, indicate that in 1985, 12,000 tons of basic slag valued at $170,220 was imported from Canada, and 418 tons valued at $26,000 was exported to Canada.

WORLD REVIEW

Estimated world production of iron-blast-furnace slag and steel slag was 126 million and 57 million tons, respectively. Reported production of iron and steel slag by country is incomplete owing to late reporting, insufficiency of data, and lack of reporting by some countries where slag is thought of as a waste product rather than a resource.

Canada.—Iron and steel slag in Canada is considered a waste product that creates disposal problems. A recent venture, planned by the Reiss Lime Co. of Canada Ltd., involves the use of slag cement for backfill at the Sudbury and Elliot Lake uranium mines, Ontario. The project entails the production of water granulated blast furnace slag from The Algoma Steel Corp. Ltd.'s Sault Ste. Marie plant to be ground to cement specifications at Reiss' Spragge operation. Slag cement was chosen over regular cement owing to considerable cost savings.[5] The project is expected to cost $9.5 million and provide employment for laid off miners.[6]

European Economic Community.—Indicated levels of slag production were essentially unchanged in Europe, since iron and steel production increased only slightly compared with that of 1984. The most current data published by the statistical office of the European Economic Community (EEC) show that a total of 20,570,207 tons of iron-blast-furnace slag was produced in the EEC in 1984.[7]

Japan.—A world leader in iron and steel production, Japan produced and utilized an estimated 26 million tons of iron slag and 14 million tons of steel slag, virtually the same as that in 1984. Approximately 40% of the blast furnace slag consumed was used in cement manufacture, and 35% was used for roadbed aggregate and railroad ballast. The remainder was used for concrete aggregate, fertilizer, soil conditioner, and other uses.[8] Most of the steel slag produced was used in road construction.

TECHNOLOGY

In 1984, the Oakland County Road Commission in Michigan used blast furnace slag in two unique roadbed designs intended to correct soft, unstable subsoil conditions for highway expansion. The first design utilized Tensar high-strength polymer reinforcing geogrids between layers of lightweight blast furnace slag. The Orchard Lake Road had a 600-foot stretch of historically unstable roadbed to be expanded, having as much as 25 feet of soft, saturated subsoils beneath. Multiple layers of compacted lightweight blast furnace slag alternated with layers of overlapping Tensar geogrid were used to prevent consolidation of the roadway, to distribute horizontal stresses, and to tie the subbase together. After 16 months of use, with average daily trips of 22,400, the highway reportedly showed no signs of stress.

The second design, used to widen Opdyke Road onto soft compressive subsoil, involved encapsulating an 18-inch-thick by 23-foot-wide compacted subbase of 6A gradation (3/8 to 1-1/4 inches) blast furnace slag with a Mirafi woven stabilization fabric. The result was a 23-foot-wide mat foundation used to stabilize the subgrade and on top of which the roadway was constructed. The project was completed in 1981 and after about 4 years of service, with average daily trips of 18,000, the highway reportedly showed no visible signs of settlement.[9]

The Aerofall mill, a dry, air-swept grinding mill, was described in a recent paper. The Aerofall mill system is designed to process course feed material from a primary crusher; to separate, clean and discharge metallics; and to reduce nonmetallics to a dry ground product in a single stage. The mill can be used for the grinding of various metallurgical slags, including iron and steel slags. It is currently being used to process iron and steel slag in Japan and iron-titanium slag in the Republic of South Africa as well as petroleum coke and various metallurgical drosses in the United States.[10]

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[1]Mineral data specialist, Division of Ferrous Metals.

[2]U.S. Department of Commerce. Construction Review. V. 31, No. 6, Nov.-Dec. 1985, pp. 2, 8-14.

[3]Industrial Minerals (London). World of Minerals: USA-Blue Circle to Acquire Atlantic Cement. No. 212, May 1985, p. 13.

[4]National Slag Association. 1985 Survey of Physical and Chemical Characteristics of Blast-Furnace and Steel-Furnace Slags. MF185-3, 1985, 5 pp.

[5]Mining Journal. V. 305, No. 7826, Aug. 16, 1985, p. 118.

[6]Where necessary, values have been converted from Canadian dollars (CAN$) to U.S. dollars at the rate of CAN$1.3188=US$1.00, the average exchange rate for 1985.

[7]Statistical Office of the European Economic Community. 1985 Iron and Steel Yearbook, p. 74.

[8]National Slag Association. Bulletin: Utilization of Blast-Furnace Slag in Japan. No. 4-85, Mar. 29, 1985, p. 1.

[9]———. Slag Used in Unique Designs For Highway Base Over Very Soft Sub-soil. MF185-7, 1985, 3 pp.

[10]Heath, R. A. The Aerofall Mill Applied to Industrial Materials. Paper on Recycle and Secondary Recovery of Metals, ed. by P. R. Taylor, H. Y. Sohn, and N. Jarrett (Proc. at Symp. Metall. Soc. AIME, Ft. Lauderdale, FL, Dec. 1-4, 1985). Metall. Soc. AIME, Warrendale, PA, 1985, pp. 625-635.

Table 2.—Iron-blast-furnace slags sold or used[1] in the United States, by region and State

(Thousand short tons and thousand dollars)

Region and State	1984				1985			
	Air-cooled, screened and unscreened		Total, all types		Air-cooled, screened and unscreened		Total, all types	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
North Central:								
Illinois, Indiana, Michigan	4,878	16,780	W	W	4,424	17,488	W	W
Ohio	2,348	12,225	W	W	2,460	13,818	W	W
Total	7,226	29,005	7,751	32,387	6,884	31,306	7,483	35,708
Middle Atlantic:								
Pennsylvania	3,773	20,485	W	W	2,488	13,298	W	W
Maryland, New York, West Virginia	957	4,374	W	W	1,066	4,603	W	W
Total	4,730	24,859	5,656	40,619	3,554	17,901	4,696	37,789
West: Colorado, Texas, Utah	2,225	6,071	2,225	6,071	1,508	5,754	1,508	5,754
South: Alabama and Kentucky	858	5,329	858	5,329	875	5,719	875	5,719
Pacific: California	288	1,026	288	1,026	543	1,908	543	1,908
Grand total[2]	15,325	66,289	16,776	85,432	13,363	62,588	15,106	86,878

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Value based on selling price at plant.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Locations and processing methods of iron slag and sources of steel slag[1] in 1985

State, city, and company	Processing method of iron slag: Air-cooled	Processing method of iron slag: Ex-panded	Processing method of iron slag: Granu-lated	Steel slag	Sources of steel slag: Open hearth	Sources of steel slag: Basic oxygen process	Sources of steel slag: Elec-tric
Alabama:							
Alabama City:							
Vulcan Materials Co	1	--	--	1	--	1	--
Fairfield:							
Vulcan Materials Co	1	--	--	1	--	1	--
Total	2	--	--	2	--	2	--
California: Fontana:							
Heckett Co	1	--	--	--	--	--	--
Colorado: Pueblo:							
Fountain Sand and Gravel Co	1	--	--	--	--	--	--
Delaware: Claymont:							
International Mill Service Co	--	--	--	1	--	1	--
Florida: Tampa:							
International Mill Service Co	--	--	--	1	--	--	1
Georgia:							
Atlanta:							
International Mill Service Co	--	--	--	1	--	--	1
Cartersville:							
International Mill Service Co	--	--	--	1	--	--	1
Total	--	--	--	2	--	--	2
Illinois:							
Alton:							
International Mill Service Co	--	--	--	1	--	--	1
Chicago:							
Heckett Co	--	--	--	1	--	1	1
Heckett Co	1	--	--	--	--	--	--
International Mill Service Co	--	--	--	1	--	1	--
Granite City:							
International Mill Service Co	--	--	--	1	--	1	--
St. Louis Slag Products Co. Inc	1	--	--	--	--	--	--
Peoria:							
International Mill Service Co	--	--	--	1	--	--	1
Total	2	--	--	5	--	3	3
Indiana:							
Burns Harbor:							
The Levy Co. Inc	1	1	--	1	--	1	--
East Chicago:							
Heckett Co	--	--	--	1	--	1	--
Vulcan Materials Co	1	--	--	--	--	--	--
Gary:							
International Mill Service Co	--	--	--	1	--	1	1
Kokomo:							
International Mill Service Co	--	--	--	1	--	--	1
Total	2	1	--	4	--	3	2
Iowa: Keokuk:							
International Mill Service Co	--	--	--	1	--	--	1
Kentucky:							
Ashland:							
Heckett Co	1	--	--	--	--	--	--
Owensboro:							
Heckett Co	--	--	--	1	--	--	1
Total	1	--	--	1	--	--	1
Louisiana: LaPlace:							
International Mill Service Co	--	--	--	1	--	--	1

See footnote at end of table.

Table 3.—Locations and processing methods of iron slag and sources of steel slag[1] in 1985—Continued

State, city, and company	Processing method of iron slag			Steel slag	Sources of steel slag		
	Air-cooled	Expanded	Granulated		Open hearth	Basic oxygen process	Electric
Maryland:							
Baltimore:							
Maryland Slag Co	1	--	--	--	--	--	--
Sparrows Point:							
Blue Circle Atlantic	--	--	1	--	--	--	--
C. J. Langenfelder & Sons Inc	--	--	--	1	1	1	--
Total	1	--	1	1	1	1	--
Michigan: Detroit:							
Edward C. Levy Co	1	1	--	1	--	1	1
Minnesota: Newport:							
International Mill Service Co	--	--	--	1	--	--	1
Missouri: Kansas City:							
International Mill Service Co	--	--	--	1	--	--	1
New Jersey:							
Perth Amboy:							
International Mill Service Co	--	--	--	1	--	--	1
Riverton:							
International Mill Service Co	--	--	--	1	--	--	1
Total	--	--	--	2	--	--	2
New York: Buffalo:							
Buffalo Crushed Stone Corp	1	--	--	--	--	--	--
North Carolina: Charlotte:							
Heckett Co	--	--	--	1	--	--	1
Ohio:							
Canton:							
Heckett Co	--	--	--	1	--	--	1
Cleveland:							
Standard Slag Co	1	--	--	--	--	--	--
Standard Slag Co	1	--	--	--	--	--	--
Stein Inc	--	--	--	1	--	1	1
Hamilton:							
American Materials Corp	1	--	--	--	--	--	--
Lorain:							
Fritz Enterprises Inc	1	--	--	--	--	--	--
Stein Inc	--	--	--	1	--	1	--
Lordstown:							
Standard Slag Co	--	--	1	--	--	--	--
Mansfield:							
Heckett Co	--	--	--	1	--	--	1
Marion:							
International Mill Service Co	--	--	--	1	--	--	1
Middletown:							
American Materials Corp	1	--	--	--	--	--	--
International Mill Service Co	--	--	--	1	--	1	--
Mingo Junction:							
International Mill Service Co	--	--	--	1	--	1	--
Standard Slag Co	1	--	--	--	--	--	--
Warren:							
Heckett Co	--	--	--	1	--	1	1
Standard Slag Co	1	--	--	--	--	--	--
Total	7	--	1	8	--	5	5
Oklahoma: Sand Springs:							
International Mill Service Co	--	--	--	1	--	--	1

See footnote at end of table.

Table 3.—Locations and processing methods of iron slag and sources of steel slag[1] in 1985 —Continued

State, city, and company	Processing method of iron slag: Air-cooled	Ex-panded	Granu-lated	Steel slag	Sources of steel slag: Open hearth	Basic oxygen process	Elec-tric
Pennsylvania:							
Bala-Cynwyd:							
Warner Co	1	1	--	--	--	--	--
Beaver Falls:							
International Mill Service Co	--	--	--	1	--	--	1
Belle Vernon:							
Duquesne Slag Products Co	1	--	--	--	--	--	--
Bethlehem:							
Bethlehem Mines Corp	1	--	--	--	--	--	--
Sheridan Slag Corp	--	1	--	--	--	--	--
Burgettstown:							
Duquesne Slag Products Co	--	--	1	--	--	--	--
Butler:							
Heckett Co	--	--	--	1	--	--	1
Coatesville:							
International Mill Service Co	--	--	--	1	--	--	1
Johnstown:							
Heckett Co	--	--	--	1	--	--	1
Lebanon:							
Sheridan Slag Corp	1	--	--	--	--	--	--
Midland:							
International Mill Service Co	--	--	--	1	--	--	1
Monessen:							
International Mill Service Co	--	--	--	1	--	1	--
Morrisville:							
Heckett Co	--	--	--	1	1	--	--
Patton:							
International Mill Service Co	--	--	--	1	--	1	--
Penn Hills:							
Gascola Slag Co	--	--	--	1	1	--	--
Phoenixville:							
International Mill Service Co	--	--	--	1	--	--	1
Riddlesburg:							
New Enterprise Stone & Lime Co. Inc	1	--	--	--	--	--	--
Steelton:							
Hempt Bros. Inc	--	--	--	1	--	--	1
West Aliquippa:							
Duquesne Slag Products Co	1	--	--	1	--	1	--
West Mifflin:							
Duquesne Slag Products Co	1	--	--	--	--	--	--
Duquesne Slag Products Co	1	--	--	1	--	1	--
Wheatland:							
Dunbar Slag Co. Inc	1	--	--	1	1	1	--
Total	9	2	1	14	3	5	7
South Carolina: Georgetown:							
Heckett Co	--	--	--	1	--	--	1
Texas:							
Baytown:							
Heckett Co	--	--	--	1	--	--	1
Beaumont:							
International Mill Service Co	--	--	--	1	--	--	1
El Paso:							
International Mill Service Co	--	--	--	1	--	--	1
Lone Star:							
Gifford-Hill Co. Inc	1	--	--	--	--	--	--
International Mill Service Co	--	--	--	1	--	--	1
Longview:							
International Mill Service Co	--	--	--	1	--	--	1
Midlothian:							
International Mill Service Co	--	--	--	1	--	--	1

See footnote at end of table.

Table 3.—Locations and processing methods of iron slag and sources of steel slag[1] in 1985 —Continued

State, city, and company	Processing method of iron slag: Air-cooled	Ex-panded	Granu-lated	Steel slag	Sources of steel slag: Open hearth	Basic oxygen process	Elec-tric
Texas —Continued							
Sequin:							
International Mill Service Co	--	--	--	1	--	--	1
Total	1	--	--	7	--	--	7
Utah:							
Plymouth:							
International Mill Service Co	--	--	--	1	--	--	1
Provo:							
Heckett Co	1	--	--	1	1	--	--
Total	1	--	--	2	1	--	1
Washington: Seattle:							
Heckett Co	--	--	--	1	--	--	1
West Virginia:							
Weirton:							
International Mill Service Co	--	--	--	1	--	1	--
Standard Slag Co	1	--	--	--	--	--	--
Total	1	--	--	1	--	1	--
Grand total	31	4	3	60	5	22	40

[1]Number indicates the existence of an active plant shown by processing method or furnace source; previous years showed the number of active processing lines for some plants.

Table 4.—Shipments of iron and steel slag in the United States in 1985, by method of transportation

Method of transportation	Quantity (thousand short tons)
Truck	18,158
Waterway	1,717
Rail	973
Not transported (used at plantsite)	230
Total	21,078

Table 5.—Air-cooled iron-blast-furnace slag sold or used[1] in the United States, by use

(Thousand short tons and thousand dollars)

Use	1984 Quantity	1984 Value	1985 Quantity	1985 Value
Asphaltic concrete aggregate	1,271	6,601	1,503	7,149
Concrete aggregate	1,396	6,350	1,613	8,740
Concrete products	539	2,588	495	2,226
Fill	1,515	4,671	1,299	4,366
Glass manufacture	165	2,022	110	W
Mineral wool	607	3,913	617	4,081
Railroad ballast	1,136	4,522	1,024	4,656
Road base	8,020	32,632	5,831	24,772
Roofing, built-up and shingles	283	1,670	156	1,114
Sewage treatment	121	461	445	2,314
Soil conditioning	49	158	48	173
Other[2]	224	701	221	[3]3,000
Total[4]	15,325	66,289	13,363	62,588

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Value based on selling price at plant.
[2]Includes ice control, miscellaneous, and value indicated by symbol W.
[3]Includes glass manufacture.
[4]Data may not add to totals shown because of independent rounding.

Table 6.—Granulated and expanded iron-blast-furnace slags sold or used[1] in the United States, by use

(Thousand short tons and thousand dollars)

Uses	1984				1985			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Cement manufacture	(2)	(2)	W	W	(2)	(2)	W	W
Concrete products	--	--	W	W	--	--	--	--
Fill	--	--	--	--	(2)	(2)	W	W
Lightweight concrete aggregate	--	--	229	2,271	--	--	W	W
Road base	(2)	(2)	W	W	(2)	(2)	W	W
Soil conditioning	(2)	(2)	W	W	(2)	(2)	W	W
Other[3]	--	--	1,223	16,871	--	--	1,742	24,290
Total	(2)	(2)	1,452	19,142	(2)	(2)	1,742	24,290

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Value based on selling price at plant.
[2]Included with "Expanded" to avoid disclosing company proprietary data.
[3]Includes miscellaneous and data indicated by symbol W.

Table 7.—Steel slag sold or used[1] in the United States, by use

(Thousand short tons and thousand dollars)

Use	1984		1985	
	Quantity	Value	Quantity	Value
Asphaltic concrete aggregate	551	2,854	417	1,811
Fill	1,037	3,230	1,436	4,145
Railroad ballast	W	W	365	1,249
Road base	2,595	7,463	3,079	9,050
Other[2]	1,104	3,780	674	1,219
Total[3]	5,287	17,327	5,972	17,472

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Excludes tonnage returned to furnace for charge material. Value based on selling price at plant.
[2]Includes ice control, soil conditioning, miscellaneous uses, and data indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.

Table 8.—Average value at the plant for iron and steel slags sold or used in the United States

(Dollars per short ton)

Year	Iron-blast-furnace slag				Steel slag	Total slag
	Air-cooled	Granulated	Expanded	Total iron slag		
1981	4.16	4.00	6.19	4.26	3.03	3.93
1982	4.17	5.42	8.91	4.40	3.07	4.07
1983	4.12	W	9.67	4.78	3.01	4.31
1984	4.33	W	11.49	5.09	3.28	4.66
1985	4.68	W	11.00	5.75	2.93	4.95

W Withheld to avoid disclosing company proprietary data.

Table 9.—Average selling price and range of selling prices at the plant for iron and steel slags in the United States in 1985, by use

(Dollars per short ton)

Use	Iron-blast-furnace slag						Steel slag	
	Air-cooled		Granulated		Expanded			
	Average	Range	Average	Range	Average	Range	Average	Range
Asphaltic concrete aggregate	4.75	2.01- 8.00	--	--	--	--	4.34	1.28-8.26
Cement manufacture	--	--	W	W	--	--	--	--
Concrete aggregate	5.41	2.76- 7.01	--	--	--	--	--	--
Concrete products	4.49	3.00- 7.01	--	--	--	--	--	--
Fill	3.35	2.00- 5.91	W	W	--	--	2.88	.52-6.15
Glass manufacture	W	W	--	--	--	--	--	--
Lightweight concrete aggregate	--	--	--	--	11.00	9.00-12.67	--	--
Mineral wool	6.61	2.75-10.54	--	--	--	--	--	--
Railroad ballast	4.54	2.75- 7.60	--	--	--	--	3.41	.75-9.48
Road base	4.24	2.29- 7.01	W	W	--	--	2.93	.70-8.21
Roofing, built-up and shingles	7.13	3.51-10.64	--	--	--	--	--	--
Sewage treatment	5.20	3.51- 7.55	--	--	--	--	--	--
Soil conditioning	3.58	3.00- 5.28	W	W	--	--	W	W
Other	4.06	1.73- 5.63	--	--	--	--	1.80	1.00-8.18

W Withheld to avoid disclosing company proprietary data; included with "Other."

Sodium Compounds

By Dennis S. Kostick[1]

The U.S. soda ash industry took advantage of the tight supply of foreign soda ash for the world market by increasing its export sales, which reached a record-high level. Domestic consumption of soda ash decreased for the third consecutive year because of competition from recycled glass, or cullet, and continued erosion of the glass container market by polyethylene terephthalate (PET) bottles. Domestic production of natural and synthetic sodium sulfate decreased to an all-time low because of the closure of two byproduct sodium sulfate plants and the availability of inexpensive substitutive caustic soda and emulsified sulfur.

Domestic Data Coverage.—Domestic production data for soda ash and sodium sulfate are developed by the Bureau of Mines from monthly and annual voluntary surveys of U.S. operations. Of the eight soda ash operations and four sodium sulfate operations to which a survey request was sent, all responded, representing 100% of the total production data shown in table 1. Two soda ash producers did not report sales value on these forms; however, their data were estimated and included in table 1.

Table 1.—Salient sodium compound statistics

(Thousand short tons and thousand dollars)

	Soda ash		Sodium sulfate	
	1984	1985	1984	1985
United States:				
Production[1]	8,511	8,597	872	827
Value[2]	[e]$611,000	[e]$622,253	$80,433	$76,237
Exports	1,648	[3]1,771	76	119
Value	$160,774	[3]$186,064	$9,587	$11,899
Imports for consumption	17	56	265	194
Value	$2,301	$8,089	$21,198	$14,492
Stocks, Dec. 31: Producers	[4]322	[4]428	[5]59	[5]31
Consumption, apparent	6,864	6,777	1,050	930
World: Production	[p]31,126	[e]31,628	[p]4,697	[e]4,647

[e]Estimated. [p]Preliminary.
[1]Includes natural and synthetic. Total production data for sodium sulfate obtained from the Bureau of the Census.
[2]The value for soda ash includes synthetic soda ash. The value for synthetic sodium sulfate is based upon the average value for natural sodium sulfate.
[3]Export data from the Bureau of the Census were adjusted by the Bureau of Mines pending data reconciliation between the Bureau of the Census and the American Natural Soda Ash Corp.
[4]Includes synthetic soda ash.
[5]Natural only.

Legislation and Government Programs.—The U.S. Department of Commerce and several members of the U.S. Congress supported soda ash for inclusion on the President's Trade Strike Force. Trade barriers, such as inhibitive import permits, tariffs, embargoes, and nonenforcement of antimonopoly laws, in several countries have impeded the export efforts of the U.S. soda ash industry. These trade practices served to protect the host countries' synthetic soda ash production facilities. Whereas certain domestic mineral industries had sought and been denied Federal action for relief from low-cost imports, the soda ash industry was seeking Government support for its export efforts. Further discussions on this issue were planned for 1986.[2]

DOMESTIC PRODUCTION

Soda Ash.—The domestic industry operated at 76% of combined nameplate capacity as production of natural and synthetic soda ash increased for the third consecutive year to reach a record high despite a slight decline in the amount of Wyoming soda ash produced. Wyoming trona production by five companies was 11,796,000 million short tons, or 9% less than the record high of 12,906,000 million tons reported in 1980. This decrease was attributed to an increase in the soda ash-trona refining efficiency ratio—more tons of soda ash processed from fewer tons of trona mined—and the decrease in Wyoming soda ash production.

Acquisitions and divestitures by parent corporations affected some of the domestic soda ash companies. Chesebrough-Ponds Inc. acquired Stauffer Chemical Co.; Anaconda Minerals Co. sought a buyer for its share of a sodium carbonate deposit at Searles Lake in California; and Allied Corp. announced plans to close its 700,000-ton-per-year synthetic soda ash plant by March 1986. Allied later merged with Signal Corp. to become Allied-Signal Corp. and transferred its soda ash operations to the Henley Group, a newly formed spinoff company. Allied's announcement prompted Church & Dwight Co. Inc., the Nation's largest sodium bicarbonate manufacturer, to cease production at its 96,000-ton-per-year facility, which used sodium carbonate from Allied as feedstock.

Kerr-McGee Chemical Corp. announced that all soda ash production would be phased out at its Searles Lake Westend facility by 1987. The plant has had a capacity of about 150,000 tons per year. FMC Wyoming Corp. began solution mining commercial quantities of soda ash. Upon reaching full-scale production planned for 1987, the operation was expected to have more than 250,000 tons per year of soda ash capacity, which would replace a comparable amount of underground mining capacity.

Table 2.—Producers of soda ash and natural sodium sulfate in 1985

Product and company	Plant nameplate capacity (thousand short tons)	Plant location	Source of sodium
Soda ash, natural:			
Allied Chemical Co[1]	2,200	Green River, WY.	Underground trona.
FMC Wyoming Corp	2,850	do	Do.
Kerr-McGee Chemical Corp	1,300	Argus, CA	Dry lake brine.
Do	150	Westend, CA	Do.
Stauffer Chemical Co. of Wyoming[2]	1,960	Green River, WY.	Underground trona.
Tenneco Minerals Co	1,000	do	Do.
T. G. Soda Ash Inc	1,100	Granger, WY	Do.
Soda ash, synthetic:			
Allied Chemical Co.[3]	700	Syracuse, NY	Ammonia-soda process.
Total	11,260		
Sodium sulfate:			
Great Salt Lake Minerals & Chemicals Corp.[4]	50	Ogden, UT	Salt lake brine.
Kerr-McGee Chemical Corp	240	Westend, CA	Dry lake brine.
Ozark-Mahoning Co	70	Brownfield, TX.	Subterranean brine.
Do	150	Seagraves, TX	Do.
Total	510		

[1]Allied Corp. merged with Signal Corp. to become Allied-Signal Corp.
[2]Acquired by Chesebrough-Ponds Inc.
[3]Plant was downrated from 900,000 tons per year in Jan. 1983.
[4]Solar ponds were flooded May 5, 1984. No significant production in 1985.

Sodium Sulfate.—Allied-Signal permanently closed its sodium bichromate and byproduct sodium sulfate facility at Baltimore, MD, at midyear. Climax Chemical Corp. modified its Grantsville, UT, plant to produce potassium sulfate instead of sodium sulfate. These actions resulted in the loss of about 135,000 tons of sodium sulfate annual capacity.

Table 3.—Synthetic and natural sodium carbonates produced in the United States

(Thousand short tons and thousand dollars)

Year	Synthetic soda ash (ammonia-soda process)[1]	Natural sodium carbonates[2]		Total quantity
	Quantity	Quantity	Value[3]	
1981	W	W	787,469	8,281
1982	W	W	721,257	7,819
1983	W	W	[e]685,100	8,467
1984	W	W	[e]611,000	8,511
1985	W	W	[e]622,253	8,597

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[2]Soda ash and trona (sesquicarbonate).
[3]Includes value for synthetic soda ash.

Table 4.—Synthetic and natural sodium sulfate[1] produced in the United States

(Thousand short tons and thousand dollars)

Year	Synthetic and natural[2] (quantity)			Natural	
	Lower purity[3] (99% or less)	High purity	Total[4]	Quantity	Value
1981	666	445	1,111	608	43,186
1982	463	401	864	W	W
1983	427	427	855	423	39,425
1984	[r]428	[r]444	872	435	40,125
1985	401	428	827	389	35,860

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]All quantities converted to 100% Na_2SO_4 basis.
[2]Current Industrial Reports, Inorganic Chemicals, Bureau of the Census.
[3]Includes Glauber's salt.
[4]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Soda Ash.—Increased use of PET containers by the food and beverage industries continued to inhibit sales of soda ash to the glass container industry. Approximately 1.3 million tons of cullet collected for reuse also reduced soda ash sales. These losses were offset by the strength of the construction and automotive industries, which were major consumers of fiberglass and of flat glass, accounting for 55% and 20% of the total flat glass market, respectively. As automobile manufacturers strive to reduce vehicle weight and thereby gasoline consumption, the quantity of glass per vehicle was forecast to decrease nearly 13% by 1992.[3]

Liquid detergents have become increasingly popular among consumers because of their convenience. In 1985, the market share of liquid home detergents increased 5% over that of 1984 and represented 30% of the home detergent market. Because powdered detergents contain soda ash in their formulations, but liquid detergents do not, the increasing preference for liquid detergents was expected to constrain domestic soda ash demand. The use of soda ash in the manufacture of sodium tripolyphosphate (STPP) for powdered detergents increased 4% in 1985, despite the ban of STPP in one-fourth of the States because of environmental considerations.

Sodium Sulfate.—Apparent consumption decreased to an all-time low because of competition from inexpensive and available caustic soda and emulsified sulfur, which were substituted for low-purity sodium sulfate, known as saltcake, in the pulp and paper industry. In addition, the use of sodium sulfate declined in glass container manufacturing and in detergent production. Sodium sulfate had been used as a filler in powdered detergent formulations, but most manufacturers were removing fillers and replacing them with additional builders, such as STPP. Liquid detergents do not contain sodium sulfate in their composition.

Table 5.—Estimated consumption of soda ash in the United States, by end use

(Thousand short tons)

End use	1984	1985
Glass:		
Bottle and container	2,300	2,200
Flat	600	700
Fiber	250	275
Other	250	225
Total	3,400	3,400
Chemicals	1,550	1,500
Soaps and detergents	600	600
Pulp and paper	250	350
Water and stackgas	600	600
Other[1]	464	327
Total	3,464	3,377
Grand total	6,864	6,777

[1]Includes soda ash used in petroleum and metal refining, leather tanning, enamels, etc.

STOCKS

Soda Ash.—Yearend stocks of dense and light soda ash in plant silos, warehouses, terminals, and on teamtracks amounted to 428,000 tons, or 33% more than 1984 yearend inventories.

Sodium Sulfate.—Inventories of natural sodium sulfate decreased 47%, primarily because of reduced domestic industry production capability and weak domestic demand.

PRICES

Soda Ash.—In mid-1985, the soda ash industry reduced the temporary voluntary allowance on soda ash from $11 to $7 per ton. This action effectively raised the f.o.b. price per ton from $79 to $83 in Wyoming and from $109.25 to $113.25 in California. The average annual value of natural soda ash, f.o.b. Green River, WY, and Searles Valley, CA, was estimated to be $67.82 per ton.

Sodium Sulfate.—The average annual value of bulk natural product, f.o.b. mine or plant, was $92.19 per ton.

Table 6.—Sodium compounds yearend prices

	1984	1985
Sodium carbonate (soda ash):		
Light, paper bags, carlots, works per ton	$150.00	$150.00
Light, bulk, carlots, works do	123.00	123.00
Dense, paper bags, carlots, works do	120.00	120.00
Dense, bulk, carlots, works do	90.00	90.00
Sodium sulfate (100% Na_2SO_4):		
Technical detergent, rayon grade, bags, carlots do	$90.00- 96.00	$90.00- 96.00
Sodium sulfate, bulk, carlots, works[1] do	113.00- 114.00	113.00- 114.00
Domestic salt cake, bulk, works[1] do	47.00- 53.00	47.00- 53.00
National Formulary (N.F. XII), drums per pound	.235	.235

[1]East of Mississippi River.

Source: Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 226, No. 27, Dec. 31, 1984, p. 27, and v. 227, No. 27, Dec. 30, 1985, p. 27.

FOREIGN TRADE

Soda Ash.—Exports of 1.639 million tons of soda ash reported by the Bureau of the Census were adjusted to include an additional 132,000 tons, pending data reconciliation between the Bureau of the Census and the American National Soda Ash Corp. Total exports, as adjusted by the Bureau of Mines, were 1.771 million tons. Exports to 43 countries, on a regional basis, were as follows: Asia, 60%; North America, 14%; Latin America, 12%; Africa, 9%; Oceania, 3%; and the Caribbean and Europe, 1% each.

At yearend, the Republic of Korea agreed to lift import controls on 603 products, including soda ash, over the following 3 years. This action offered potential for increasing U.S. exports.

Four companies comprising the Japanese synthetic soda ash industry considered filing dumping charges against U.S. producers. The Japanese claimed that U.S. soda ash consumers paid $92 per ton at the mine whereas exports to Japan were priced at $66 per ton.[4]

Table 7.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value[1]	Quantity	Value[1]
1982	1,109	140,616	111	12,162
1983	1,636	154,584	91	11,380
1984	1,648	160,774	76	9,587
1985	[2]1,771	[2]186,064	119	11,899

[1]Free alongside ship (f.a.s.) value at U.S. port.
[2]Adjusted by the Bureau of Mines to account for discrepancies in data.

Source: Bureau of the Census.

Table 8.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)[1]		Anhydrous		Total[1]	
	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]
1982	210	13,820	184	14,938	394	28,758
1983	144	10,312	199	17,609	343	27,921
1984	61	4,223	204	16,975	265	21,198
1985	40	2,549	154	11,943	194	14,492

[1]Includes Glauber's salt as follows: 1982—2 tons ($1,241); 1983—3 tons ($1,648); and 1984—12 tons ($4,997).
[2]Customs, insurance, and freight (c.i.f.) value at U.S. port.

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of sodium carbonate

	1984		1985	
	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)
Sodium carbonate, calcined	16,659	$2,292	56,198	$8,085
Sodium carbonate, hydrated, and sesquicarbonate	5	9	4	4
Total	16,664	2,301	56,202	8,089

[1]Customs, insurance, and freight (c.i.f.) value at U.S. port.

Source: Bureau of the Census.

WORLD REVIEW

Egypt.—At midyear, MISR Chemical Industries Co., the Nation's sole soda ash producer, elected Chemieanlagen Co. of the German Democratic Republic and Krebs and Co. of France as engineering contractors for the proposed expansion of production capacity at the El Mex synthetic soda ash facility. If completed, the project could increase total capacity from 80,000 tons to 200,000 tons per year.[5]

India.—The Government reduced duties from 70% to 35% on light soda ash imports and from 70% to 15% on dense soda ash imports. These duty reductions were in response to a surge in soda ash demand by the Indian detergent industry and soda ash supply problems. The light soda ash duty was expected to be reduced to 25% in early 1986. Less expensive imports were expected to ease the supply imbalance temporarily. In addition, in 1985 approval was granted to construct five new synthetic soda ash plants to increase India's production capability.[6]

Turkey.—Progress continued toward development of the Baypazari trona deposit as FMC and Etibank, the state-owned mining company, each agreed to have a 35% equity share in the venture; the International Bank for Reconstruction and Development held 10%, and private Turkish investors held the remainder. Turkey has been an associate member of the European Economic Community. Full member status by the early 1990's when the project is targeted for completion could provide FMC with a competitive advantage for supplying soda ash to western European markets.[7]

Table 10.—Sodium carbonate: World production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Albania[e]	27,600	[r]29,700	[r]30,800	[r]33,000	34,100
Australia[e]	330,000	330,000	330,000	330,000	330,000
Austria[e]	190,000	190,000	190,000	165,000	165,000
Belgium	300,931	361,170	286,340	451,224	500,000
Brazil	207,234	219,360	231,485	[e]210,000	210,000
Bulgaria	1,618,948	1,607,940	1,400,918	[e]1,610,000	1,610,000
Canada[e]	500,000	500,000	470,000	400,000	385,000
Chad[e 2]	5,500	5,500	NA	NA	NA
Chile[e]	11,000	NA	NA	NA	NA
China	1,821,016	1,911,406	1,976,442	[e]2,070,000	2,200,000
Colombia	[r]117,087	122,136	130,392	142,683	140,000
Czechoslovakia	130,293	117,313	104,694	111,711	110,000
Denmark[3]	164	131	159	139	138
Egypt	25,754	45,496	47,399	[e]45,000	45,000
France[e]	1,765,000	[r]1,100,000	[r]1,100,000	[r]990,000	990,000
German Democratic Republic	967,828	972,237	977,749	981,056	990,000
Germany, Federal Republic of	1,310,647	1,218,053	1,342,614	1,503,551	1,600,000
Greece[e]	1,100	1,100	1,100	1,100	1,100
India	[e]676,000	646,836	820,481	915,869	850,000
Italy[e]	105,000	100,000	95,000	100,000	100,000
Japan	1,298,185	1,281,323	1,216,265	1,142,140	1,290,000
Kenya[2]	275,578	176,855	213,506	249,177	250,000
Korea, Republic of	222,736	204,666	254,193	273,292	[4]276,559

See footnotes at end of table.

Table 10.—Sodium carbonate: World production, by country[1] —Continued

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Mexico[5]	442,026	429,901	[e]440,000	466,300	[4]504,000
Netherlands[e]	460,000	460,000	460,000	440,000	440,000
Norway	(6)	(6)	(6)	(6)	
Pakistan	[r]111,507	[r]109,254	[r e]112,400	[r e]135,000	130,000
Poland	771,617	822,323	909,406	1,011,921	940,000
Portugal[e]	190,000	190,000	180,000	165,000	165,000
Romania	1,020,739	959,010	868,620	881,848	890,000
Spain[e]	550,000	550,000	550,000	610,000	610,000
Sweden[e]	(6)	(6)	(6)	(6)	--
Switzerland[e]	51,000	[r]50,000	50,000	49,000	50,000
Taiwan	79,437	65,279	103,419	118,179	110,000
Turkey[e]	65,000	65,000	[r]65,000	[r]65,000	65,000
U.S.S.R	5,357,227	5,250,303	5,620,679	5,639,418	5,730,000
United Kingdom[e]	1,430,000	1,430,000	1,430,000	[r]1,100,000	1,100,000
United States[5]	8,281,495	7,819,083	8,467,118	8,511,359	[4]8,597,180
Yugoslavia	162,212	200,488	202,135	207,555	[4]220,053
Total	[r]30,879,861	[r]29,541,863	30,678,314	31,125,522	31,628,130

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 6, 1986. Synthetic unless otherwise specified.
[2]Natural only.
[3]Production for sale only; excludes output consumed by producers.
[4]Reported figure.
[5]Includes natural and synthetic.
[6]Revised to zero.

Table 11.—Sodium sulfate: World production, by country[1]

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Natural:					
Argentina	57	47	50	[e]50	44
Canada	590	603	500	[e]427	413
Chile[3]	(4)	1	1	1	1
Egypt	[e]3	3	2	[e]2	2
Iran[e]	11	11	13	13	13
Mexico[5]	[r]465	[r]519	436	456	463
South Africa, Republic of	5	3	1	1	(4)
Spain	207	232	345	405	364
Turkey	73	72	68	92	94
U.S.S.R.[e 6]	386	397	397	397	408
United States	608	[7]W	423	435	[8]389
Total	[r]2,405	[r]1,888	2,236	2,279	2,191
Synthetic:					
Austria[e]	61	61	61	55	55
Belgium[e]	276	276	276	276	287
Chile[9]	64	52	57	63	61
Finland[e]	[r]44	[r]44	[r]39	[r]39	39
France[e]	165	165	165	[r]132	138
German Democratic Republic	141	157	168	181	182
Germany, Federal Republic of	281	236	138	141	149
Greece	[r]11	[r]8	[r e]9	[r e]10	10
Hungary[e]	11	11	11	11	11
Italy[e]	99	94	99	[r]88	88
Japan	314	282	287	307	320
Netherlands[e]	55	55	55	50	50
Portugal[e]	[8]64	63	62	55	55
Spain[e 10]	193	187	187	187	176
Sweden[e]	[r]110	[r]110	[r]110	[r]110	110

See footnotes at end of table.

Table 11.—Sodium sulfate: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Synthetic: —Continued					
U.S.S.R.[e 6]	276	276	276	276	287
United States[11]	503	[7]864	432	437	[8]438
Total	[r]2,668	[r]2,941	2,432	2,418	2,456
Grand total	[r]5,073	[r]4,829	4,668	4,697	4,647

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 6, 1986.
[2]In addition to the countries listed, China, Norway, Poland, Romania, Switzerland, and the United Kingdom are known to or are assumed to have produced synthetic sodium sulfate, and other unlisted countries may have produced this commodity, but production figures are not reported, and available general information is not adequate for the formulation of reliable estimates of output levels.
[3]Natural mine output, excluding byproduct output from the nitrate industry, which is reported separately under "Synthetic" in this table.
[4]Less than 1/2 unit.
[5]Series reflects output reported by Industrias Peñoles S.A. de C.V., Mexico's principal producer, plus an additional 22,000 short tons (estimated) by a smaller producer.
[6]Conjectural estimates based on 1968 information on natural sodium sulfate and general economic conditions.
[7]Natural sodium sulfate included with synthetic sodium sulfate production.
[8]Reported figure.
[9]Byproduct of nitrate industry.
[10]Quantities of synthetic sodium sulfate credited to Spain are reported in official sources in a way such as to indicate that they are in addition to the quantities reported as mined (reported in this table under "Natural"), but some duplication may exist.
[11]Derived approximate figures; data presented are the difference between reported total sodium sulfate production (natural and synthetic not differentiated) and reported natural sodium sulfate sold by producers (reported under "Natural" in this table).

TECHNOLOGY

FMC designed and built a flue gas desulfurization unit that was installed at yearend, with the cooperation of the City of Colorado Springs Department of Utilities, on a coal-fired boiler at the Nixon powerplant in Fountain, CO. The scrubbing agent, sodium sesquicarbonate, reacted with sulfur oxide emissions from the burning coal to form sodium sulfite and sodium sulfate. Reducing sulfur oxide emissions by 70% is required to comply with new Environmental Protection Agency standards and Colorado air quality regulations. Eventually, sodium bicarbonate and trona also were to be tested as scrubbing agents. Proof of the economic effectiveness of any of these commodities as desulfurizing mediums could be a significant boon to the Wyoming soda ash industry, which has sustained stagnant or declining domestic soda ash demand.[8]

Ontario Paper Co. at Thorold, Ontario, Canada, developed a process to produce sodium bicarbonate as a byproduct of pulp and paper manufacturing. By reacting carbon dioxide with a solution containing sodium carbonate and sodium sulfate, which usually are recovered and recycled in a pulp and paper operation, the sodium carbonate was converted to sodium bicarbonate and the sodium sulfate could be separated subsequently by fractional crystallization. A substantial increase in domestic sodium bicarbonate demand could promote the use of this technique in U.S. pulp mills.[9]

[1]Physical scientist, Division of Industrial Minerals.
[2]U.S. Senate. Barriers to U.S. Exports. Congr. Rec., v. 131, No. 177, Dec. 19, 1985, pp. S18380-S18385.
[3]Chemical Week. In New Cars, Plastics Are Taking the Driver's Seat. V. 137, No. 17, 1985, pp. 6-8.
[4]Glass Industry. Japanese Producers Charge Soda Ash Dumping. V. 66, No. 13, 1985, p. 10.
[5]Industrial Minerals (London). Egyptian Soda Ash Plant Retrofit. No. 216, 1985, p. 94.
[6]European Chemical News. V. 45, No. 1196, 1985, p. 9.
[7]Industrial Minerals (London). Soda Ash Progress. No. 220, 1986, p. 11.
[8]———. Trona in Desulfurization. No. 222, 1986, p. 25.
[9]Corpus Chemical Report. Ontario Paper Considering Sodium Bicarbonate Project. V. 17, No. 38, Sept. 23, 1985, p. 1.

Crushed Stone

By Valentin V. Tepordei[1]

A total of 1.0 billion short tons of crushed stone valued at $4.1 billion, f.o.b. plant, was reported produced in the United States in 1985. The tonnage is 9% below the record-high production of 1979 but 5% higher than the estimated production of 1984. About three-quarters of the crushed stone production continued to be limestone and dolomite, followed by granite, traprock, sandstone and quartzite, shell, calcareous marl, volcanic cinder, marble, and slate, in order of volume.

Exports of crushed stone were unchanged from the 1984 level, while imports for consumption decreased 7%. Ninety-five percent of the exported and 48% of the imported crushed stone was limestone. Apparent consumption of crushed stone was 1.0 billion tons.

Domestic Data Coverage.—Domestic production data for crushed stone are developed by the Bureau of Mines from voluntary surveys of U.S. producers. Beginning with 1981, full surveys of crushed stone producers were conducted for odd-numbered years only. For even-numbered years, annual preliminary surveys, which collect production information on a sample basis, are conducted to generate annual estimates at the State level. This survey canvasses most of the large companies in each State producing up to 75% of that State's total tonnage.

Table 1.—Salient U.S. crushed stone statistics

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
Sold or used by producers:					
Quantity[1]	872,600	[e]790,030	861,600	[e]956,000	1,000,800
Value[1]	$3,125,000	[e]$2,918,300	$3,327,000	[e]$3,755,600	$4,053,000
Exports (value)	$25,949	$19,026	$23,021	$23,970	$29,347
Imports for consumption (value)	$13,473	$16,382	[2]$12,610	[2]$17,543	[2]$11,640

[e]Estimated. [r]Revised.
[1]Does not include American Samoa, Guam, Puerto Rico, and the Virgin Islands.
[2]Excludes precipitated calcium carbonate.

Of the 4,788 crushed stone operations surveyed by the Bureau of Mines in 1985, 3,557 were active. Of these, 3,147, or 88.5%, responded. Their total production represented 87.6% of the U.S. total crushed stone output. The nonrespondents' production was estimated using adjusted prior years production reports and/or employment data. Of the 3,147 reporting operations, some did not indicate a breakdown by end use. Their production as well as that of 1,350 nonrespondents, representing 19.1% of the U.S. total, is included in tables 11, 13, 15-18 under "Other unspecified uses." A total of 1,205 operations were either idle or presumed to be idle, because no information was available to estimate their production. A significant number of the idle quarries were operated by State and local governments, mostly to supply crushed stone for maintenance or road construction projects.

Legislation and Government Programs.—On March 5, the U.S. Congress approved the Interstate Cost Estimate (ICE) legislation that retroactively gave the U.S. Department of Transportation the authority to disburse to the States construction funds collected into the Federal Highway

Trust Fund for the period ending September 30, 1985. On September 19, 1985, additional ICE legislation was passed by the U.S. Congress for the period ending September 30, 1986. Most of these funds were used for highway construction and repair work, and their late release impacted to some extent upon the demand for crushed stone.

In August, the Environmental Protection Agency (EPA) issued its final regulations establishing particulate emission standards of performance for nonmetallic mineral processing plants. These regulations went into effect on August 1, 1985, and will be implemented under section III of the Clean Air Act. The standards were based on emission levels achievable using well-designed and operated baghouse controls or wet-dust suppression techniques. The standards apply to new, modified, and reconstructed facilities at plants processing 18 nonmetallic minerals, including crushed stone.

DOMESTIC PRODUCTION

Of the total 1.0 billion tons of crushed stone produced in the United States, 716 million tons or 72% was limestone and dolomite, 145 million tons or 15% was granite, and 84 million tons or 8% was traprock. A comparison of the four major geographic regions indicated that in 1985, the South continued to lead the Nation in the production of crushed stone with 51% of the total, followed by the North Central with 25%, and the Northeast with 14%. Approximately 76% of the total U.S. crushed stone output was produced in two major geographic regions, the South and North Central.

Of the nine geographic regions, the South Atlantic led the Nation in the production of crushed stone with 266 million tons or 27% of the U.S. total. Next was the East North Central region with 148 million tons or 15% of the total, followed by the West South Central with 137 million tons or 14%.

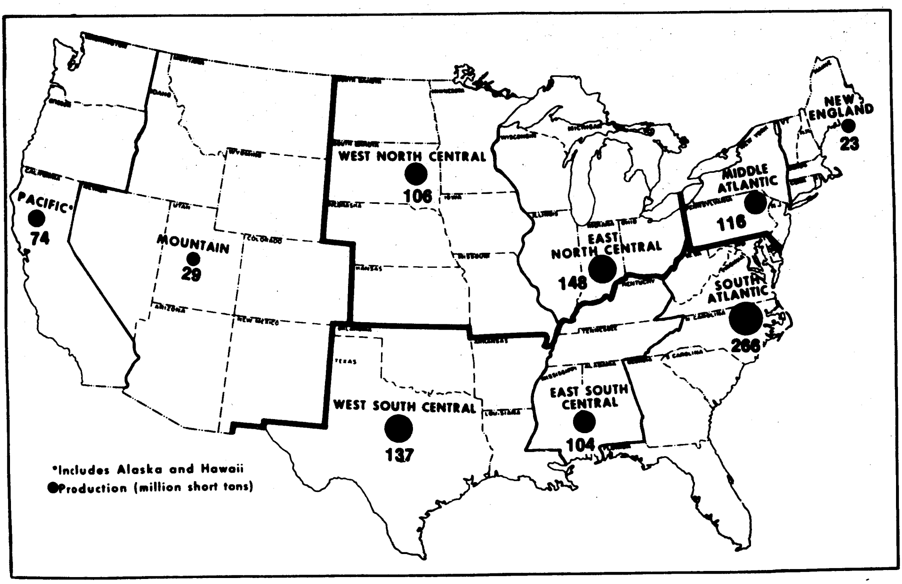

Figure 1.—Production of crushed stone in the United States in 1985, by geographic region.

A comparison of the estimated 1984 and reported 1985 production data by regions indicated that the output of crushed stone increased in all regions except the East North Central. The largest increases were recorded in Middle Atlantic, 12%; West North Central, 10%; and South Atlantic, 7%.

Based on 1980 census data on population, per capita crushed stone production in 1985 was 4.4 tons. At the regional level, per capita production was 6.7 tons in the South, followed by the North Central with 4.3 tons, the Northeast with 2.8 tons, and the West with 2.4 tons.

Crushed stone was produced in every State except Delaware. The 10 leading States in the production of crushed stone, in order of volume, were Texas, Florida, Pennsylvania, Georgia, Virginia, Missouri, North Carolina, California, Illinois, and Ohio. Their combined production represented 54% of the national total.

Production of crushed stone increased in 31 States, including 7 of the top 10. The increases, in order of volume, were significant in Missouri, Pennsylvania, and Georgia, while Illinois, Texas, and Ohio were the only high producing States that showed a decrease in output.

Most of the crushed stone produced came from quarries with an annual output larger than 300,000 tons. Of the total tonnage produced, 941 quarries, representing 26% of the total number of active operations, produced 80%; of these, 218 quarries with an annual output of more than 1,000,000 tons produced 40%. The number of large quarries and their share of the market continues to increase, while the number of small operations is on the decrease.

The 10 leading producers of crushed stone were, in descending order of tonnage: Vulcan Materials Co., Martin Marietta Aggregates, Koppers Co. Inc., Lone Star Industries Inc., Florida Rock Industries Inc., Genstar Stone Products Co., General Dynamics Corp., United States Steel Corp., Gifford-Hill & Co. Inc., and Dolese Bros. Inc.

Compared with 1983, the year when the last full survey of crushed stone producers was conducted, the underground mining of mostly limestone increased 7% to 47 million tons, while the number of active mines decreased from 120 to 108. By operating underground, a variety of problems usually connected with surface mining, especially in locations close to urban areas, such as environmental impacts and community acceptance, are significantly reduced.

Lone Star Industries sold its south Texas aggregate operations, which included one crushed stone quarry, four sand and gravel operations, and seven ready-mix concrete plants, to Pioneer Concrete of Texas Inc.

Genstar began a $9 million expansion program at its Texas, MD, quarry. The new facility, when completed in 1986, will increase production capacity by 50% and improve overall efficiency of the crushing operation. The expansion included a continuous crushing system and new state-of-the-art automated equipment for tertiary crushing. The entire system will be programmed by on-site minicomputers and will be one of the most advanced facilities in the industry. Crushed stone produced at this quarry is used primarily for construction purposes. A special section of the operation produces chemical-grade limestone for the paint, paper, plastics, and rubber industries.

Limestone.—Starting with the 1983 survey, a new canvassing procedure was implemented that is designed to collect separate information on the amount of limestone and dolomite produced in the United States. In 1985, 87 quarries reported producing only dolomite, while 46 quarries reported producing both limestone and dolomite without making a distinction between the two kinds of stone. Therefore, the limestone totals shown in this chapter include an undetermined amount of dolomite in addition to the dolomite reported separately. Compared with 1983, the 1985 output of crushed limestone, including dolomite, increased 15% to 716 million tons valued at $2.8 billion. Limestone and dolomite were produced by 1,117 companies at 2,316 quarries in 46 States. Leading States, in order of tonnage, were Texas, Florida, Pennsylvania, Missouri, and Illinois; these five States accounted for 40% of the total U.S. output. Leading U.S. producers were, in order of volume, Vulcan Materials, Martin Marietta Aggregates, and Lone Star Industries. These three companies accounted for 12% of total U.S. output.

Dolomite.—A total of 31 million tons of dolomite valued at $133 million was reported produced by 60 companies in 24 States. An additional undetermined amount of dolomite is included in the total crushed limestone data. Leading States in the production of dolomite, in order of tonnage, were New York, Pennsylvania, and Michigan; these three States accounted for 51% of the total U.S. output as reported by producers. Leading U.S. producers were, in order of volume, Lone Star Industries, ASARCO Incorporated, and Glasgow Inc.; their combined production represented 28% of the total U.S. dolomite production.

Marble.—Production of crushed marble increased 36% to 2.4 million tons valued at $20 million. Crushed marble was produced by 12 companies at 22 quarries in 13 States. Leading States, in order of tonnage, were Georgia, Alabama, and Texas; these three

States accounted for 91% of the total U.S. output. Leading producers of crushed marble, in order of tonnage, were Georgia Marble Co., Thompson-Weinsman Co., and Basins Engineering Co.; their combined production represented 84% of the total U.S. output.

Calcareous Marl.—Output of marl increased 15% to 4 million tons valued at $8 million. Marl was produced by 14 companies at 14 quarries in 7 States. South Carolina accounted for 80% of total U.S. output, followed by Texas and North Carolina. Leading producers, in order of tonnage, were Dundee Cement Co., Giant Portland Cement Co., and Gifford-Hill; their combined output accounted for 80% of the total U.S. production. These three leading producers of marl were also manufacturers of portland cement.

Shell.—Shell is mainly derived from fossil reefs of oyster shell. The output of crushed shell increased 9% to 9 million tons valued at $38 million. Crushed shell was produced by 13 companies from 17 operations in 5 States. The major producing States were Louisiana and Florida. Leading producers, in order of tonnage, were Dravo Corp., Quality Aggregates, and Ashland Oil Inc.; their combined production represented 63% of U.S. output.

Granite.—Compared with 1983, the 1985 output of crushed granite increased 24% to 145 million tons valued at $670 million. Granite was produced by 130 companies at 580 quarries in 29 States. Leading States, in order of tonnage, were Georgia, North Carolina, Virginia, South Carolina, and California; these five States accounted for 81% of U.S. output. Leading U.S. producers, in order of tonnage, were Vulcan Materials, Martin Marietta Aggregates, and Koppers; their combined production represented 48% of the U.S. total.

Traprock.—Production of crushed traprock increased 13% to 84 million tons valued at $388 million. Traprock was produced by 242 companies at 644 quarries in 23 States. Leading States, in order of tonnage, were New Jersey, Oregon, California, Washington, and Virginia; these five States accounted for 58% of U.S. output. Leading U.S. producers, in order of tonnage, were Tilcon Inc., Traprock Industries Inc., and the U.S. Forest Service; their combined production accounted for 19% of total U.S. output.

Sandstone and Quartzite.—The combined output of crushed sandstone and quartzite increased 9% to 23 million tons valued at $103 million. Crushed sandstone was produced by 103 companies at 361 quarries in 24 States, while crushed quartzite was produced by 16 companies at 17 quarries in 12 States. Leading States in the production of sandstone and quartzite, in order of volume, were Pennsylvania, Arkansas, and Georgia. Leading producers, in order of tonnage, were Weaver Construction Co., the U.S. Forest Service, and H. M. B. Construction Co.; their combined production represented 14% of the U.S. total.

Slate.—Output of crushed slate increased 1% to 773,000 tons valued at $3.8 million. Crushed slate was produced by seven companies at seven quarries in five States. Leading States, in order of tonnage, were Virginia, Georgia, and New York; their combined production accounted for 90% of U.S. output. Leading producers, in order of tonnage, were Galite Corp., Solite Corp., and Arvonia-Buckingham Slate Co. The top three producers accounted for 80% of U.S. output.

Volcanic Cinder and Scoria.—Production of volcanic cinder and scoria increased 61% to 3 million tons valued at $12.5 million. Volcanic cinder and scoria were produced by 38 companies from 256 operations in 10 States. Leading States, in order of volume, were Oregon, Arizona, and California; their combined production accounted for 62% of the total U.S. output. Leading producers, in order of tonnage, were the U.S. Forest Service and Gilbert Central Corp.; their combined production accounted for 29% of U.S. output.

Miscellaneous Stone.—Output of miscellaneous crushed stone increased 28% to 13 million tons valued at $56.9 million.

Table 2.—Crushed stone sold or used in the United States, by kind

Kind	1983				1985			
	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value	Number of quarries	Quantity (thousand short tons)	Value (thousands)	Unit value
Limestone	r2,476	r599,308	r$2,217,216	r$3.69	2,316	685,002	$2,618,621	$3.82
Dolomite	r79	r23,807	r99,673	r4.18	87	31,348	133,271	4.25
Marble	r24	r1,798	r29,613	r16.46	22	2,437	20,439	8.39
Calcareous marl	20	3,451	7,937	r2.29	14	3,959	8,083	2.04
Shell	19	8,348	33,314	3.99	17	9,106	37,951	4.16
Granite	509	r116,678	r487,017	r4.17	580	145,254	669,807	4.61
Traprock	r587	r74,017	r305,509	r4.12	644	83,548	388,027	4.64
Sandstone and quartzite	300	21,259	r87,945	r4.13	378	23,148	103,483	4.47
Slate	8	r763	r8,383	r10.98	7	773	3,758	4.86
Volcanic cinder and scoria	186	1,832	9,149	4.99	256	2,953	12,504	4.23
Miscellaneous stone	r183	r10,384	r41,225	r3.97	81	13,269	56,875	4.29
Total[1]	XX	861,600	3,327,000	r3.86	XX	1,000,800	4,053,000	4.05

[r]Revised. XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Table 3.—Crushed stone[1] sold or used in the United States, by region

(Thousand short tons and thousand dollars)

Region	1984[e]		1985	
	Quantity	Value	Quantity	Value
Northeast:				
New England	21,650	108,300	22,540	112,910
Middle Atlantic	102,800	438,000	115,595	570,333
North Central:				
East North Central	157,600	567,000	147,923	520,118
West North Central	96,200	347,500	106,035	369,972
South:				
South Atlantic	248,800	1,077,800	265,665	1,169,994
East South Central	97,500	375,300	103,525	404,456
West South Central	134,000	465,300	136,929	495,687
West:				
Mountain	28,050	108,700	28,971	106,938
Pacific	69,400	267,700	73,612	302,409
Total[2]	956,000	3,755,600	1,000,800	4,053,000

[e]Estimated.
[1]Includes volcanic cinder and scoria.
[2]Data may not add to totals shown because of independent rounding.

Table 4.—Crushed stone sold or used by producers in the United States, by State[1]

(Thousand short tons and thousand dollars)

State	1984e Quantity	1984e Value	1985 Quantity	1985 Value
Alabama	22,000	98,500	25,853	109,176
Alaska	2,500	10,800	1,907	8,535
Arizona	5,200	27,300	5,929	23,111
Arkansas	15,200	59,800	14,815	60,874
California	38,600	158,000	41,199	174,395
Colorado	7,200	26,200	7,037	25,930
Connecticut	8,300	49,400	7,277	43,937
Florida	68,500	290,000	69,266	287,237
Georgia	45,900	220,000	52,062	256,588
Hawaii	5,400	29,700	5,627	34,183
Idaho	1,800	7,100	2,019	6,977
Illinois	48,500	191,600	41,044	164,117
Indiana	26,700	99,400	[2]23,384	[2]81,117
Iowa	23,800	100,000	23,657	94,496
Kansas	13,600	48,500	15,653	57,155
Kentucky	37,300	133,000	[3]38,022	[3]134,978
Louisiana	4,100	19,500	[4]4,820	[4]25,956
Maine	1,300	4,400	1,459	5,114
Maryland	22,100	94,000	24,406	98,584
Massachusetts	8,400	39,000	9,354	42,881
Michigan	28,100	92,000	30,685	95,953
Minnesota	8,900	25,800	7,756	22,601
Mississippi	2,000	5,800	1,582	4,282
Missouri	41,600	137,000	50,646	162,097
Montana	950	2,400	[5]1,730	[5]5,044
Nebraska	4,500	23,400	4,175	19,134
Nevada	1,100	4,700	1,334	6,218
New Hampshire	850	2,700	1,612	6,434
New Jersey	13,500	75,000	15,692	94,339
New Mexico	4,700	17,000	3,641	15,232
New York	33,100	135,000	35,139	165,136
North Carolina	38,100	168,000	41,771	194,818
North Dakota	--	--	W	W
Ohio	38,500	139,000	38,310	136,544
Oklahoma	25,500	86,000	31,173	98,811
Oregon	12,500	37,500	15,336	54,244
Pennsylvania	56,200	228,000	64,765	310,859
Rhode Island	1,000	5,800	[4]1,135	[4]7,016
South Carolina	17,900	72,500	17,079	72,520
South Dakota	3,800	12,800	4,071	14,412
Tennessee	36,200	138,000	[6]37,939	[6]155,760
Texas	89,200	300,000	85,764	306,821
Utah	5,200	16,400	4,657	14,180
Vermont	1,800	7,000	1,689	7,468
Virginia	47,200	196,000	51,686	221,900
Washington	10,400	31,700	9,543	31,052
West Virginia	9,100	37,300	9,393	38,348
Wisconsin	15,800	45,000	14,496	42,380
Wyoming	1,900	7,600	[6]2,030	[6]7,329
Other	--	--	1,177	6,545
Total[7]	956,000	3,755,600	1,000,800	4,053,000

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]To avoid disclosing company proprietary data, certain State totals do not include all kinds of stone produced within the State; the portion not shown has been included with "Other."

[2]Excludes marl.

[3]Excludes sandstone.

[4]Excludes other stone.

[5]Excludes traprock.

[6]Excludes granite.

[7]Data may not add to totals shown because of independent rounding.

Table 5.—U.S. crushed stone sold or used by producers in 1985, by size of operation

Size range (thousand short tons)	Number of operations	Quantity (thousand short tons)	Percent
0 to 25	931	9,233	0.9
25 to 50	463	16,597	1.7
50 to 75	272	16,789	1.7
75 to 100	182	15,832	1.6
100 to 200	506	76,825	7.6
200 to 300	262	64,040	6.4
300 to 400	192	65,828	6.6
400 to 500	156	69,257	6.9
500 to 600	117	63,940	6.4
600 to 700	79	50,765	5.0
700 to 800	76	56,157	5.6
800 to 900	64	53,737	5.4
900 to 999	39	36,740	3.7
1,000 and over	218	405,057	40.5
Total	3,557	[1]1,000,800	100

[1]Data do not add to total shown because of independent rounding.

Table 6.—Crushed limestone and dolomite sold or used in the United States in 1985, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
Alabama	24,770	98,723
Alaska	W	W
Arizona	3,749	15,626
Arkansas	4,940	17,200
California	17,233	77,687
Colorado	3,035	9,644
Connecticut	308	1,356
Florida	65,326	278,088
Georgia	6,992	31,484
Hawaii	1,006	6,927
Idaho	1,200	3,286
Illinois	41,044	164,117
Indiana	23,384	81,119
Iowa	23,657	94,496
Kansas	15,082	53,546
Kentucky	38,022	134,978
Maine	1,089	3,985
Maryland	15,810	56,262
Massachusetts	W	W
Michigan	30,604	95,810
Minnesota	5,692	17,057
Mississippi	1,582	4,282
Missouri	48,609	157,700
Montana	1,675	4,846
Nebraska	4,175	19,134
Nevada	1,096	4,832
New Jersey	W	W
New Mexico	2,131	8,200
New York	31,332	140,569
North Carolina	4,809	25,325
Ohio	38,217	136,092
Oklahoma	29,192	92,962
Oregon	W	4,082
Pennsylvania	50,933	248,314
Rhode Island	700	4,763
South Carolina	3,523	16,098
South Dakota	3,032	8,981
Tennessee	37,936	155,638
Texas	82,935	290,774
Utah	4,364	13,389
Vermont	1,311	5,699
Virginia	19,116	76,362
Washington	1,556	4,156
West Virginia	8,220	33,383
Wisconsin	12,030	35,369
Wyoming	1,643	6,063
Other	3,284	13,486
Total[1]	716,400	2,751,900

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.

Table 7.—Crushed calcareous marl sold or used by producers in the United States in 1985, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
Florida	W	W
Indiana	W	W
Maine	W	W
Michigan	W	W
North Carolina	37	135
South Carolina	3,171	6,642
Texas	W	W
Other	750	1,307
Total[1]	3,959	8,083

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.

Table 8.—Crushed granite, traprock, and sandstone and quartzite sold or used by producers in the United States in 1985, by State

(Thousand short tons and thousand dollars)

State	Granite		Traprock		Sandstone and quartzite	
	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	267	1,165	--	--	--	--
Alaska	430	2,112	586	2,201	129	759
Arizona	1,307	3,983	--	--	--	--
Arkansas	W	W	--	--	4,017	15,414
California	8,156	31,827	9,733	41,523	1,051	4,116
Colorado	3,513	13,967	W	W	284	1,120
Connecticut	--	--	6,970	42,581	--	--
Georgia	41,263	206,508	--	--	W	W
Hawaii	--	--	4,487	26,786	--	--
Idaho	150	823	375	1,141	287	1,727
Kansas	--	--	--	--	565	3,564
Kentucky	--	--	--	--	W	W
Maine	--	--	W	W	W	W
Maryland	2,660	13,924	W	W	W	W
Massachusetts	1,743	10,231	6,504	26,140	--	--
Michigan	--	--	W	W	--	--
Minnesota	1,916	4,859	22	86	W	W
Missouri	W	W	--	--	W	W
Montana	--	--	W	W	W	198
Nevada	W	W	--	--	--	--
New Hampshire	515	2,430	1,097	4,004	--	--
New Jersey	W	W	12,064	68,748	--	--
New Mexico	W	W	293	951	W	W
New York	W	W	2,878	20,083	614	4,001
North Carolina	33,689	152,988	2,984	15,230	W	W
Ohio	--	--	--	--	93	452
Oklahoma	W	W	--	--	632	2,214
Oregon	90	342	12,050	42,528	1,089	4,333
Pennsylvania	W	W	5,696	23,766	4,847	24,830
Rhode Island	435	2,253	--	--	--	--
South Carolina	10,385	49,780	--	--	--	--
South Dakota	W	W	--	--	1,039	5,431
Tennessee	W	W	--	--	--	--
Texas	W	W	782	3,838	951	5,871
Utah	--	--	--	--	197	476
Vermont	W	W	--	--	--	--
Virginia	23,681	105,410	7,055	34,222	1,112	4,309
Washington	185	668	7,434	24,674	218	1,128
West Virginia	--	--	--	--	1,173	4,965
Wisconsin	667	2,158	19	53	1,781	4,801
Wyoming	W	W	--	--	--	--
Other	14,204	64,379	2,522	9,471	3,067	13,775
Total[1]	145,300	669,800	83,550	388,000	23,150	103,500

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.

Table 9.—Volcanic cinder and scoria and miscellaneous crushed stone sold or used by producers in the United States in 1985, by State

(Thousand short tons and thousand dollars)

State	Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value
Alaska	--	--	W	W
Arizona	628	1,771	W	W
California	W	W	4,473	15,652
Colorado	W	W	7	27
Hawaii	133	469	(1)	(1)
Kansas	--	--	6	45
Louisiana	--	--	W	W
Maryland	--	--	3,286	16,628
Massachusetts	--	--	W	W
Michigan	--	--	W	W
Nevada	84	448	W	W
New Mexico	379	2,042	--	--
New York	--	--	W	W
North Carolina	--	--	W	W
North Dakota	--	--	W	W
Oklahoma	--	--	203	437
Oregon	672	2,375	229	584
Pennsylvania	--	--	W	W
Rhode Island	--	--	W	W
Texas	--	--	283	2,315
Utah	96	314	(1)	2
Vermont	--	--	W	W
Virginia	--	--	W	W
Washington	(1)	2	150	425
Wyoming	305	W	--	--
Other	655	5,084	4,632	20,761
Total[2]	2,953	12,500	13,270	56,880

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Table 10.—Kind of crushed stone produced in the United States in 1985, by State

State	Lime-stone	Dolo-mite	Marble	Marl	Shell	Granite	Trap-rock	Sand-stone	Quartzite	Slate	Volcanic cinder and scoria	Miscella-neous
Alabama	X	X	X			X						X
Alaska	X				X	X	X					X
Arizona	X	X	X			X		X		X	X	
Arkansas	X	X				X		X				
California	X	X			X	X	X	X	X		X	X
Colorado	X					X	X	X			X	X
Connecticut	X						X					
Florida	X	X		X	X					X		
Georgia	X	X	X			X			X			
Hawaii	X						X				X	X
Idaho	X	X				X	X	X	X			
Illinois	X	X										
Indiana	X	X		X								
Iowa	X											
Kansas	X							X	X			X
Kentucky	X							X				
Louisiana					X							X
Maine	X			X			X	X				
Maryland	X				X	X	X	X				X
Massachusetts	X					X	X					X
Michigan	X	X		X			X					X
Minnesota	X	X				X	X	X	X			
Mississippi	X											
Missouri	X	X	X			X		X				
Montana	X						X	X	X			
Nebraska	X											
Nevada	X	X				X					X	X
New Hampshire						X	X					
New Jersey	X					X	X					
New Mexico	X					X	X		X	X	X	
New York	X	X				X	X	X		X		X
North Carolina	X			X		X	X		X			X
North Dakota												X
Ohio	X	X						X	X			
Oklahoma	X	X				X		X				X
Oregon	X					X	X	X			X	X
Pennsylvania	X	X				X	X	X				X
Rhode Island	X					X						X
South Carolina	X			X		X						
South Dakota	X							X	X			
Tennessee	X	X	X			X						
Texas	X	X	X	X			X	X				X
Utah	X	X						X	X		X	X

Vermont	X		X	X						X
Virginia	X	X		X	X	X		X		X
Washington	X	X		X	X	X	X		X	X
West Virginia	X					X				
Wisconsin	X	X		X	X	X				
Wyoming	X	X	X	X					X	
American Samoa					X					
Guam	X									
Puerto Rico	X		X	X	X					X

CONSUMPTION AND USES

Crushed stone production reported to the Bureau of Mines is actually material "sold or used" by the producers. Stockpiled production is not reported. Therefore, the sold or used tonnage represents the amount of production released for domestic consumption or export in a given year. Because some of the crushed stone producers did not report a breakdown by end use, their total production as well as the estimated production of nonrespondents, was included in the tables under "Other unspecified uses," starting with the 1983 survey. This change in the processing procedures should be taken into account when 1983 and 1985 use patterns are compared with prior years.

In 1985, U.S. consumption of crushed stone was 1.0 billion tons valued at $4.1 billion, a 5% increase over the estimated consumption of 1984, and a 16% increase over the reported consumption of 1983. About 63% of this tonnage was used as construction aggregates, mostly for highway and road construction and maintenance, 11% for cement and lime manufacturing, 3% for agricultural purposes, 1% for metallurgical purposes, 2% for a variety of industrial uses, and 20% for other miscellaneous or unspecified uses.

Limestone.—Of the 685 million tons of crushed limestone consumed, 57% was used as construction aggregates, 16% for cement and lime manufacturing, and 3% for agricultural purposes. No significant changes occurred in the use patterns of crushed limestone at the national level, except for the large increase of the amount included in table 12 under "Other unspecified uses."

U.S. consumption of crushed limestone for total construction aggregates increased 10%, from 353 million tons in 1983, to 388 million tons in 1985. U.S. consumption of limestone for concrete aggregates decreased 6%, while limestone used as roadstone and coverings increased 3%. Among the major producing States, consumption of limestone as concrete aggregates increased in Florida, Kentucky, Texas, and Virginia, and decreased in Alabama, Illinois, Ohio, and Pennsylvania. Consumption of limestone as roadstone and coverings increased in Florida, Ohio, Pennsylvania, and Tennessee, but decreased in Illinois, Texas, and Wisconsin.

U.S. consumption of limestone and dolomite for cement manufacturing increased 17%, from 79 million tons in 1983, to 92 million tons in 1985. Among the major producing States, consumption of crushed limestone and dolomite for cement manufacturing increased in California, Michigan, Missouri, Pennsylvania, and Texas. U.S. consumption of limestone and dolomite for lime manufacturing decreased 18%, from 22 million tons in 1983, to 18 million tons in 1985. Among the major producing States, consumption of limestone and dolomite for lime manufacturing increased in Michigan and Texas, but decreased in Alabama, Kentucky, and Pennsylvania. U.S. consumption of aglime increased 17%, from 21 million tons in 1983, to 25 million tons in 1985. Among major producing States, consumption of aglime increased in Florida, Illinois, Kentucky, and Missouri, but decreased in Indiana, Iowa, and Pennsylvania.

Dolomite.—Of the 31 million tons of crushed dolomite consumed, 52% was used as construction aggregates, 9% as flux stone, 5% as aglime, and 2% for lime manufacturing. An additional amount of dolomite consumed in a variety of uses is reported with the limestone.

Marble.—Of the 2.4 million tons of crushed marble consumed, 52% was used as fillers and extenders and 35% was used for construction purposes. No other significant changes in the end-use pattern of crushed marble occurred.

Granite.—Of the 145 million tons of crushed granite consumed, 83% was used as construction aggregates and 7% was used as railroad ballast. Compared with 1983, consumption of both construction aggregates and railroad ballast increased 33% and 10%, respectively.

Traprock.—Of the 84 million tons of crushed traprock consumed, 71% was used as construction aggregates and 3% was used as railroad ballast.

Sandstone and Quartzite.—Of the 23 million tons of crushed sandstone and quartzite consumed, 63% was used as construction aggregates, some as railroad ballast, and 2% for cement and lime manufacturing. Compared with 1983, consumption of sandstone and quartzite as construction aggregates increased 37%, while consumption for cement manufacturing decreased 6%.

Slate.—Of the 773,000 tons of slate consumed, 51% was used as construction aggregates and the remaining 49% was used for a variety of industrial applications.

Calcareous Marl.—Of the 4.0 million tons consumed in 1985, 98% was used for cement manufacturing and 1% was used for agricultural purposes.

Shell.—Of the 9.1 million tons of crushed shell consumed, 69% was used as construction aggregates, mostly for roads, with cement and lime manufacturing as the next major use.

Volcanic Cinder and Scoria.—Of the 2.9 million tons of volcanic cinder and scoria consumed, 45% was used as construction aggregates, mainly for road construction and maintenance, and 15% was used as lightweight aggregate.

Miscellaneous Stone.—Of the 13.3 million tons of miscellaneous crushed stone consumed, 95% was used as construction aggregates, mainly for road construction and maintenance.

Table 11.—Crushed stone sold or used by producers in the United States in 1985, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1-1/2 inch):		
Macadam	14,860	57,354
Riprap and jetty stone	21,449	89,377
Filter stone	6,202	26,376
Other coarse aggregate	1,043	4,795
Coarse aggregate, graded:		
Concrete aggregate, coarse	106,526	507,642
Bituminous aggregate, coarse	63,635	287,531
Bituminous surface treatment aggregate	25,462	120,831
Railroad ballast	23,257	91,177
Other graded coarse aggregate	736	2,698
Fine aggregate (-3/8 inch):		
Stone sand, concrete	21,526	108,247
Stone sand, bituminous mix or seal	13,641	54,842
Screening, undesignated	19,797	81,076
Other fine aggregate	3,602	12,542
Coarse and fine aggregate:		
Graded road base or subbase	175,952	647,320
Unpaved road surfacing	41,924	159,394
Terrazzo and exposed aggregate	3,281	22,676
Crusher run or fill or waste	67,892	272,633
Other coarse and fine aggregate	964	3,632
Other construction materials[1]	20,160	82,425
Agricultural:		
Agricultural limestone	22,430	96,712
Poultry grit and mineral food	1,972	16,304
Other agricultural uses	485	2,458
Chemical and metallurgical:		
Cement manufacture	96,586	258,953
Lime manufacture	17,343	67,385
Dead-burned dolomite manufacture	966	6,442
Flux stone	10,343	41,788
Chemical stone	604	2,655
Glass manufacture	404	3,500
Sulfur oxide removal	1,459	5,889
Special:		
Mine dusting or acid water treatment	732	5,194
Asphalt fillers or extenders	811	5,292
Whiting or whiting substitute	1,091	17,266
Other fillers or extenders	4,533	50,266
Abrasives	312	1,309
Lightweight aggregate	803	3,158
Roofing granules	2,543	14,349
Sugar refining	267	781
Paper manufacture	685	2,031
Other miscellaneous uses	12,998	66,506
Other unspecified uses[2]	191,521	752,012
Total[3]	1,000,800	4,053,000

[1]Includes building products, dam construction, and drain fields.
[2]Includes production reported without a breakdown by use and estimates for nonrespondents.
[3]Data may not add to totals shown because of independent rounding.

Table 12.—Crushed limestone and dolomite sold or used by

(Thousand short tons

State	Concrete aggregate		Bituminous aggregate		Roadstone and coverings		Riprap and railroad ballast	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,546	11,694	4,334	17,949	2,399	10,057	877	3,151
Alaska	--	--	--	--	W	W	--	--
Arizona	W	W	--	--	--	--	W	W
Arkansas	W	W	306	1,359	388	1,221	583	2,282
California	1,007	4,114	W	W	1,210	6,125	W	W
Colorado	--	--	--	--	--	--	--	--
Connecticut	--	--	--	--	--	--	--	--
Florida	21,160	122,485	5,183	25,312	13,448	36,544	446	2,358
Georgia	W	W	W	W	1,691	7,733	W	W
Hawaii	386	3,807	--	--	103	799	--	--
Idaho	40	115	150	380	W	1,745	--	--
Illinois	3,419	14,978	4,273	18,791	12,405	43,900	1,867	7,395
Indiana	1,153	4,496	5,445	17,206	3,185	11,008	1,180	3,967
Iowa	1,779	7,423	2,347	10,390	5,475	21,190	236	1,123
Kansas	1,758	6,670	1,776	7,709	3,486	11,705	307	1,308
Kentucky	6,377	22,919	4,630	17,302	8,579	30,878	1,935	6,905
Maine	W	W	W	W	W	W	W	W
Maryland	2,825	10,740	2,533	10,254	5,570	21,518	288	1,593
Massachusetts	--	--	(2)	W	W	W	W	W
Michigan	1,680	4,900	1,549	5,162	4,191	11,701	856	3,072
Minnesota	270	901	W	W	2,420	6,520	142	489
Mississippi	W	W	W	W	W	W	W	W
Missouri	4,072	15,850	3,624	13,012	10,019	31,932	5,284	14,432
Montana	--	--	W	W	434	1,401	--	--
Nebraska	791	4,266	161	781	1,048	5,403	267	1,621
Nevada	--	--	--	--	W	W	W	W
New Jersey	W	W	W	W	W	W	--	--
New Mexico	343	897	187	696	581	2,361	244	1,451
New York	1,145	5,738	5,787	29,501	3,328	15,788	828	3,931
North Carolina	W	W	W	W	W	W	W	W
Ohio	3,375	11,684	3,750	15,159	11,911	41,889	1,391	4,902
Oklahoma	1,815	7,307	1,253	4,059	2,298	5,710	113	429
Oregon	--	--	--	--	--	--	--	--
Pennsylvania	4,065	17,379	6,955	30,337	11,042	45,621	532	2,024
Rhode Island	--	--	--	--	--	--	--	--
South Carolina	W	W	W	W	W	W	W	W
South Dakota	W	W	58	234	31	89	8	21
Tennessee	4,805	21,830	6,061	25,956	13,496	60,223	639	2,532
Texas	14,998	59,817	6,373	26,819	23,846	61,054	1,322	6,296
Utah	--	--	--	--	849	1,751	790	2,805
Vermont	W	W	411	1,957	W	W	W	W
Virginia	3,671	15,943	1,977	9,869	4,248	13,220	767	3,010
Washington	--	--	--	--	W	W	4	18
West Virginia	719	2,756	650	5,071	1,085	4,590	323	1,498
Wisconsin	812	2,644	617	1,748	5,102	14,662	241	986
Wyoming	W	W	66	W	246	W	W	W
Total (excluding withheld)[1]	85,011	381,353	70,456	297,013	154,114	528,338	21,470	79,599
Total withheld	2,707	13,714	1,528	7,798	3,542	13,399	2,371	9,906
Grand total[1]	87,718	395,068	71,984	304,813	157,655	541,739	23,841	89,505
Guam	231	1,896	W	398	W	762	5	55
Puerto Rico	827	4,876	38	213	8	42	15	23

W Withheld to avoid disclosing company proprietary data; included with "Total withheld" and "Other uses."
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

producers in the United States in 1985, by State and use

and thousand dollars)

Other construction uses		Cement manufacture		Agricultural uses		Lime manufacture		Other uses		Total[1]	
Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
2,346	9,721	2,625	7,703	274	1,643	W	W	9,370	36,806	24,770	98,723
--	--	--	--	--	--	--	--	W	W	W	W
W	W	W	W	--	--	W	W	3,749	15,626	3,749	15,626
165	589	W	W	162	1,296	W	W	3,336	10,452	4,940	17,200
295	2,641	13,297	41,502	71	581	513	6,762	839	15,964	17,233	77,687
--	--	W	W	--	--	--	--	3,035	9,644	3,035	9,644
2	W	46	93	28	W	26	54	206	1,209	308	1,356
9,364	38,659	2,225	8,175	3,899	9,690	--	--	9,601	34,865	65,326	278,088
1,235	5,983	W	W	1,038	5,250	--	--	3,028	12,516	6,992	31,484
W	W	W	W	21	171	--	--	496	2,150	1,006	6,927
(2)	(2)	W	W	27	80	1	2	990	964	1,207	3,286
1,376	5,439	2,577	6,551	3,165	11,701	W	W	11,962	55,362	41,044	164,117
2,004	7,525	W	W	1,307	5,170	W	23	9,110	31,724	23,384	81,119
2,851	10,243	2,373	5,768	1,245	9,348	4	23	7,347	28,988	23,657	94,496
1,142	4,621	2,977	7,747	874	3,934	W	W	2,762	9,850	15,082	53,546
2,596	9,853	W	W	2,354	8,694	W	W	11,551	38,428	38,022	134,978
W	W	W	W	W	W	--	--	1,089	3,985	1,089	3,985
812	3,136	2,619	5,057	W	W	19	78	1,145	3,886	15,810	56,262
--	--	--	--	156	1,062	W	W	W	W	W	W
1,288	4,163	6,146	14,250	444	1,760	5,801	18,222	8,648	32,579	30,604	95,810
572	1,834	--	--	255	821	W	W	2,032	6,491	5,692	17,057
W	W	W	W	199	1,037	--	--	1,383	3,244	1,582	4,282
7,547	26,402	6,190	14,966	2,068	7,929	205	892	9,600	32,284	48,609	157,700
--	--	W	W	--	--	--	--	1,241	3,445	1,675	4,846
348	1,935	W	W	229	1,839	--	--	1,330	3,289	4,175	19,134
--	--	W	W	W	W	W	W	1,096	4,832	1,096	4,832
W	W	--	--	W	W	--	--	W	W	W	W
W	W	W	W	--	--	--	--	776	2,797	2,131	8,200
2,495	9,745	4,221	9,432	598	3,263	W	W	12,929	63,171	31,332	140,569
W	W	--	--	6	75	--	--	4,803	25,250	4,809	25,325
2,613	8,703	2,062	6,895	1,220	5,080	1,087	3,868	10,810	37,913	38,217	136,092
1,899	5,400	2,625	3,970	85	287	--	--	19,105	65,800	29,192	92,962
W	W	W	W	--	--	--	--	W	W	W	W
1,953	8,157	6,571	25,420	1,229	10,605	1,895	12,149	16,688	96,624	50,933	248,315
--	--	--	--	W	854	--	--	700	3,909	700	4,763
W	W	--	--	W	W	--	--	3,523	16,098	3,523	16,098
19	67	950	1,994	--	--	--	--	1,966	6,575	3,032	8,981
4,732	16,730	W	W	733	2,876	--	--	7,469	25,492	37,936	155,638
3,426	12,969	11,487	23,167	643	2,568	2,088	8,979	18,752	89,105	82,935	290,774
(2)	(2)	1,433	4,918	W	W	W	W	1,292	3,915	4,364	13,389
W	W	--	--	--	--	--	--	900	3,742	1,311	5,699
2,793	9,272	1,616	2,680	1,030	8,126	W	W	3,013	14,241	19,116	76,362
20	101	W	W	W	W	--	--	1,532	4,037	1,556	4,156
622	3,397	1,530	3,169	52	461	W	W	3,238	12,439	8,220	33,383
849	1,920	W	W	577	3,418	W	W	3,832	9,991	12,030	35,369
W	W	304	1,064	--	--	--	--	1,027	4,999	1,643	6,063
55,364	209,205	73,874	194,521	23,989	109,619	11,639	51,052	217,304	884,681	713,067	2,734,323
4,568	25,594	18,123	53,690	529	3,132	6,557	22,307	3,128	16,507	3,284	17,569
59,932	234,798	91,998	248,213	24,517	112,750	18,195	73,359	XX	XX	716,400	2,751,900
147	621	--	--	--	--	--	--	165	--	548	3,731
--	--	1,124	5,089	--	--	--	--	1,380	6,508	3,392	16,751

XX Not applicable.

Table 13.—Crushed limestone and dolomite sold or used by producers in the United States in 1985, by use

(Thousand short tons and thousand dollars)

Use	Limestone		Dolomite	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1-1/2 inch):				
Macadam	11,910	43,974	206	700
Riprap and jetty stone	13,862	51,263	538	1,848
Filter stone	4,677	19,262	93	273
Other coarse aggregate	628	2,902	W	1
Coarse aggregate, graded:				
Concrete aggregate, coarse	68,571	312,520	2,284	8,537
Bituminous aggregate, coarse	42,274	177,932	2,552	10,620
Bituminous surface treatment aggregate	15,321	67,989	919	4,959
Railroad ballast	7,544	28,764	1,896	7,630
Other graded coarse aggregate	667	2,427	--	--
Fine aggregate (-3/8 inch):				
Stone sand, concrete	12,663	58,514	613	3,015
Stone sand, bituminous mix or seal	8,431	32,210	1,026	3,675
Screening, undesignated	10,028	38,737	426	1,618
Other fine aggregate	3,560	12,389	W	W
Coarse and fine aggregate:				
Graded road base or subbase	110,918	369,794	3,400	12,466
Unpaved road surfacing	30,093	110,284	498	1,617
Terrazzo and exposed aggregate	676	4,167	36	197
Crusher run or fill or waste	36,768	139,492	1,214	4,310
Other coarse and fine aggregate	942	3,549	--	--
Other construction materials	8,594	30,007	666	2,194
Agricultural:				
Agricultural limestone	20,637	86,925	1,455	7,936
Poultry grit and mineral food	1,875	15,351	W	W
Other agricultural uses	422	2,024	W	W
Chemical and metallurgical:				
Cement manufacture	91,930	247,826	W	W
Lime manufacture	16,657	64,732	520	1,921
Dead-burned dolomite manufacture	433	4,467	W	W
Flux stone	7,560	31,435	2,717	10,049
Chemical stone	558	2,383	W	W
Glass manufacture	404	3,500	--	--
Sulfur oxide removal	1,427	5,527	32	W
Special:				
Mine dusting or acid water treatment	651	4,057	--	--
Asphalt fillers or extenders	785	4,977	W	25
Whiting or whiting substitute	672	12,687	W	100
Other fillers or extenders	2,978	38,173	373	4,314
Abrasives	302	1,277	--	--
Lightweight aggregate	181	1,319	--	--
Roofing granules	1,993	12,595	2	5
Paper manufacture	640	1,779	--	--
Other miscellaneous uses	8,480	43,985	1,422	6,134
Other unspecified uses[1]	138,289	527,426	8,460	39,132
Total[2]	685,000	2,618,600	31,350	133,300

W Withheld to avoid disclosing company proprietary data; included with "Special: Other miscellaneous uses."
[1]Includes production without a breakdown by use and estimates for nonrespondents.
[2]Data may not add to totals shown because of independent rounding.

Table 14.—Crushed marble sold or used by producers in the United States in 1985, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Other agricultural uses	W	215
Stone sand, concrete	W	W
Terazzo and exposed aggregate	44	382
Other construction and maintenance uses[1]	454	2,376
Whiting or whiting substitute and fillers	1,276	10,741
Other[2]	103	3,120
Other miscellaneous uses	560	3,604
Total	2,437	[3]20,440

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes concrete aggregate (coarse), graded road base or subbase, bituminous surface treatment aggregate, unpaved road surfacing, riprap and jetty stone, railroad ballast, and crusher run (select material or fill).
[2]Includes poultry grit and mineral food, stone sand, and fillers and extenders.
[3]Data do not add to total shown because of independent rounding.

Table 15.—Crushed granite and traprock sold or used by producers in the United States in 1985, by use

(Thousand short tons and thousand dollars)

Use	Granite		Traprock	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1-1/2 inch):				
Macadam	580	2,833	1,989	9,150
Riprap and jetty stone	3,255	18,091	2,555	11,240
Filter stone	681	3,419	636	2,790
Other coarse aggregate	79	288	257	1,477
Coarse aggregate, graded:				
Concrete aggregate, coarse	24,260	125,242	8,785	48,008
Bituminous aggregate, coarse	10,490	53,564	6,710	36,849
Bituminous surface treatment aggregate	5,818	30,448	2,108	9,750
Railroad ballast	10,637	41,107	2,422	9,876
Other graded coarse aggregate	W	W	W	W
Fine aggregate (-3/8 inch):				
Stone sand, concrete	6,158	32,565	1,679	12,033
Stone sand, bituminous mix or seal	2,228	9,936	1,472	6,816
Screening, undesignated	7,727	33,226	1,179	5,954
Coarse and fine aggregate:				
Graded road base or subbase	25,635	110,238	21,616	91,322
Unpaved road surfacing	2,038	8,965	4,749	16,761
Terrazzo and exposed aggregate	303	1,653	2,088	14,455
Crusher run or fill or waste	24,046	109,520	2,422	7,942
Other coarse and fine aggregate	--	--	W	W
Other construction materials	6,711	30,205	1,374	6,975
Agricultural:				
Agricultural limestone	W	W	W	W
Poultry grit and mineral food	W	W	--	--
Chemical and metallurgical:				
Cement manufacture	W	W	--	--
Lime manufacture	W	W	--	--
Chemical stone	--	--	W	W
Special:				
Asphalt fillers or extenders	17	290	--	--
Whiting or whiting substitute	--	--	45	116
Abrasives	W	W	--	--
Roofing granules	W	W	W	W
Sugar refining	--	--	W	W
Other miscellaneous uses	1,240	4,959	1,456	5,830
Other unspecified uses[1]	13,350	53,255	19,998	90,681
Total[2]	145,300	669,800	83,550	388,000

W Withheld to avoid disclosing company proprietary data; included with "Special: Other miscellaneous uses."
[1]Includes production reported without a breakdown by end use, and estimates for nonrespondents.
[2]Data may not add to totals shown because of independent rounding.

Table 16.—Crushed sandstone and quartzite sold or used by producers in the United States in 1985, by use

(Thousand short tons and thousand dollars)

Use	Sandstone		Quartzite	
	Quantity	Value	Quantity	Value
Coarse aggregate (+1-1/2 inch):				
Macadam	W	W	--	--
Riprap and jetty stone	899	4,087	34	140
Filter stone	85	482	W	W
Other coarse aggregate	W	W	--	--
Coarse aggregate, graded:				
Concrete aggregate, coarse	1,163	6,149	594	3,391
Bituminous aggregate, coarse	1,106	5,855	117	597
Bituminous surface treatment aggregate	684	4,595	130	763
Railroad ballast	317	2,010	W	W
Other graded coarse aggregate	W	W	--	--
Fine aggregate (-3/8 inch):				
Stone sand, concrete	355	1,883	W	W
Stone sand, bituminous mix or seal	386	1,683	W	W
Screening, undesignated	364	1,391	W	W
Other fine aggregate	W	W	--	--
Coarse and fine aggregate:				
Graded road base or subbase	4,637	19,074	1,027	4,247
Unpaved road surfacing	217	933	W	W
Terrazzo and exposed aggregate	29	435	--	--
Crusher run or fill or waste	765	2,588	W	W
Other coarse and fine aggregate	W	W	--	--
Other construction materials	1,203	4,479	617	3,753
Agricultural:				
Poultry grit and mineral food	--	--	W	W
Chemical and metallurgical:				
Cement manufacture	244	580	118	385
Flux stone	W	W	W	W
Special:				
Whiting or whiting substitute	--	--	121	W
Lightweight aggregate	([1])	10	--	--
Other miscellaneous uses	7,345	30,295	592	3,677
Other unspecified uses[2]	W	W	--	--
Total[3]	19,800	86,530	3,348	16,950

W Withheld to avoid disclosing company proprietary data; included with "Special: Other miscellaneous uses."
[1]Less than 1/2 unit.
[2]Includes production reported without a breakdown by end use, and estimates for nonrespondents.
[3]Data may not add to totals shown because of independent rounding.

Table 17.—Crushed volcanic cinder and scoria sold or used by producers in the United States in 1985, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1-1/2 inch):		
Riprap and jetty stone	9	49
Filter stone	W	W
Other coarse aggregate	63	65
Concrete aggregate, graded:		
Concrete aggregate, coarse	49	152
Bituminous surface treatment aggregate	32	168
Railroad ballast	W	W
Fine aggregate (-3/8 inch):		
Stone sand, concrete	4	W
Stone sand, bituminous mix or seal	W	W
Screening, undesignated	W	W
Coarse and fine aggregate:		
Graded road base or subbase	462	2,283
Unpaved road surfacing	585	1,612
Terrazzo and exposed aggregate	94	1,314
Crusher run or fill or waste	58	W
Other coarse and fine aggregate	3	6
Other construction materials[1]	350	2,125
Special:		
Other fillers or extenders	W	W
Lightweight aggregate	452	1,607
Roofing granules	17	66
Paper manufacture	W	W
Other miscellaneous uses[2]	260	1,443
Other unspecified uses[3]	513	1,613
Total[4]	2,953	12,500

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."

[1]Includes railroad ballast, filler stone, other fillers or extenders, stone sand (bituminous mix or seal), and fine aggregate screen.

[2]Includes paper manufacture, waste material, and miscellaneous uses.

[3]Includes production reported without a breakdown by use and estimates for nonrespondents.

[4]Data may not add to totals shown because of independent rounding.

Table 18.—Crushed miscellaneous stone[1] sold or used by producers in the United States in 1985, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+1-1/2 inch):		
Macadam	W	W
Riprap and jetty stone	288	2,534
Other coarse aggregate	(2)	2
Coarse aggregate, graded:		
Concrete aggregate, coarse	555	2,303
Bituminous aggregate, coarse	W	W
Bituminous surface treatment aggregate	W	W
Railroad ballast	83	239
Fine aggregate (-3/8 inch):		
Stone sand, concrete	W	W
Stone sand, bituminous mix or seal	44	W
Screening, undesignated	(2)	2
Coarse and fine aggregate:		
Graded road base or subbase	8,111	37,179
Unpaved road surfacing	3,329	17,413
Terrazzo and exposed aggregate	10	72
Crusher run or fill or waste	1,887	6,991
Other construction materials	643	2,675
Poultry grit and mineral food	82	6,207
Other agricultural uses	W	W
Chemical and metallurgical:		
Cement manufacture	3,922	8,015
Chemical stone	W	W
Other miscellaneous uses[3]	3,126	7,447
Other unspecified uses[4]	5,027	15,662
Total[5]	27,100	106,700

W Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous uses."

[1]Includes marl, other stone, shell, and slate.

[2]Less than 1/2 unit.

[3]Includes abrasives, lime manufacture, mine dusting, roofing granules, and sugar refining.

[4]Includes production reported without a breakdown by end use, and estimates for nonrespondents.

[5]Data may not add to totals shown because of independent rounding.

PRICES

Compared with 1983, the 1985 average unit price of crushed stone increased 5% to $4.05. By kind of stone, the average unit prices showed increases of 1% for dolomite, 3% for limestone, 4% for shell, 8% for sandstone and quartzite, 10% for granite, and 12% for traprock, and decreases of 11% for calcareous marl and 15% for volcanic cinder and scoria. Some very large decreases, mostly owing to changes in end uses, occurred for marble (-52%) and slate (-55%).

TRANSPORTATION

Of the total crushed stone produced, 85% was transported by truck from the plant or quarry to the site of the first point of sale or use, 5% was transported by rail, and 4% by waterway. Information regarding the distance to which crushed stone was shipped or cost per ton per mile was not available.

Table 19.—Crushed stone sold or used by producers in the United States in 1985, by method of transportation

Method of transportation	Quantity (thousand short tons)	Percent
Truck	850,109	85
Rail	48,830	5
Water	39,536	4
Other	62,321	6
Total	[1]1,000,800	100

[1]Data do not add to total shown because of independent rounding.

FOREIGN TRADE

Exports.—Exports of crushed stone were unchanged from the 1984 level and totaled 2.4 million tons, while the value increased 22% to $29 million. Exports of limestone accounted for 95% of the 2.4 million tons, an increase of 4% over that of 1984. Ninety-eight percent of this total was exported to Canada.

Imports.—Imports of crushed stone decreased 7% in volume to 2.7 million tons and 32% in value to $10.2 million. About 48% of this tonnage was limestone, 64% of which came from Canada.

Imports of calcium carbonate fines decreased 4% in volume to 281,000 tons and 42% in value to $1.4 million. Of the natural calcium carbonate (aragonite), over 99% came from the Bahamas, while most of the processed calcium carbonate was imported, in decreasing order of tonnage, from France, the United Kingdom, and the Federal Republic of Germany. Precipitated calcium carbonate is covered in the "Calcium and Calcium Compounds" chapter.

Table 20.—U.S. exports of crushed stone in 1985, by destination

(Thousand short tons unless otherwise specified)

Destination	Quartzite	Limestone[1]	Other	Total[2]
North America:				
Canada	1	2,222	71	2,293
Mexico	([3])	([3])	11	11
Total	1	2,222	82	2,304
South America:				
Bolivia	--	18	--	18
Venezuela	--	18	1	19
Other	([3])	6	3	9
Total[2]	([3])	42	4	45
Europe:				
France	1	--	3	4
Germany, Federal Republic of	3	([3])	([3])	3
Netherlands	1	--	--	1
United Kingdom	1	--	3	4
Other	1	--	1	1
Total[2]	6	([3])	7	13
Asia:				
Japan	1	([3])	1	3
Other	1	([3])	([3])	1
Total[2]	2	([3])	2	4
Oceania	--	1	4	4
Middle East and Africa	([3])	([3])	([3])	1
Grand total[2]	9	2,265	98	2,372
Total value thousands	$10,645	$15,107	$3,594	$29,347

[1]Includes ground limestone.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

Source: Bureau of the Census.

Table 21.—U.S. imports for consumption of crushed stone and calcium carbonate fines, by type

(Thousand short tons and thousand dollars)

Type	1984 Quantity	1984 Customs value	1985 Quantity	1985 Customs value
Crushed stone and chips:				
Limestone	1,645	10,646	1,299	5,261
Marble, breccia	2	181	29	547
Quartzite	64	945	33	638
Slate	10	47	2	99
Other	1,202	3,251	1,361	3,664
Total[1]	2,923	15,071	2,725	10,209
Calcium carbonate fines:[2]				
Natural aragonite[3]	275	710	274	716
Chalk, whiting	17	1,761	7	715
Total[1]	292	2,471	281	1,432
Grand total[1]	3,215	17,543	3,006	11,640

[1]Data may not add to totals shown because of independent rounding.
[2]Excludes precipitated calcium carbonate.
[3]Includes some chalk and other calcareous materials.

Source: Bureau of the Census.

WORLD REVIEW

Australia.—The government of Western Australia introduced a computerized information system that will allow instant access to the results of previous mineral explorations performed by mining companies. Under the provisions of the Mining Act, companies are required to report all technical details of their exploration activities to the Department of Mines. These reports become eligible for open-file release when the exploration tenements are relinquished. Companies interested in new explorations will be able to review previous exploration programs and, therefore, avoid costly duplications by having access to such reports.[2]

Canada.—The 1984 production of stone in Canada was 81.8 million tons valued at $393 million; about 95% of this output was crushed stone. The Province of Ontario continued to be the largest producer of stone with 34 million tons valued at $160 million, followed by Quebec with 31 million tons valued at $139 million. Preliminary estimates for 1985 stone production indicate a decrease of 5% to 78 million tons valued at $378 million, with the Province of Ontario accounting for about 40% of the total output.

TECHNOLOGY

Effective January 1, 1985, the National Crushed Stone Association and the National Limestone Institute were consolidated into one organization called the National Stone Association. This new trade organization became the sole representative of the entire crushed stone industry. The first annual convention of the new association was held in Bal Harbour, FL, on January 20-23, 1985, and was attended by over 700 members and prospective members. The goal of the new association, the economic outlook, and the legislative matters that may impact the crushed stone industry were the major topics discussed.[3]

Beginning with the 1985 biennial survey, the Bureau of Mines implemented new reporting procedures for crushed stone production at the State level. Most of the States were subdivided into Bureau districts by grouping several adjacent counties. Consequently, the number of companies within each district increased significantly, making more information available for publication. The new tables showing production of crushed stone within each district are published in the Bureau of Mines "Minerals Yearbook, Volume II, Area Reports: Domestic."[4]

The potential demand in the 1990's for limestone and lime used for sulfur removal was analyzed by the Illinois Department of

Energy and Natural Resources in a study based on the projections for sulfur control prepared by the North American Electric Reliability Council. Two models were considered in these projections. One was based on the provisions of the present Clean Air Act regulations, and the second was based on the requirements of the proposed acid rain legislation. The study concludes that, in 1992, the demand for limestone used for sulfur removal is expected to be between 7.9 and 9.9 million tons under the first scenario, and an additional 21.3 to 26.6 million tons of limestone under the assumptions made for the second.[5]

An extensive review of limestone specifications from construction aggregates and road materials to cement manufacturing, agricultural uses, glass manufacturing, and use as fillers and extenders, was published. The specifications were derived from the British Standards Institute and other British Government and corporate guidelines. Although the published specifications are related to British manufacturing practice, they provide a general guide to the typical properties required for limestone used in a variety of applications.[6]

The recent advances achieved in high intensity wet- and dry-magnetic separation techniques extended their usefulness for processing of industrial minerals. New developments included the use of strong rare-earth permanent magnetic separators, large particle size electromagnetic separators, and superconducting cryogenic wet and dry systems. Several systems capable of separating minerals on the basis of their magnetic repelling properties rather than their attracting properties are also being studied.[7]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Clark, G. Mines Department Launches First Computerized Database. Ind. Miner. (London), No. 214, July 1985, p. 9.

[3]Huhta, R. S. Stone Producers "On Their Way." Rock Prod., v. 88, No. 3, Mar. 1985, pp. 41-46.

[4]Tepordei, V. V. Bureau of Mines Revises System. Rock Prod., v. 88, No. 12, Dec. 1985, pp. 56-57, 84.

[5]Bhagwat, S. B. The Lime and Limestone Market for Sulfur Removal: Potential for 1992. IL State Geol. Surv.—IL Miner. Note 90, 1985, p. 13.

[6]Power, T. Limestone Specifications—Limiting Constraints on the Market. Ind. Miner. (London), No. 217, Oct. 1985, pp. 65-91.

[7]Clark, G. Magnetic Separation. Ind. Miner. (London), No. 212, May 1985, pp. 21-23.

Dimension Stone

By Harold A. Taylor, Jr.[1]

Production of dimension stone decreased 3%, to 1.12 million short tons valued at $172 million, after showing little change over the previous 7 years. Approximately one-half of the dimension stone produced was granite. Limestone, sandstone, slate, and marble were also produced.

Exports of dimension stone decreased 40% in value to $14 million. The value of dimension stone imports increased 32% to $295 million, equivalent to 172% of the value of domestic production.

Domestic Data Coverage.—Domestic production data for dimension stone are developed by the Bureau of Mines from voluntary surveys of U.S. producers of rough and finished dimension stone. Of the 408 dimension stone operations surveyed, including those that were idle, 341, or 82%, responded, representing 95% of the total value shown in table 1. Production data for nonrespondents were estimated using preliminary production reports, adjusted prior years production levels, and employment data.

Table 1.—Salient U.S. dimension stone statistics

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
Sold or used by producers[1]	1,331	[e]1,089	1,090	[e]1,157	1,121
Value[1]	$150,463	[e]$137,671	$147,843	[e]$154,949	$171,667
Exports (value)	$20,698	$18,678	[r]$19,126	[r]$23,007	$13,835
Imports for consumption (value)	$132,904	$169,874	[r]$191,862	[r]$223,150	$295,094

[e]Estimated. [r]Revised.
[1]Does not include Puerto Rico.

DOMESTIC PRODUCTION

Dimension stone was produced by 196 companies at 275 quarries in 36 States. Leading States, in order of tonnage, were Indiana, Georgia, and Vermont, producing, together, 44% of the Nation's total. Notable was an 8% decrease in Georgia and an 18% increase in Indiana. Of the total production, 54% was granite, 27% was limestone, 11% was sandstone, 4% was slate, 3% was marble, and the remaining 1% was miscellaneous stone, including argillite, schist, soapstone, and traprock (basalt). Leading producing companies in terms of tonnage were Rock of Ages Corp., in Vermont and New Hampshire, and Cold Spring Granite Co., principally in California, Minnesota, South Dakota, and Texas.

Granite.—Dimension granite includes all coarse-grained igneous rocks. Production decreased 6% to 602,000 tons and decreased slightly in value to $93.9 million. Dimension granite was produced by 74 companies at 115 quarries in 20 States. Georgia continued to be the leading State producing 27% of the U.S. total, followed by Vermont and New Hampshire. These three States together produced over one-half of the U.S. total. Of significance was a production decrease of 10% in Georgia, while New Hampshire registered a 34% production increase. Leading producing companies were Rock of Ages, Cold Spring Granite, and H. E. Fletcher

Co. It was estimated that the three leading companies produced about one-third of U.S. output.

Keystone Memorials Inc. built a new saw building and installed a new West German automatic computerized diamond block saw at its Missouri Red granite quarry at Graniteville, MO.

New England Stone Industries Inc. of Providence, RI, bought the old Crotch Island, ME, granite quarry and its adjacent finishing facility in October and employed seven men to begin quarrying the granite. The firm planned to employ 40 to 50 people within the next few years.

Limestone.—Dimension limestone includes bituminous, dolomitic, and siliceous limestones. It was produced by 40 companies at 51 quarries in 16 States. Indiana continued to be the leading State, followed by Wisconsin. The top three producers, in order of value, were Indiana Limestone Co. Inc., Vetter Stone Co., and Elliott Stone Co. Inc., in Indiana, Minnesota, and Indiana, respectively.

Marble.—Dimension marble includes certain hard limestones, travertines, and any other calcareous stone that can be polished. Dimension marble was produced by 9 companies at 13 quarries in 9 States. Georgia, Vermont, and Montana, in order of tonnage, were the three leading States, accounting for approximately 72% of U.S. output. Leading producers were Georgia Marble Co., Vermont Marble Co., and Moretti-Harrah Marble Co. The top three companies accounted for 93% of U.S. output.

Rocky Mountain Stone Co., a travertine producer in New Mexico, has equipped its plant with new Italian state-of-the-art stone finishing machinery valued at $500,000. The plant was designed to cut and polish 2,000 square feet of stone per day. Part of the capital required was obtained through a State development loan fund.

Sandstone.—Dimension sandstone includes calcareous- and siliceous-cemented sandstones or conglomerates. Quartzite, which is also included, may be described as any siliceous-cemented sandstone. It was produced by 47 companies at 59 quarries in 18 States. Leading States continued to be, in order of volume, Ohio, Pennsylvania, and Georgia; these three States accounted for almost two-thirds of U.S. output. Standard Slag Co. in Ohio, Delaware Quarries Inc. in Pennsylvania, and Waller Bros. Stone Co. in

Table 2.—Dimension stone sold or used by producers in the United States, by State

State	1984[e]		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Alabama	7,585	$2,674	10,629	$2,881
Arizona	20	(1)	(1)	(1)
Arkansas	--	--	5,145	305
California	22,240	2,990	23,181	2,449
Colorado	999	87	2,350	204
Connecticut	17,578	1,080	19,715	1,285
Georgia	202,030	20,007	185,202	19,466
Illinois	--	--	1,750	107
Indiana	159,126	14,269	188,245	20,186
Maryland	16,693	864	17,833	1,218
Massachusetts	56,982	11,657	72,577	13,724
Michigan	4,225	129	4,162	113
Minnesota	38,746	13,369	36,808	13,598
New Hampshire	58,740	4,198	78,642	6,532
New Mexico	19,257	149	20,495	277
New York	14,859	4,271	16,032	3,666
North Carolina	W	W	35,333	6,132
Ohio	36,853	3,454	53,067	3,661
Oklahoma	12,074	771	10,862	836
Pennsylvania	44,376	6,001	51,268	8,214
South Carolina	16,130	1,092	7,756	541
South Dakota	59,597	18,642	W	W
Tennessee	7,021	1,097	4,793	773
Texas	46,937	11,236	37,262	11,760
Vermont	116,005	20,462	116,166	26,346
Virginia	22,063	3,052	9,653	3,136
Washington	--	--	761	53
Wisconsin	24,028	2,863	21,920	2,733
Other[2]	152,458	10,534	88,929	21,471
Total[3]	1,156,622	154,949	1,120,535	171,667

[e]Estimated. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes Idaho, Iowa, Kansas, Maine, Missouri, Montana, Oregon, Utah, and data indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.

Ohio were the leading producers and accounted for 36% of U.S. production.

Slate.—Dimension slate was produced by 19 companies at 28 quarries in 6 States. The two leading States in order of volume, Pennsylvania and Vermont, accounted for 70% of U.S. output. The top three producers, A. Dally and Sons Inc., Vermont Structural Slate Co. Inc., and Le Sueur-Richmond Slate Co. Inc., accounted for an estimated 45% of U.S. output by value. Hilltop Slate Co., a slate producer in New York and Vermont, was bought by the Penrhyn Quarries Ltd., a subsidiary of the Alfred McAlpine PLC of the United Kingdom.

Miscellaneous Stone.—Miscellaneous dimension stone, including traprock, was produced by seven companies from seven quarries in six States, and totaled 15,288 tons valued at $956,488.

Table 3.—Dimension granite sold or used by producers in the United States, by State

State	1984[e]		1985[p]		
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Connecticut	W	W	11,310	136	$919
Georgia	179,000	$9,500	160,377	1,606	9,133
Massachusetts	55,000	W	W	W	W
New Hampshire	58,700	4,200	78,642	953	6,532
Oklahoma	W	W	6,112	74	734
South Carolina	16,100	1,100	7,756	97	541
South Dakota	59,600	18,600	W	W	W
Texas	37,000	11,000	W	W	W
Wisconsin	W	W	3,133	37	1,891
Other[1]	232,600	50,600	334,903	4,071	74,134
Total	638,000	95,000	602,233	6,974	93,884

[e]Estimated. [p]Preliminary. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes California, Colorado, Maine, Maryland, Minnesota, Missouri, New York, North Carolina, Pennsylvania, Vermont, Virginia (1984), Washington (1985), and data indicated by symbol W.

Table 4.—Dimension limestone sold or used by producers in the United States in 1985, by State

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
California	3,331	42	$116
Illinois	1,750	21	107
Indiana	W	W	W
Virginia	611	7	33
Wisconsin	18,787	235	842
Other[1]	277,795	3,728	33,797
Total	302,274	4,033	34,895

[1]Includes Alabama, Iowa, Kansas, Maryland, Michigan, Minnesota, New Mexico, Ohio, Oklahoma, Texas, Washington, and data indicated by symbol W.

Table 5.—Dimension sandstone sold or used by producers in the United States in 1985, by State

State	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Arkansas	5,145	64	$305
Connecticut	8,405	108	366
Maryland	6,055	76	502
Missouri	230	3	18
New York	7,788	99	491
Pennsylvania	23,803	305	1,019
Other[1]	74,490	995	4,909
Total	125,916	[2]1,652	7,610

[1]Includes Alabama, Arizona, California, Colorado, Georgia, Idaho, Michigan, North Carolina, Ohio, Oklahoma, Tennessee, and Utah.
[2]Data do not add to total shown because of independent rounding.

Table 6.—Dimension marble sold or used by producers in the United States in 1985, by State

State	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Idaho	845	W	W
Other[1]	33,315	387	$20,658
Total	34,160	387	20,658

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Alabama, Georgia, Massachusetts, Montana, New Mexico, North Carolina, Tennessee, Vermont, and data indicated by symbol W.

CONSUMPTION AND USES

Dimension stone was marketed over wide areas. Industry stockpiles were not monitored, and production during 1985 was assumed to equal consumption.

Consumption of domestic dimension stone decreased slightly to 1.12 million tons valued at $171.7 million. Dressed slabs and blocks for building construction were 19% of the total value of consumption, followed by ashlars and partially squared, dressed pieces, 19%; dressed monumental stone, 15%; and rough stone used for monumental purposes, 14%; and rough blocks used for building and construction, 10%.

Of the total consumption of domestic granite, 24% by value was rough monumental stone, 23% was other dressed stone, and 22% was dressed monumental granite.

Consumption of domestic limestone totaled 302,300 tons valued at $34.9 million, of which 76% by value was dressed stone for building, and 21% was other rough stone.

Several manufacturing facilities to make resin agglomerated stone, a marble and granite look-alike, recently came on-stream. Armstar's Breton-equipped plant at Lenoir City, TN, produced a 3/8-inch and 3/16-inch-thick marblelike tile out of a mixture of marble chips and resin. The color of the tile was a reflection of the natural colors of the chips used to make it. Marmor Works Ltd. began making celtic granite slabs for cladding and flooring at its new plant in Wales from silica-rich aggregate and pigmented polyester resin binders. The product was said to be 90% cheaper than natural stone cladding to match the performance characteristics of granite for fire, weathering, and abrasion resistance, and to exceed these characteristics for marble.

The appearance of several artificial slate roofing materials accompanied the strong British market for natural slate roofing in the last several years. Redland Roof Tiles Ltd. began production of its new lightweight interlocking roofing slatelike product, which it will market first in southwest England. The product, called Cambrian, was mostly made from crushed and ground natural slate and stone (65%) combined with glass fiber and a resin binder and individually molded to give a single reinforced tile with an interlocking fixing mechanism. The tile surface was made to resemble that of natural slate and undergoes a preweathering process to make it look even more natural. The interlocking feature allows the tile to be laid single lap, thus lessening substantially the amount of material required to cover the roof, compared with natural slate, which must be double lapped on the roof. The interlocking feature also minimized the nailing required and therefore lengthens the time until corroding nails make roof repair or replacement necessary.[2]

Anglia Resins Ltd. began selling its Anglia Slate on the British roofing market. The product was made from a blend of fine-grained silica, colorfast pigment and a methacrylate resin binder. Anglia Slate can convincingly substitute for any natural slate because the pigments can be mixed to match any color, and the product varies from piece to piece as the natural slate would because it is made in different molds that give different surface textures. The firm invented the process and designed its own production machinery. The product usually was priced under British natural roofing slate but above Spanish imported slate. Anglia Slate is easy to install because it is predrilled, lighter, and more consistent in size than natural slate. Both of these manufactured slatelike roofing products provided formidable competition to roofing slate.

Table 7.—Dimension stone sold or used by producers in the United States in 1985, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Rough blocks for building and construction	267,866	3,445	$17,189
Irregular-shaped stone[1]	152,182	1,864	6,005
Monumental	232,129	2,566	23,240
Flagging	923	12	61
Other[2]	6,988	83	233
Dressed stone:			
Ashlars and partially squared pieces	138,405	1,765	32,987
Slabs and blocks for building and construction[3]	102,669	1,303	33,195
Monumental	58,227	682	25,400
Curbing	92,319	1,121	16,298
Flagging	43,850	521	5,239
Roofing slate	12,534	138	6,342
Structural and sanitary	5,906	65	3,028
Flooring slate	6,537	72	2,450
Total	1,120,535	13,637	171,667

[1]Includes rubble.
[2]Includes other rough stone, and uses not specified.
[3]Includes veneer and a small amount of billiard tabletops.

Table 8.—Dimension granite sold or used in the United States in 1985, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Rough blocks for building and construction	102,342	1,228	$8,671
Irregular-shaped stone[1]	54,870	623	2,819
Monumental[2]	227,066	2,502	22,826
Dressed stone:			
Monumental[3]	54,737	654	20,971
Curbing and flagging	93,843	1,136	16,909
Other[4]	69,375	830	21,688
Total	602,233	[5]6,974	93,884

[1]Includes rubble.
[2]Includes small amount of unspecified rough stone.
[3]Includes small amount of stone for billiard tabletops.
[4]Includes ashlars and partially squared pieces, and slabs and blocks for building and construction.
[5]Data do not add to total shown because of independent rounding.

Table 9.—Dimension limestone sold or used by producers in the United States in 1985, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Irregular-shaped stone[1]	36,897	463	$770
Other[2]	147,295	2,014	7,429
Dressed stone:			
Monumental	1,775	22	174
Curbing	532	7	18
Other[3]	115,775	1,526	26,505
Total[4]	302,274	4,033	34,895

[1]Includes rubble.
[2]Includes rough blocks for building and construction and a small amount of flagging and monumental.
[3]Includes ashlars and partially squared pieces, slabs and blocks for building and construction, a small amount of flagging, billiard tabletops, and veneer.
[4]Data may not add to totals shown because of independent rounding.

Table 10.—Dimension sandstone sold or used by producers in the United States in 1985, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Rough blocks for building and construction	15,685	212	$377
Irregular-shaped stone[1]	54,869	713	2,144
Other[2]	4,251	55	177
Dressed stone:			
Ashlars and partially squared pieces[3]	29,465	389	2,493
Slabs and blocks for building and construction	7,300	100	1,568
Flagging	7,805	101	551
Other[4]	6,541	83	299
Total[5]	125,916	1,652	7,610

[1]Includes rubble.
[2]Includes flagging, other rough stone, and uses not specified.
[3]Includes veneer.
[4]Includes curbing, monumental, and billiard tabletops.
[5]Data may not add to totals shown because of independent rounding.

Table 11.—Dimension slate sold or used by producers in the United States in 1985, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Flagging	15,575	171	$1,799
Roofing slate	12,534	138	6,342
Structural and sanitary[1]	6,018	66	3,073
Flooring slate	6,537	72	2,450
Total	40,664	447	13,664

[1]Includes small amount of billiard tabletops.

Table 12.—Dimension marble sold or used by producers in the United States in 1985, by use

Use	Quantity (short tons)	Cubic feet (thousands)	Value (thousands)
Rough stone:			
Rough blocks for building and construction	3,496	39	$747
Other[1]	15,525	170	6,945
Dressed stone:			
Ashlars and partially squared pieces	5,362	63	6,077
Slabs and blocks for building and construction[2]	9,777	115	6,890
Total	34,160	387	[3]20,658

[1]Includes irregular-shaped stone and other rough and dressed stone.
[2]Includes small amount of flagging and monumental.
[3]Data do not add to total shown because of independent rounding.

PRICES

The average price for dimension stone increased 14% to $153 per ton.

FOREIGN TRADE

Exports.—Exports of dimension stone, about one-half of which was granite, decreased 40% in value to $14 million.

Imports.—Imports of dimension stone increased 32% in value to $295 million, mostly because of increases in imports of dressed granite and polished slabs of marble. Imports of polished marble slabs, mostly from Italy, increased 45% to $88 million. Imports of dressed granite increased 42% to $103.7

million, primarily because of a significant increase from Italy. On a value basis, granite accounted for 37% of imports, followed by marble, 30%; travertine, 6%; and slate, 2%.

Table 13.—U.S. exports of dimension stone, by type

(Thousand short tons and thousand dollars unless otherwise specified)

Type	1984 Quantity	1984 Value	1985 Quantity	1985 Value	Major destination in 1985 (percent[1])
Granite articles	NA	4,878	NA	1,388	Canada 54%.
Granite, rough	79.7	8,895	42.1	5,828	Japan 52%, Canada 16%.
Limestone, dressed, for building or monumental	.9	69	1.0	116	United Kingdom 64%.
Limestone articles	34.1	1,593	2.6	100	Canada 70%.
Marble, breccia, and onyx, rough or squared	13.6	346	9.7	329	Canada 77%.
Marble, breccia, and onyx articles	NA	991	NA	1,191	Canada 29%.
Slate building articles	NA	177	NA	133	Canada 42%.
Slate building articles, other	NA	960	NA	1,568	Canada 35%.
Stone, rough, for building or monumental	9.8	1,270	9.8	1,299	Japan 52%.
Stone, other, including alabaster or jet	NA	3,828	NA	1,883	Canada 24%.
Total	NA	[r]23,007	NA	13,835	

[r] Revised. NA Not available.
[1]By value.

Source: Bureau of the Census.

Table 14.—U.S. imports for consumption of dimension granite, by country

(Thousand cubic feet and thousand dollars)

Country	Rough[1] Quantity	Rough[1] Value	Dressed Quantity	Dressed Value	Other n.s.p.f. undecorated[2] (value)
1983	345	4,993	1,828	79,958	5,063
1984:					
Brazil	2	18	190	3,527	156
Canada	1,249	4,215	283	11,102	2,617
India	752	214	18	659	1
Italy	11	325	2,596	49,955	1,224
Japan	([3])	2	9	159	20
Portugal	([3])	([3])	27	400	1
Saudi Arabia	1,976	95	59	134	103
South Africa, Republic of	259	415	([3])	17	3
Spain	--	--	230	4,096	96
Other	968	111	127	3,021	1,257
Total	5,217	5,395	3,539	73,070	5,478
1985:					
Brazil	5	11	239	3,353	$260
Canada	2,439	4,107	252	10,073	5,785
India	6	127	42	1,255	19
Italy	192	157	5,519	73,687	1,926
Japan	--	--	20	383	34
Portugal	62	217	387	874	78
Saudi Arabia	155	129	499	534	28
South Africa, Republic of	37	555	2	60	--
Spain	([3])	12	538	8,626	54
Other	124	783	430	4,835	2,883
Total[4]	3,020	6,097	7,928	103,680	11,064

[1]Does not include unmanufactured, nonmonumental granite.
[2]Quantity not reported. Does not include granite n.s.p.f. decorated.
[3]Less than 1/2 unit.
[4]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 15.—Imports for consumption of major categories of dimension marble, travertine, and other calcareous stones, by country

Country	Marble, breccia, or onyx, polished slabs		Marble, breccia, or onyx, other n.s.p.f.[1 2]	Travertine dressed[3]	
	Quantity (thousand square feet)	Value (thousands)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983	17,318	$41,938	$28,461	67,340	$18,414
1984:					
France	918	1,333	308	70	38
Germany, Federal Republic of	178	304	579	13	4
Greece	773	1,266	336	5	1
Italy	19,354	42,917	15,978	135,031	15,000
Mexico	1,178	1,793	2,592	18,179	741
Pakistan	26	88	392	--	--
Philippines	222	441	94	--	--
Portugal	2,018	3,962	894	361	154
Spain	3,677	5,836	965	3,490	169
Taiwan	635	1,169	17,465	159	175
Other	822	1,848	1,333	226	89
Total	29,801	60,957	40,936	157,534	16,371
1985:					
France	588	2,021	1,110	2	3
Germany, Federal Republic of	427	483	375	--	--
Greece	1,340	3,086	310	2	2
Italy	38,573	60,637	19,627	168,734	18,088
Mexico	1,143	1,934	3,673	779	284
Pakistan	35	137	593	--	--
Philippines	419	655	145	--	--
Portugal	3,753	4,719	1,424	42	9
Spain	7,419	11,168	1,743	3,437	143
Taiwan	910	1,583	8,662	--	--
Other	1,529	2,155	1,860	7,315	125
Total[4]	56,137	88,579	39,521	180,311	18,654

[1]Does not include certain special kinds of rough marble, breccia, or onyx.
[2]Quantity not reported.
[3]Suitable for use as monumental, paving, or building stone. Does not include travertine articles.
[4]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 16.—U.S. imports for consumption of other dimension stone, by type

Type	1984		1985		Major source in 1985 (percent[1])
	Quantity	Value (thousands)	Quantity	Value (thousands)	
Granite, unmanufactured, nonmonumental short tons	27,753	$554	21,522	$848	Portugal 39%.
Granite, n.s.p.f., decorated	--	620	--	402	Italy 62%.
Limestone, dressed, hewn short tons	4,855	612	15,937	1,145	France 40%.
Marble and breccia, rough cubic feet	57,629	397	131,755	609	Italy 49%.
Marble, breccia, onyx, slab and tiles, unpolished square feet	1,413,100	1,625	1,563,636	1,881	Italy 55%.
Slate, roofing do	1,008,911	597	1,727,961	926	Spain 35%.
Slate, other, n.s.p.f	--	5,178	--	6,747	Italy 54%.
Travertine articles, undecorated	--	3,999	--	6,012	Italy 89%.
Travertine articles, decorated	--	1,489	--	2,105	Italy 96%.
Stone, unmanufactured short tons	161,258	825	35,769	1,156	Belgium 54%.
Stone, dressed, building do	12,039	659	7,729	1,185	Mexico 35%.
Stone, other n.s.p.f., undecorated	--	1,869	--	1,837	Mexico 33%.
Stone, other n.s.p.f., decorated	--	2,519	--	2,646	Mexico 25%.

[1]By value.

Source: Bureau of the Census.

WORLD REVIEW

Some production of dimension stone occurred in most countries of the world. As usual, Italy produced about one-half of the world's total. Other significant producers were Brazil, Finland, India, Norway, Portugal, Spain, Sweden, Turkey, and the United States.

Canada.—Canadian production of dimension stone, mostly granite, expanded substantially in the last several years because modern finishing plants with new European equipment came on-stream or will do so shortly. Granicor Inc. brought on-stream a new plant equipped with European saws and polishing equipment in Quebec, resulting in the opening of six new granite quarries in the Province. Karnuk Marble Industries Inc. announced plans to establish a similar plant in Cornwall, Ontario. RPS Marble Limitee announced a $7 million expansion and modernization of its dimension stone finishing facilities, to be partly paid for by a grant of $1.4 million from La Société de Developpement Industrial du Quebec.

China.—Local authorities announced the discovery of a black marble deposit with reserves of 22 million tons near Tuoyaoling, Jilin Province. The authorities announced plans to develop the deposit.

The Provincial Geological Department of Hebei Province announced that it discovered over 7 billion cubic feet of marble reserves in 20 counties of the Province. Reserves of more than 50 different varieties of marble are available, with many of them presently being quarried and processed. The provincial authorities indicated that they plan to quarry over 35 million cubic feet of marble each year in the Baoding area alone and to import Italian quarrying and processing equipment. Some of these stones have appeared in European markets.

Ethiopia.—The Ethio-Libyan Joint Mining Co. began mining large reserves of pure white fine-grained marble with a hint of translucency called Boka White. It is being quarried from 16 sites in the Mendi District in the western part of Wollega Province, near the Sudanese border. The firm, which is only 4 years old, planned to produce about 350,000 cubic feet of marble per year. It also announced plans to build a finishing plant in central Ethiopia to make marble tiles. The firm also indicated that it produced 210,000 cubic feet of good quality granite blocks, including some of a black granite and pink granite. The marble and the black and pink granite were commercially available on European markets.

Finland.—Outokumpu Oy expanded its activities into dimension granite by founding a subsidiary, Granite Products Ltd., with a granite deposit in Taivassalo, in southwestern Finland. The firm planned to open a quarry and bring Finland's first finishing plant on-stream in 1985. Production was scheduled to be in a range from 105,000 to 175,000 cubic feet. The plant will cost $5 million. Finland has been a major exporter of rough granite blocks, mostly to European destinations.

Greece.—The Drama-Kavala area produced 3.15 million cubic feet of white and white-gray marbles, much of which was exported as rough blocks and finished products. The Ioannina area produced 1.75 million cubic feet of beige marble, almost all of which was consumed domestically. The Argolis area produced 1.40 million cubic feet of beige, brown, and red marbles, most of which was finished in Athens. The Attica area produced 0.72 million cubic feet of white (Pentelikos) and ash-blue marble, most of which was exported. The major firms are Hellenic Chemical Products and Fertilizers Co. Ltd., Kavala Marbles S.A., and Skaris Marble S.A.[3]

Jamaica.—Marble production is presently quite small, but fairly sizable reserves would allow it to be expanded. The small amounts now being produced were used locally for mosaic slabs and tiles, tabletops, bar counters, and terrazzo tiles. There are a number of deposits, but only the Serge Island deposit has been explored. The upper 15 feet of this deposit was severely shocked by unnecessary blasting during past quarrying and would probably not be commercially usable as a dimension stone. The large amount of material beneath this upper layer, down to at least 150 feet, is high grade, competent, and quarriable. The material found acceptance in the North American market before 1965 and, therefore, was believed to be ready for commercialization.[4]

Saudi Arabia.—The Saudi Arabian Government continued its dimension stone program. Eight model quarries in the western part of the country near the Red Sea were operated. Most of the quarries were worked for granite, two for anorthosite, and one for limestone. The stone was made into slabs for building at two pilot finishing plants at Jiddah. Exploration continued to add to existing sizable reserves.

Spain.—The Instituto Geologico y Minero de España issued its latest figures for marble production by geographic unit. Of the total quantity of marble produced in 1980, 25.4% originated in Alicante Province in the Levantine Region, 19.3% in Murcia Province in the Levantine Region, 13.8% in Barcelona Province of the Catalonia Region, 9.7% in Almería Province, 7.6% in Navarra Province of the North Region, 7.4% in Valencia Province of the Levantine Region, and the balance in other Provinces.

United Kingdom.—The British slate industry prospered and expanded in 1985. Penrhyn Quarries, part of the Alfred McAlpine Minerals group, bought the Buttermere & Westmorland Green Slate Co. Ltd. of Borrowdale, Cumbria. This firm had an underground green slate quarry, which has been operated since 1753, at the top of the Honister Pass and a small plant that produced flooring, roofing, and other slate products. Plans called for developing reserves and increasing production of roofing and architectural slate, with some of the production to go to the U.S. market. The firm planned to buy another quarry in Cumbria. Penrhyn Quarries also bought the Hilltop Slate plant and quarries in New York and Vermont. Penrhyn Quarries Welsh quarry produced a number of colors of slate, but blue and plum were the most important. The installation of new saws and equipment was planned for the plant at the quarry site. Production at the Welsh quarry expanded since 1982. Published data indicate that Penrhyn Quarries produced 13,200 tons of roofing slate and 15,400 tons of architectural slate in 1984, compared with a total British production of 24,200 tons of roofing slate in 1984. British production of nonroofing types of slate increased markedly in the last several years.[5]

Delabole Slate Ltd., a subsidiary of Carnon Consolidated Ltd., expanded its quarry in Cornwall and brought it up to modern quarrying standards. When completed, the firm planned to expand production capacity by renovating the plant with the latest Italian equipment and installing diamond wire saws in the quarry.

Burlington Slate Ltd. began a $1.5 million effort to upgrade equipment and to consolidate all its processing at the Kirkby-in-Furness plant. The roofing section with its three new circular saws was already onstream. Production continued from most or all of the presently operating quarries scattered about Cumbria. The newly equipped roofing section of the plant was expected to almost double output per employee. The balance of the new plant, featuring two Italian 30-blade frame saws and two more large circular saws, was expected to be on-stream in late 1985. Some finishing equipment will also be added, such as a flame-texturing machine.[6] After the new equipment is installed, the product mix would shift from roofing slate toward architectural slate.

Burlington Slate has been a very active exporter in the last several years. It recently supplied China with $180,000 worth of polished slate flooring for a museum, despite the fact that China itself is a major producer and exporter of slate. According to published data, Burlington Slate produced 4,950 tons of roofing slate and 3,000 tons of architectural slate in 1984, 30% to 40% of which was exported.[7]

Dimension stone quarrying in Scotland has revived in the last few years, mostly because of a need to restore buildings built of Scottish stone. The creamy brown Newbigging sandstone was first returned to production to restore a Swedish cathedral and now will continue to be produced for use in the new National Library of Scotland building. The whitish gray Dunmore sandstone was produced to restore a hunting lodge and will be used in an office redevelopment project in Edinburgh. The red Ross of Mull granite was quarried again, but with no specific restoration or other market in mind.[8]

TECHNOLOGY

A Bureau of Mines study on the use of geotechnology to identify and reduce ground control hazards at slate quarries was published. The study was performed at one quarry in eastern Pennsylvania. The major hazard covered was falling rock attributable to weathered bedding plane faults. Results indicated that the bedding plane faults can be detected outside the quarry perimeter by using surface resistivity measurements. The other major hazard, falls of ice from quarry highwalls, was found to be rectifiable using water diversion as the basic control method. In situ stresses were usually a minor problem in slate extraction, although they could interact with developed stresses to result in failure of barriers between quarries. Pull tests showed that loose rock can be secured by rockbolts, which anchor firmly in the slate.[9]

A conference on the "Degradation of Materials Due to Acid Rain" was held in response to a rising concern about the damage caused by acid pollutants to concrete, dimension stone, metals, paint, and wood. The Environmental Protection Agency estimated that the damage would total at least $5 billion per year. Acid pollutants are known to attack limestone and marble in ancient monuments like the Acropolis. This fact has been verified by preliminary results from experiments now under way. It is believed that granite and sandstone also are probably vulnerable to attack. The precise causes of the damage and the processes by which it happens are not clear, but the completion of experiments now under way may increase the understanding of atmospheric degradation of stone.[10]

The deterioration of marble in tombstones was studied in the New York City area. Tombstone thickness and depth of emblem inscription were measured in two cemeteries, one in an industrial area in New York City and one in a semirural area on Long Island. Weathering rates were higher in the industrial area. Sulfur dioxide concentrations from 1880 to 1980 were estimated for New York City from a retrospective air quality model and were found to have a linear relationship with the weathering rates. The weathering coefficient for New York City was determined to be one-half inch, per century, per part per million of sulfur dioxide for fine-grained marble.[11]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Industrial Minerals (London). Redland Launches Cambrian Slate Product. No. 217, Oct. 1985, p. 17.

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[4]Geddes, A. J. S. Industrial Minerals in Jamaica—an Overview. Ind. Miner (London), No. 214, July 1985, pp. 61-62.

[5]Industrial Minerals (London). Penrhyn Acquires Buttermere's Green Slate. No. 214, July 1985, p. 15.

[6]Stone Industries. Investing in the Future. V. 20, No. 8, Oct. 1985, pp. 29-31.

[7]Industrial Minerals (London). Burlington Slate—A First for China. No. 214, July 1985, p. 15.

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[11]Husar, R. B., D. E. Patterson, and N. S. Baer. Deterioration of Marble. A Restrospective Analysis of Tombstone Measurements in the New York City Area. Washington Univ., St. Louis, MO, Mar. 1985, 31 pp.; NTIS PB 85-174134/WEP.

Sulfur

By David E. Morse[1]

The United States retained its position as the world's largest sulfur producer, with an increased output of sulfur in all forms of nearly 1 million metric tons compared with that of 1984. Output from Frasch mines increased 20%, exceeding 5 million tons for the first time since 1981. Production of recovered elemental sulfur from petroleum refineries and natural-gas-processing plants increased to an all-time high and was over 5 million tons for the second consecutive year. Domestic demand continued to exceed production, and the United States remained a net sulfur importer. Shipments of sulfur in all forms from domestic producers decreased about 200,000 tons; production surpassed shipments by nearly 400,000 tons.

Apparent consumption of elemental sulfur from all sources declined 7%. Shipments of Frasch sulfur to domestic consumers, however, declined 10% and supplied 35% of elemental demand. The average annual price for all elemental sulfur increased domestically and worldwide despite a drop in world spot pricing during the final 4 months of the year.

Table 1.—Salient sulfur statistics

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production:					
Frasch	6,348	4,210	3,202	4,193	5,011
Recovered[1]	4,259	4,404	4,955	5,214	5,313
Other forms	1,538	1,173	1,133	1,245	1,285
Total	12,145	9,787	9,290	10,652	11,609
Shipments:					
Frasch	5,910	3,598	4,111	5,001	4,678
Recovered[1]	4,207	4,344	5,041	5,210	5,266
Other forms	1,538	1,173	1,133	1,245	1,285
Total	11,655	9,115	10,285	11,456	11,229
Imports, elemental	2,522	1,905	1,695	2,557	2,104
Exports, elemental[2]	1,392	961	992	1,334	1,365
Consumption, apparent, all forms	12,785	10,059	10,988	12,679	11,968
Stocks, Dec. 31: Producer, Frasch and recovered	r3,546	r4,218	r3,223	r2,419	2,799
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$715,683	$434,660	$414,210	$546,106	$573,570
Recovered[1]	412,115	425,217	384,214	416,878	485,084
Other forms	140,618	122,177	116,255	121,692	123,937
Total	1,268,416	982,054	914,679	1,084,676	1,182,591
Imports, elemental[3]	$209,766	$164,885	$129,110	$200,189	$199,240
Exports, elemental[4]	$187,407	$122,143	$109,298	$156,067	$189,248
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$111.48	$108.27	$87.24	$94.31	$106.46
World: Production, all forms (including pyrites)	r53,550	r50,870	50,530	p52,607	e54,856

eEstimated. pPreliminary. rRevised.
[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes exports from the Virgin Islands to foreign countries.
[3]Declared customs valuation.
[4]Includes value of exports from the Virgin Islands to foreign countries.

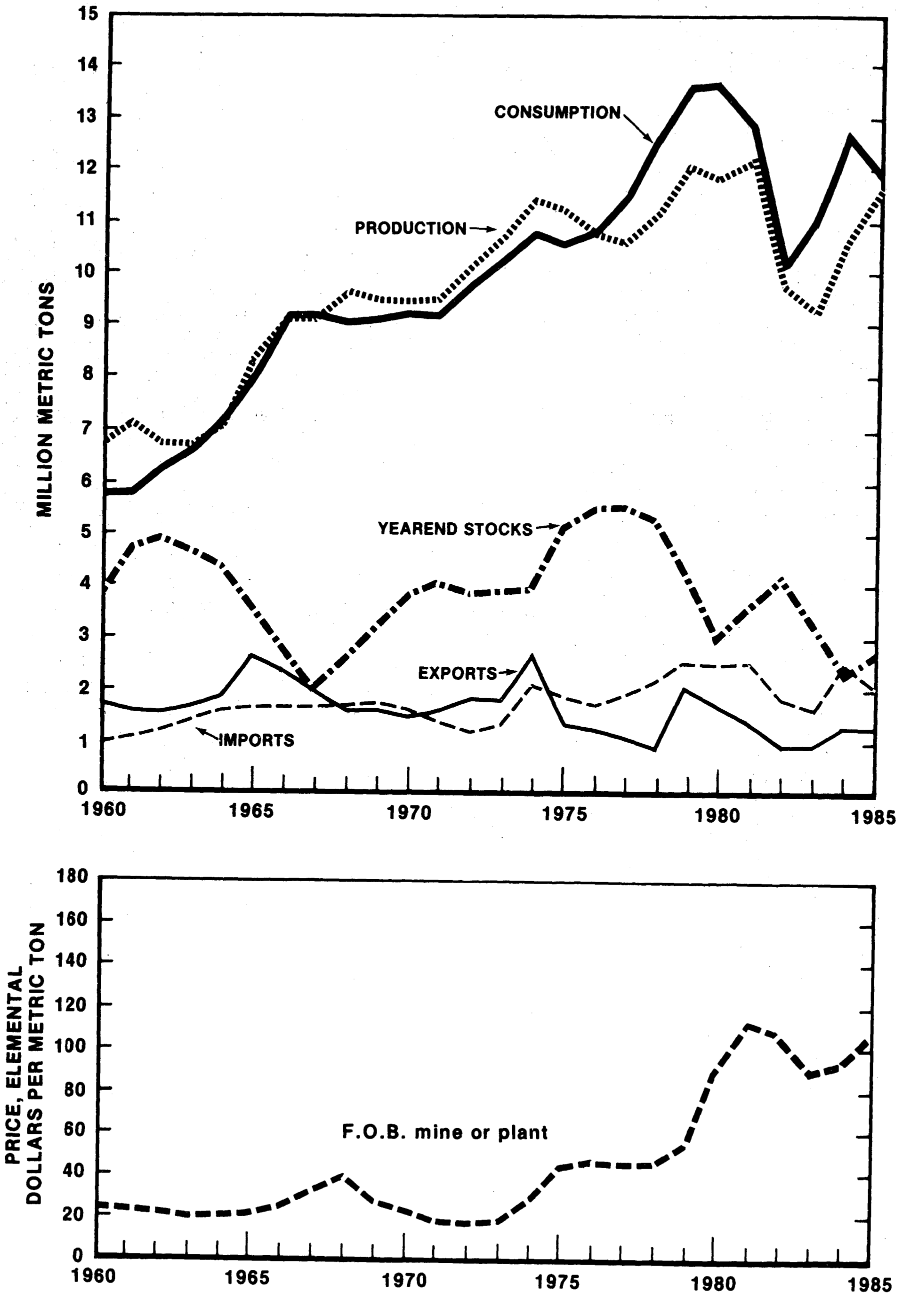

Figure 1.—Trends in the sulfur industry in the United States.

World sulfur production continued to recover from the depressed levels of 1982 and 1983, but failed to satisfy world demand, which required a drawdown from inventories of about 2 million tons. This inventory reduction was less severe than the 3- and 4-million-ton reductions in 1983 and 1984, respectively.

Domestic Data Coverage.—Domestic production data for sulfur are developed by the Bureau of Mines from four separate, voluntary surveys of U.S. operations. Typical of these surveys is the "Elemental Sulfur" survey. Of the 190 operations to which a survey request was sent, all responded, representing 100% of the total production shown in tables 1 and 2.

DOMESTIC PRODUCTION

Sulfur is one of the few elements that occurs in nature in the native, or elemental, state. It also occurs combined with iron and base metals as sulfide minerals, and with the alkali metals and alkali earths as sulfate minerals. In coal and petroleum, sulfur is found in a variety of complex organosulfur compounds, and in natural gas, as hydrogen sulfide (H_2S) gas. Commercial production of sulfur, either as elemental sulfur or combined in another chemical form, in the United States is accomplished by a variety of methods dictated by the sulfur source. Native sulfur in sedimentary deposits or associated with the caprocks of salt domes is mined by the Frasch hot water process, in which the sulfur is melted underground and brought to the surface with an airlift. Sulfur from iron and base metal sulfides is usually recovered as sulfuric acid during roasting or smelting. Sulfur from coal may be recovered in the elemental form or as ammonium sulfate during the production of coke; as sulfuric acid or sulfur dioxide when burning coal; or when producing low-British-thermal-unit coal gas, as ammonium sulfate while scrubbing the gas with ammonia. Sulfur is recovered from petroleum and natural gas by absorbing the H_2S in an amine solution, then regenerating H_2S, and processing it into elemental sulfur in a Claus converter.

Frasch.—In January, the United States had five Frasch mines operating in Texas and Louisiana. Mines in Louisiana were Freeport Minerals Co. at Garden Island Bay on the Mississippi River Delta and Grand Isle, 7 miles offshore in the Gulf of Mexico. Companies in Texas were Farmland Industries Inc. at Fort Stockton; Pennzoil Sulphur Co., formerly Duval Corp., a subsidiary of Pennzoil Co. renamed in 1985, at Culberson; and Texasgulf Chemicals Co. at Boling Dome in Wharton County. Farmland discontinued operations at its Fort Stockton facility in March because of sulfur reserve depletion. Texasgulf's Comanche Creek, TX, facility was idle for the entire year. Freeport announced that Frasch operations would be undertaken in 1986 at its Caminada Pass, LA, property, which had last produced sulfur in 1968. At yearend 1985, the Frasch mining industry was operating at about 90% of capacity.

Frasch sulfur output increased 800,000 tons over the depressed quantity produced in 1984. Shipments to domestic and overseas consumers, however, declined by 300,000 tons. Frasch sulfur accounted for about 43% of domestic production in 1985, compared with 39% in 1984. Approximately 79% of Frasch sulfur shipments was for domestic consumption, and 21% for export.

Recovered.—Production of recovered elemental sulfur, a nondiscretionary byproduct from petroleum refining, natural gas processing, and coking plants, accounted for 46% of the total domestic output of sulfur in all forms, compared with 49% in 1984. Production and shipments reached all-time highs exceeding 5.25 million tons because of record-high production from petroleum refineries. A decline in output from natural gas plants in Florida and Mississippi was partially offset by increased production from plants in Wyoming. This designated type of sulfur was produced by 54 companies at 155 plants in 26 States, 1 plant in Puerto Rico, and 1 plant in the U.S. Virgin Islands. Most of these plants were of relatively small size, with only 11 reporting annual production exceeding 100,000 tons. By source, 55% was produced at 84 refineries or satellite plants treating refinery gases and 3 coking plants, and 45% was produced by 26 companies at 68 natural gas treatment plants. The five largest recovered-sulfur-producing companies were Chevron U.S.A. Inc., Exxon Co. U.S.A., Shell Oil Co., Standard Oil Co. of Indiana, and Texaco Inc. These companies' 59 plants accounted for 63% of recovered elemental sulfur output during the year.

The leading States in production of recovered sulfur were California, Louisiana, Mississippi, Texas, and Wyoming. These five States contributed 71% of total output; shipments from Texas accounted for 28% of total recovered sulfur shipments. The total value of recovered sulfur shipments increased 16% compared with that of 1984.

Table 2.—Production of sulfur and sulfur-containing raw materials in the United States

(Thousand metric tons)

	1984		1985	
	Gross weight	Sulfur content	Gross weight	Sulfur content
Frasch sulfur	4,193	4,193	5,011	5,011
Recovered sulfur[1]	5,214	5,214	5,313	5,313
Byproduct sulfuric acid (100% basis) produced at copper, lead, molybdenum, and zinc plants	2,942	962	2,928	957
Other forms[2]	723	283	814	328
Total	XX	10,652	XX	11,609

XX Not applicable.
[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes hydrogen sulfide, liquid sulfur dioxide, and pyrites.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

(Thousand metric tons and thousand dollars)

Year	Production			Shipments	
	Texas	Louisiana	Total[1]	Quantity	Value[2]
1981	3,908	2,440	6,348	5,910	715,683
1982	2,898	1,312	4,210	3,598	434,660
1983	1,915	1,286	3,202	4,111	414,210
1984	2,257	1,937	4,193	5,001	546,106
1985	2,940	2,071	5,011	4,678	573,570

[1]Data may not add to totals shown because of independent rounding.
[2]F.o.b. mine.

Table 4.—Recovered sulfur produced and shipped in the United States[1]

(Thousand metric tons and thousand dollars)

Year	Production			Shipments	
	Natural gas plants	Petroleum refineries[2]	Total	Quantity	Value[3]
1981	1,971	2,288	4,259	4,207	412,115
1982	1,960	2,444	4,404	4,344	425,217
1983	2,371	2,584	4,955	5,041	384,214
1984	2,407	2,807	5,214	5,210	416,878
1985	2,373	2,940	5,313	5,266	485,084

[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes a small quantity from coking operations and utility plants in 1981-82; includes only a small quantity from coking operations in 1983-85.
[3]F.o.b. plant.

Table 5.—Recovered sulfur produced and shipped in the United States, by State

(Thousand metric tons and thousand dollars)

State	1984			1985		
	Production (quantity)	Shipments		Production (quantity)	Shipments	
		Quantity	Value		Quantity	Value
Alabama	380	380	34,492	370	367	35,421
California	516	516	28,695	590	576	47,087
Florida	111	111	W	91	91	W
Illinois	182	181	15,838	193	194	19,895
Louisiana	320	318	29,901	405	403	45,053
Michigan and Minnesota	139	139	9,627	137	138	11,623
Mississippi	745	754	74,382	578	565	62,156
New Jersey	58	59	6,636	74	74	9,357
New Mexico	63	63	4,245	55	55	4,281
North Dakota	112	112	5,572	108	109	6,127
Ohio	39	39	3,983	36	36	3,891
Pennsylvania	53	52	4,487	50	50	4,475
Texas	1,417	1,413	121,447	1,500	1,496	147,426
Wisconsin	2	2	108	1	2	96
Wyoming	626	624	23,280	703	699	35,335
Other[1]	453	447	54,185	420	411	52,862
Total[2]	5,214	5,210	416,878	5,313	5,266	485,084

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Arkansas, Colorado, Delaware, Indiana, Kansas, Kentucky, Montana, Utah, Virginia, Washington, Puerto Rico, the Virgin Islands, and data indicated by symbol W.
[2]Data may not add to totals shown because of independent rounding.

Table 6.—Recovered sulfur produced and shipped in the United States, by Petroleum Administration for Defense (PAD) district

(Thousand metric tons)

District and source	1984		1985	
	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	228	228	230	227
Natural gas	110	111	91	91
Total[1]	339	339	321	318
PAD 2:				
Petroleum and coke	504	500	495	495
Natural gas	114	114	111	112
Total[1]	618	615	606	608
PAD 3:[2]				
Petroleum	1,440	1,443	1,498	1,468
Natural gas	1,565	1,563	1,476	1,479
Total[1]	3,006	3,007	2,975	2,948
PAD 4 and 5:				
Petroleum	633	633	715	700
Natural gas	616	613	693	690
Total[1]	1,250	1,247	1,408	1,390
Grand total[1]	5,214	5,210	5,313	5,266

[1]Data may not add to totals shown because of independent rounding.
[2]Includes Puerto Rico and the Virgin Islands.

Byproduct Sulfuric Acid.—Sulfur contained in byproduct sulfuric acid produced at copper, lead, molybdenum, and zinc roasters and smelters amounted to 8% of the total domestic production of sulfur in all forms. Production was essentially the same as that of 1984 despite the closure of three copper, one lead, and one zinc smelter during 1985. A copper smelter in Washington and another in Arizona were closed permanently because the cost for installation of pollution control systems, required by Federal law, had rendered the facilities uneconomic in terms of existing and projected copper prices. Ten acid plants operated in conjunction with copper smelters, and 11 were accessories to lead, molybdenum, and zinc smelting and roasting operations. The five largest acid plants accounted for 67% of the output, and production in five States was 84% of the total. The five largest producers of byproduct sulfuric acid were ASARCO Incorporated, Inspiration Consolidated Copper Co., Kennecott, Magma Copper Co., and Phelps Dodge Corp. These companies' 13 plants produced 81% of the total.

Table 7.—Byproduct sulfuric acid[1] produced in the United States

(Thousand metric tons, sulfur content, and thousand dollars)

Year	Copper plants[2]	Zinc plants[3]	Lead and molybdenum plants[3]	Total	Value
1981	848	179	132	1,159	75,657
1982	615	112	101	828	63,674
1983	601	126	104	831	54,995
1984	736	145	81	962	59,098
1985	729	141	87	957	56,299

[1]Includes acid from foreign materials.
[2]Excludes acid made from pyrites concentrates.
[3]Excludes acid made from native sulfur.

Pyrites, Hydrogen Sulfide, and Sulfur Dioxide.—Contained sulfur in these products represented 3% of the total domestic production of sulfur in all forms. The total sulfur contained in these products was 16% greater than that of 1984. The three largest producers were Shell Oil Co., Stauffer Chemical Co., and Tennessee Chemical Co. These three companies' mines and plants accounted for 98% of the total contained sulfur in the form of these products.

Table 8.—Pyrites, hydrogen sulfide, and sulfur dioxide sold or used in the United States

(Thousand metric tons, sulfur content, and thousand dollars)

Year	Pyrites	Hydrogen sulfide	Sulfur dioxide	Total	Value
1981	307	28	44	379	64,961
1982	265	32	48	345	58,503
1983	W	W	50	302	61,260
1984	W	W	45	283	62,594
1985	W	W	43	328	67,638

W Withheld to avoid disclosing company proprietary data; included in "Total."

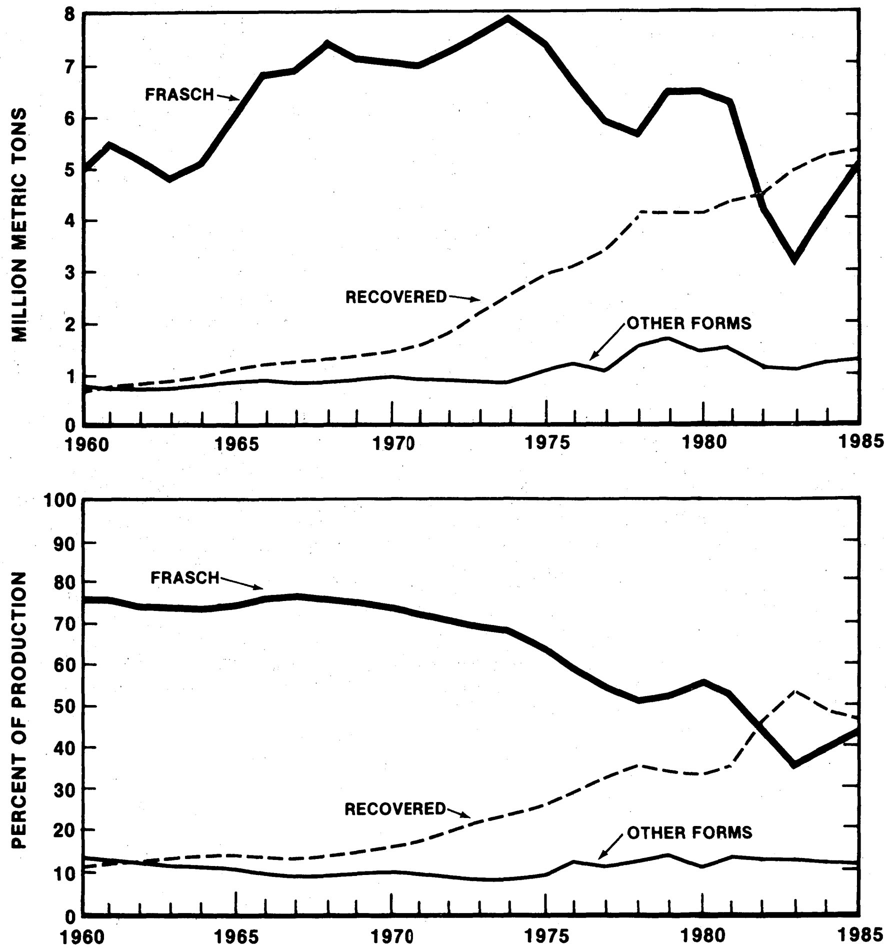

Figure 2.—Trends in the production of sulfur in the United States.

CONSUMPTION AND USES

Sulfur is a relatively unusual mineral commodity because most of it is converted to a chemical intermediate, sulfuric acid, for use in a myriad of chemical processes. Usually, the sulfur values do not become constituents of the final chemical product but are retained either in a byproduct or as wastes requiring disposal in an environmentally acceptable manner. In 1985, sulfuric acid retained its position, both domestically and worldwide, as the most universally used mineral acid and the largest volume inorganic chemical in terms of the quantity produced and consumed annually.

Apparent domestic consumption of sulfur in all forms decreased from that of 1984. Eighty-three percent of the sulfur consumed was obtained from domestic sources compared with 80% in 1984. The sources of supply in 1985 were domestic recovered elemental sulfur, 41%; domestic Frasch sulfur, 31%; and combined domestic byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide, 11%. The remaining 17% was supplied by imports of Frasch and recovered elemental sulfur.

The Bureau of Mines collected end-use data on sulfur and sulfuric acid according to the Standard Industrial Classification of industrial activities. Shipments by end use of elemental sulfur were reported by 58 companies, and shipments of sulfuric acid were reported by 57 companies. Eleven companies reported shipments of both elemental sulfur and sulfuric acid.

The largest sulfur end use, sulfuric acid, represented 82% of shipments for domestic consumption. Some identified end uses were tabulated in the "Unidentified" category because these data were proprietary. Data collected from companies that did not identify shipments by end use were also tabulated as "Unidentified." Although supporting data are unavailable, it could be reasonably assumed that a significant portion of the sulfur in the "Unidentified" category could have been shipped to sulfuric acid producers or exported. The difference between exports reported in the Bureau canvass and exports of 1,365,000 tons reported by the Bureau of the Census may have been caused by differences in accounting between company records and compilations of the Census Bureau, or by sales to other parties that exported sulfur and were not included in the Bureau of Mines canvass.

Shipments of 100% sulfuric acid declined slightly because production of phosphatic fertilizers, the largest single end use of sulfuric acid, decreased. Most of the falloff in demand, which occurred during the final 4 months, was a direct result of decreased fertilizer sales to domestic farmers while the U.S. Congress was debating the Food Security Act of 1985. Shipments of sulfuric acid for petroleum refining and other petroleum and coal products, the second largest end use, increased slightly. Usage of sulfuric acid for copper ore leaching was over 1 million tons for the second consecutive year, significantly higher than in 1982 and 1983, because of U.S. copper producers' attempts to lower their costs of production. Copper from leaching was considerably less expensive than copper from conventional smelting.

According to the 1985 canvass reports, company receipts of spent or contaminated sulfuric acid for reclaiming totaled 3 million tons. The largest source of this spent acid continued to be the petroleum refining industry, which accounted for 51% of the total returned. The petroleum refining industry was a net user of 700,000 tons of sulfuric acid. About 750,000 tons of spent acid was reclaimed from plastic and synthetic materials operations. The remaining reclaimed acid was returned from manufacturers of soaps and detergents, steel, industrial organic chemicals, other chemical products, storage batteries, synthetic rubber, agricultural chemicals, and some unidentified sources.

The largest use of sulfur in all forms, for agricultural purposes, decreased to nearly 8.6 million tons. Industrial use was also lower.

Table 9.—Apparent consumption of sulfur[1] in the United States

(Thousand metric tons)

	1981	1982	1983	1984	1985
Frasch:					
Shipments	5,910	3,598	4,111	5,001	4,678
Imports	856	690	604	722	724
Exports	1,216	731	601	r911	986
Total	5,550	3,557	4,114	r4,812	4,416
Recovered:					
Shipments[2]	4,207	4,344	5,041	5,210	5,266
Imports	1,666	1,215	1,091	1,835	1,380
Exports	176	230	391	r423	379
Total	5,697	5,329	5,741	r6,622	6,267
Pyrites, shipments	307	265	W	W	W
Byproduct sulfuric acid, shipments	1,159	828	831	962	957
Other forms, shipments[3]	72	80	302	283	328
Total, all forms	12,785	10,059	10,988	12,679	11,968

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other forms, shipments."
[1]Crude sulfur or sulfur content.
[2]Includes Puerto Rico and the Virgin Islands.
[3]Includes consumption of hydrogen sulfide, liquid sulfur dioxide, and data indicated by symbol W.

Table 10.—Elemental sulfur sold or used in the United States, by end use

(Thousand metric tons)

SIC	End use	Quantity 1984	Quantity 1985
20	Food and kindred products	W	W
26, 261	Pulp and paper products	29	27
282, 2822, 2823	Synthetic rubber, cellulosic fibers,[1] other plastic products	65	25
287	Agricultural chemicals	480	579
28, 2816, 285, 286	Paint and allied products, inorganic pigments,[2] industrial organic chemicals, other chemical products	127	105
284	Soaps and detergents	14	31
29, 291	Petroleum refining and petroleum and coal products	278	189
281	Other industrial inorganic chemicals	285	222
30	Rubber and miscellaneous plastic products	W	W
	Sulfuric acid:		
	Domestic sulfur	6,909	6,880
	Imported sulfur	2,425	2,052
	Total	9,334	8,932
	Unidentified	734	733
	Total domestic uses	11,346	10,843
	Exports	1,289	1,112
	Grand total	12,635	11,955

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
[1]Includes cellulosic fibers in 1984.
[2]Includes inorganic pigments in 1985.

Table 11.—Sulfuric acid sold or used in the United States, by end use

(Thousand metric tons of 100% H_2SO_4)

SIC	End use	Quantity 1984	Quantity 1985
102	Copper ores	1,043	1,018
1094	Uranium and vanadium ores	163	62
10	Other ores	194	54
261	Pulpmills	700	705
26	Other paper products	114	89
285, 2816	Inorganic pigments and paints and allied products	332	331
281	Other inorganic chemicals	1,160	834
282, 2822	Synthetic rubber and other plastic materials and synthetics	959	742
2823	Cellulosic fibers including rayon	155	129
283	Drugs	74	52
284	Soaps and detergents	254	272
286	Industrial organic chemicals	938	1,010
2873	Nitrogenous fertilizers	261	191
2874	Phosphatic fertilizers	26,373	24,082
2879	Pesticides	70	74
287	Other agricultural chemicals	47	64
2892	Explosives	118	94
2899	Water-treating compounds	213	291
28	Other chemical products	405	151
29, 291	Petroleum refining and other petroleum and coal products	2,067	2,215
30	Rubber and miscellaneous plastic products	W	11
331	Steel pickling	270	212
333	Nonferrous metals	50	56
33	Other primary metals	113	161
3691	Storage batteries (acid)	177	206
	Unidentified	1,584	1,613
	Total domestic	37,834	34,719
	Exports	61	69
	Grand total	37,895	34,788

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."

Table 12.—Sulfur and sulfuric acid sold or used in the United States, by end use

(Thousand metric tons, sulfur content)

SIC	End use	Elemental sulfur[1] 1984	Elemental sulfur[1] 1985	Sulfuric acid (sulfur equivalent) 1984	Sulfuric acid (sulfur equivalent) 1985	Total 1984	Total 1985
102	Copper ores	--	--	341	333	341	333
1094	Uranium and vanadium ores	--	--	53	20	53	20
10	Other ores	--	--	63	18	63	18
20	Food and kindred products	W	W	--	--	W	W
26, 261	Pulpmills and paper products	29	27	266	259	295	286
28, 285, 286, 2816	Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products	[2]127	105	109	109	236	214
281	Other inorganic chemicals	285	222	379	273	664	495
282, 2822	Synthetic rubber and other plastic materials and synthetics	[3]65	25	314	243	[3]379	268
2823	Cellulosic fibers, including rayon	([4])	--	51	42	51	42
283	Drugs	--	--	24	17	24	17
284	Soaps and detergents	14	31	83	89	97	120
286	Industrial organic chemicals	--	--	307	330	307	330
2873	Nitrogenous fertilizers	--	--	85	62	85	62
2874	Phosphatic fertilizers	--	--	8,621	7,872	8,621	7,872
2879	Pesticides	--	--	23	24	23	24
287	Other agricultural chemicals	480	579	15	21	495	600
2892	Explosives	--	--	39	31	39	31
2899	Water-treating compounds	--	--	70	95	70	95
28	Other chemical products	--	--	132	49	132	49
29, 291	Petroleum refining and other petroleum and coal products	278	189	676	724	954	913
30	Rubber and miscellaneous plastic products	W	W	W	4	W	4
331	Steel pickling	--	--	88	69	88	69
333	Nonferrous metals	--	--	16	18	16	18
33	Other primary metals	--	--	37	53	37	53
3691	Storage batteries (acid)	--	--	58	67	58	67
	Exported sulfuric acid	--	--	20	23	20	23
	Total identified	1,278	1,178	11,870	10,845	13,148	12,023
	Unidentified	734	733	518	527	1,252	1,260
	Grand total	2,012	1,911	12,388	11,372	14,400	13,283

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
[1]Does not include elemental sulfur used for production of sulfuric acid.
[2]No elemental sulfur used in inorganic pigments.
[3]Includes elemental sulfur used in cellulosic fibers.
[4]Included with "Synthetic rubber and other plastic materials and synthetics."

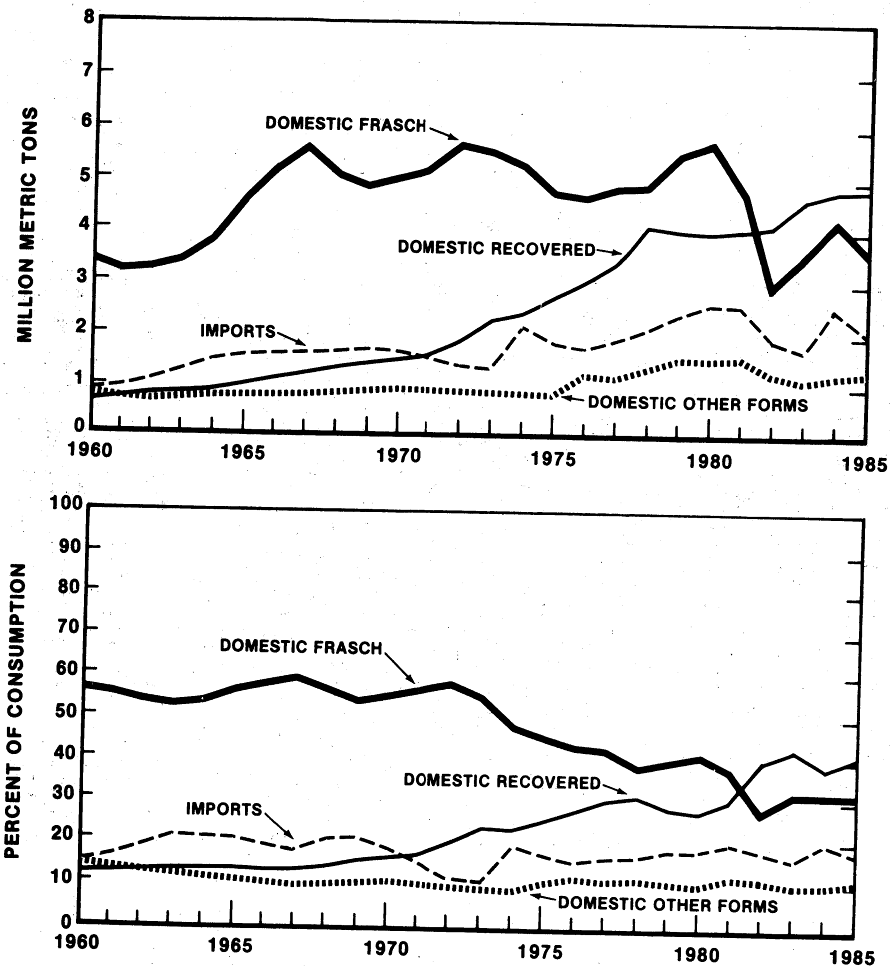

Figure 3.—Trends in the consumption of sulfur in the United States.

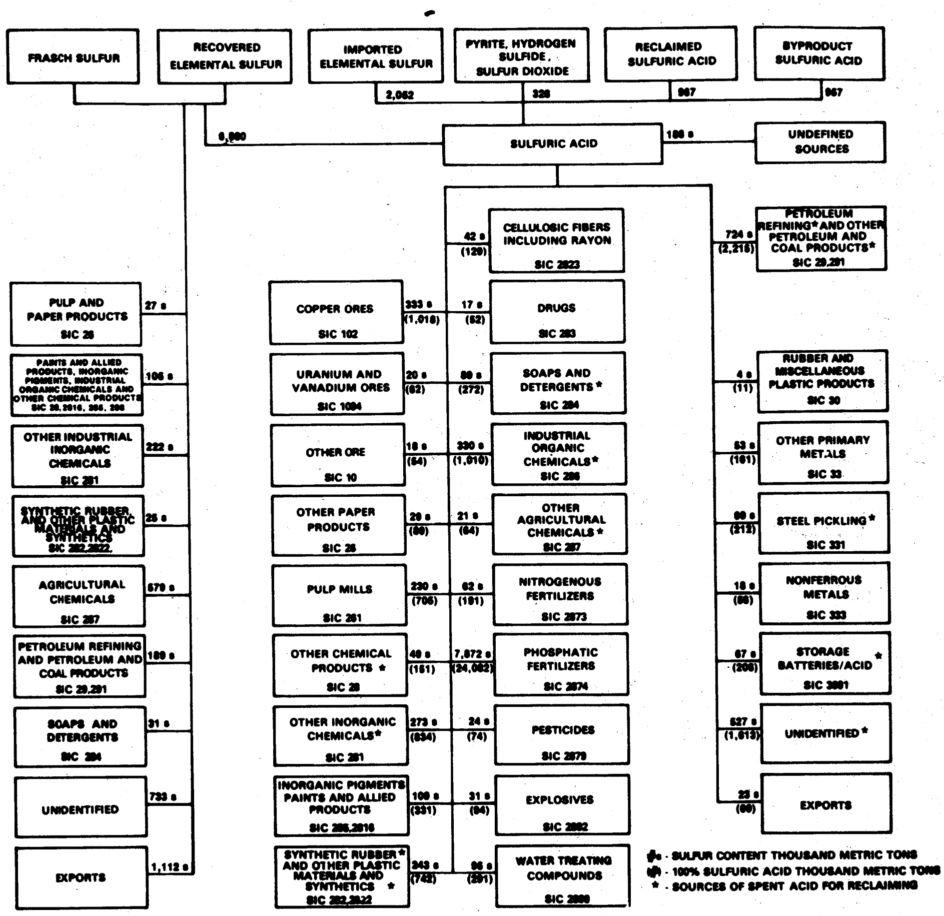

Figure 4.—Sulfur-sulfuric acid supply and end-use relationship in 1985.

STOCKS

An increase in inventories held by Frasch producers occurred primarily during the last quarter of the year when sulfur demand by the fertilizer industry decreased. Combined yearend stocks amounted to approximately a 3-1/2-month supply compared with a 2-1/2-month supply in 1984, based on domestic and export demands for Frasch and recovered sulfur.

Table 13.—Yearend sulfur stocks of U.S. producers

(Thousand metric tons)

Year	Frasch	Recovered	Total
1981	r3,354	192	r3,546
1982	r3,980	238	r4,218
1983	r3,070	153	r3,223
1984	r2,264	155	r2,419
1985	2,598	201	2,799

rRevised.

PRICES

The posted price for liquid sulfur, exterminal Tampa, FL, was unchanged during 1985 at $157.50 per long ton; price discounts, which had begun in 1983 for large-volume customers, of $10 per long ton remained in effect. Spot prices for sulfur, f.o.b. Vancouver, British Columbia, Canada, were $140 to $152 per metric ton during the first half of the year but decreased slowly to the Vancouver contract price of $135 per metric ton by yearend.

On the basis of total shipments and value reported to the Bureau of Mines, the average value of shipments of Frasch sulfur, f.o.b. mine, for domestic consumption and exports combined increased. The average value, f.o.b. plant, for shipments of recovered elemental sulfur varied widely by geographic region as follows: lowest in the Rocky Mountain States, higher on the west coast, somewhat higher in the midcontinent, and near the values for Frasch sulfur in the East and South. Although reported values for recovered elemental sulfur were generally higher throughout the Nation, the disproportionately low value for Wyoming distorts the average value calculation for all recovered elemental shipments.

Table 14.—Reported sales values of shipments of sulfur, f.o.b. mine or plant

(Dollars per metric ton)

Year	Frasch	Recovered	Average
1981	121.11	97.97	111.48
1982	120.79	97.89	108.27
1983	100.76	76.22	87.24
1984	109.20	80.02	94.31
1985	122.62	92.11	106.46

FOREIGN TRADE

Exports of elemental sulfur from the United States, including the Virgin Islands, were about the same as those of 1984 in quantity but increased 21% in value. According to the Bureau of the Census, exports from the west coast increased by nearly 70,000 tons in 1985 to 318,000 tons, or 23% of total U.S. exports.

The United States continued to be a net sulfur importer with imports exceeding exports by over 700,000 tons. Frasch sulfur from Mexico and recovered elemental sulfur from Canada, both delivered to U.S. terminals and consumers in the liquid phase, continued to furnish nearly all U.S. sulfur import requirements. Total elemental sulfur imports decreased 18% in quantity; the average value for the imports, however, increased substantially so that the total value of imports was essentially unchanged from that of 1984.

The United States also had significant trade in sulfuric acid. Sulfuric acid exports increased slightly in terms of quantity, but total value was essentially unchanged from that of 1984. Imports were mostly from Canada; the quantity increased slightly, while the value was lower than in 1984.

Table 15.—U.S. exports[1] of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1984		1985	
	Quantity	Value	Quantity	Value
Argentina	1	512	31	3,216
Belgium-Luxembourg	397	46,983	394	48,678
Brazil	205	23,903	173	26,617
Canada	2	124	5	270
Chile	3	532	8	1,236
Colombia	(²)	263	17	2,591
Egypt	132	17,535	28	4,693
France	20	1,913	26	3,577
India	127	14,334	76	11,130
Indonesia	18	2,278	(²)	1
Israel	--	--	37	4,994
Italy	16	1,470	22	3,128
Mexico	54	2,955	97	9,799
Morocco	162	21,973	220	35,074
Netherlands	13	1,399	6	772

See footnotes at end of table.

Table 15.—U.S. exports[1] of elemental sulfur, by country —Continued

(Thousand metric tons and thousand dollars)

Country	1984 Quantity	1984 Value	1985 Quantity	1985 Value
Philippines	5	588	11	1,594
Romania	21	2,400	24	2,658
Senegal	11	909	--	--
Spain	(2)	10	15	2,288
Taiwan	43	4,566	23	2,883
Tunisia	40	1,918	83	11,856
Turkey	21	2,383	24	3,388
Uruguay	10	980	3	465
Venezuela	1	179	14	2,290
Yugoslavia	16	1,963	15	1,944
Other	r15	r3,996	14	4,104
Total[3]	1,334	156,067	1,365	189,248

rRevised.
[1]Includes exports from the Virgin Islands.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 16.—U.S. exports of sulfuric acid (100% H_2SO_4), by country

Country	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Brazil	26,831	$1,012	28,397	$982
Canada	33,798	1,510	15,258	708
Chile	10,355	343	4,099	177
Dominican Republic	2,966	299	2,729	227
Ecuador	6,198	330	2,083	97
France	1,424	50	242	11
Guyana	1,539	224	2	4
Jamaica	1,665	114	172	17
Korea, Republic of	658	399	1,388	716
Mexico	6,815	293	16,699	742
Netherlands	32	4	2	2
Netherlands Antilles	6,295	331	4,357	213
Panama	2,500	126	2,368	121
Saudi Arabia	1,239	252	659	32
Switzerland	--	--	8,198	300
Trinidad and Tobago	2,379	136	1,561	65
Venezuela	6,182	308	31,960	1,367
Other	8,441	1,042	5,146	863
Total	119,317	6,773	[1]125,320	[1 2]6,645

[1]Excludes 900 tons valued at $3,662,856 to Morocco not believed to be sulfuric acid.
[2]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 17.—U.S. imports of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1984 Quantity	1984 Value[1]	1985 Quantity	1985 Value[1]
Canada	1,812	117,776	1,354	110,231
Mexico	722	79,756	724	85,778
Venezuela	22	2,531	24	2,972
Other[2]	1	126	2	259
Total	2,557	200,189	2,104	199,240

[1]Declared customs valuation.
[2]Includes Belgium, China, the Federal Republic of Germany, Italy, Japan, and Netherlands Antilles in 1984 and China, the Federal Republic of Germany, Italy, Japan, New Caledonia, and the United Kingdom in 1985.

Source: Bureau of the Census.

Table 18.—U.S. imports of sulfuric acid (100% H_2SO_4), by country

Country	1984		1985	
	Quantity (metric tons)	Value[1] (thousands)	Quantity (metric tons)	Value[1] (thousands)
Belgium	--	--	38	$46
Canada	356,484	$15,175	426,909	17,871
France	(2)	2	23	28
Germany, Federal Republic of	13,672	929	46	30
Mexico	15,105	784	--	--
Netherlands	--	--	4,475	429
Norway	6,464	568	--	--
Spain	18,468	1,323	9,560	611
Switzerland	15,513	595	--	--
Other	r3	r16	4	23
Total	425,709	[3]19,391	441,055	19,038

rRevised.
[1]Declared c.i.f. valuation.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World production increased for the second consecutive year as recovery continued from the depressed levels of 1982 and 1983. Elemental sulfur production increased by nearly 2 million tons, and sulfur production in all forms approached the record-high level of 1980. Nevertheless, continued world sulfur demand in excess of production in 1985 required stock withdrawals of nearly 2 million tons, which was substantially less than had been required during each of the previous 2 years.

International trade in elemental sulfur decreased by more than 1 million tons to about 16 million tons. Canada continued as the world's leading exporter, followed, in descending order of quantity, by Poland, the United States, Saudi Arabia, Mexico, the Federal Republic of Germany, and France. The United States was again the leading importer. Other nations that imported significant quantities of sulfur, in decreasing order of quantity, were Morocco, the U.S.S.R., Brazil, India, the United Kingdom, and Tunisia.

International sulfur prices remained high for most of the year with a moderate increase in price for contract tonnage instituted at midyear. Spot prices, which were about $150 per ton, f.o.b. Vancouver, British Columbia, Canada, and Persian Gulf ports for much of the year, declined in the final 4 months to approach the contract price of $135 to $140 per ton. The spot-price decline was attributed to a weakening of demand and the decision by buyers for India to reduce reliance on spot sales and enter into long-term contracts with several major sulfur suppliers.

Canada.—Shipments of sulfur in all forms were about 8.66 million tons, or 1.9 million tons greater than output, but 7% less than 1984 shipments. Exports decreased slightly to 7.54 million tons. Although exports through the Port of Vancouver, British Columbia, increased to a record-high volume of 6.14 million tons, exports to the United States fell about 500,000 tons to 1.35 million tons. Canadian sulfur stocks in block located in Alberta Province and awaiting shipment at Vancouver declined to less than 10 million tons. Canadian block inventory, which had exceeded 21 million tons in 1978, had for many years been regarded by the industry as a buffer to accommodate changes in world demand and to provide a reasonably stable price environment. The fall in stocks through the 10-million-ton level signaled the world sulfur industry that this huge inventory was transitory and that a search for new economic sources of elemental sulfur should be undertaken.

Iran.—Sulfur production remained substantially less than capacity because of the ongoing war with neighboring Iraq. Some sulfur exports were transferred overland to a port east of the Strait of Hormuz that was beyond Iraqi aircraft range.

Iraq.—Sulfur exports continued to be routed overland through neighboring countries because safe passage could not be assured for Iraqi material in the Persian Gulf. Production remained relatively unchanged and well below capacity at natural gas plants and the Mishraq Frasch mine.

Mexico.—Increased Frasch sulfur output reflected efforts to bring the Patapa Mine up to its design capacity of 350,000 tons per year. Production also increased at Coachapa in the Salinas Basin. Engineering work to supply air, steam, and hot water to the Otapan deposit was well under way. Sulfur production from Otapan was planned to begin in 1986. Mexican sulfur exports continued to decline because of growing domestic demand. Solid sulfur was imported from Canada and the United States because of difficulties in transporting sulfur to the Lázaro Cárdenas fertilizer facility on the Pacific coast from the mining areas near the gulf coast.

Poland.—Frasch sulfur production declined because of severe winter weather, and in February, a force majeure declared that contract tonnages would be decreased by 8% during 1985. Sulfur exports decreased nearly 200,000 tons to 3.9 million tons. Of this, 1.9 million tons was exported to Eastern Europe, and 1.1 million tons, to Western Europe; most of the remainder was shipped to Brazil, Morocco, and Tunisia.

Saudi Arabia.—Sulfur production increased despite the low level of petroleum production because of increased output of nonassociated gas. Production of sulfur excess to exports and internal consumption caused stocks to increase by nearly 200,000 tons. Sulfur exports declined nearly 600,000 tons to slightly over 900,000 tons.

The Fletcher-process prilling plant was operated by the Saudi Sulfur Co. adjacent to the Berri natural gas plant. In December, the General Petroleum and Mineral Organization, a Government agency and owner of the nation's sulfur facilities, contracted with Saudi Sulfur's parent company, Devco International of the United States, to build a new three-unit Fletcher-process prilling plant at Jubail to replace the plant destroyed by fire in 1984. Plans were for Saudi Sulfur to continue operating the plant at Berri until the new facility was completed.

U.S.S.R.—In April, a French consortium led by Lurgi S.A. won a $135 million contract to supply the process plant of the Tengiz oil and gas project in Kazakhstan northeast of the Aral Sea. Tengiz associated gas contains about 16% H_2S and 5% carbon dioxide. The plant was designed to process the 1.5-billion-cubic-meter-per-day gas output and recover 1,600 tons per day of sulfur along with ethane, butane, and other condensates.[2] In June, the Tengiz Field's development was complicated by a major blowout and fire. The fiery plume, about 200 meters high, was reportedly visible 90 miles away.[3] Extinguishing the fire was complicated by the high H_2S concentration of the associated gas and the 12,000-pound-per-square-inch formation pressure. The fire was reportedly still burning at yearend.

Technip of France was awarded a contract to install the second stage of the Astrakhan gas-processing complex in the Volga River Delta north of the Caspian Sea. Astrakhan II was designed to process up to 6.9 billion cubic meters per year of gas in four trains and to recover 2.7 million tons per year of sulfur from the gas, which contained about 16% H_2S. These design capacities were similar to those of stage 1. Contracts for stage 1 had been awarded in 1983 to Creusot-Loire Entreprise of France and Mannesmann AG of the Federal Republic of Germany.[4] The two-phase complex was planned to be the largest sulfur-producing facility in the world.

Table 19.—Sulfur: World production in all forms, by country and source[1]

(Thousand metric tons)

Country[2] and source[3]	1981	1982	1983	1984[p]	1985[e]
Algeria: Byproduct, petroleum and natural gas[e]	15	10	15	20	20
Argentina:[e]					
Native (from caliche)	10	--	--	([4])	--
Byproduct, all sources	NA	--	--	([4])	--
Total	10	--	--	([4])	--
Australia:					
Byproduct:					
Metallurgy	[r]142	[r]146	170	190	190
Petroleum	14	17	13	13	[5]13
Total	[r]156	[r]163	183	203	203
Austria:					
Byproduct:					
Metallurgy	9	10	9	10	10
Petroleum and natural gas	28	38	32	28	25
Gypsum	25	27	26	26	26
Total	62	75	67	64	61
Bahamas: Byproduct, petroleum[e]	5	5	5	[r]3	2
Bahrain: Byproduct, petroleum	[e]36	34	49	[e]50	50
Belgium: Byproduct, all sources[e]	270	270	250	240	240
Bolivia: Native	10	6	3	2	2
Brazil:					
Frasch	--	--	1	[e]1	2
Pyrites	44	54	55	[e]55	60
Byproduct:					
Metallurgy	17	30	150	[e]150	150
Petroleum	102	100	110	[e]110	125
Total	163	184	316	[e]316	337
Bulgaria:[e]					
Pyrites	[r]300	[r]300	[r]300	[r]300	300
Byproduct, all sources	70	70	70	70	70
Total	[r]370	[r]370	[r]370	[r]370	370
Canada:					
Pyrites[e] [6]	10	[r]8	[r]9	[r]10	10
Byproduct:					
Metallurgy	783	627	678	[e]875	900
Natural gas	5,599	5,226	5,390	5,260	[5]5,296
Petroleum[e]	160	160	170	165	150
Tar sands	247	259	330	296	[5]392
Total	6,799	[r]6,280	6,577	6,606	6,748
Chile:					
Native:					
Refined	5	7	16	14	[5]15
From caliche	110	98	83	40	[5]64
Byproduct, metallurgy	28	32	32	32	[5]30
Total	143	137	131	86	[5]109
China:[e]					
Native	200	200	200	200	300
Pyrites	1,800	1,800	2,300	2,100	2,200
Byproduct, all sources	300	300	350	350	400
Total	2,300	2,300	2,850	2,650	2,900
Colombia:					
Native	26	33	31	36	35
Byproduct, petroleum	2	2	[e]3	[e]3	3
Total	28	35	34	39	38
Cuba:[e]					
Pyrites	14	20	[r]5	([4])	--
Byproduct, petroleum	8	8	8	8	8
Total	22	28	[r]13	[r]8	8
Cyprus:[7] Pyrites	9	[e]26	21	[e]20	20

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1981	1982	1983	1984[p]	1985[e]
Czechoslovakia:[e]					
Native	5	5	5	5	6
Pyrites	60	60	60	60	62
Byproduct, all sources	10	10	10	10	12
Total	75	75	75	75	80
Denmark: Byproduct, petroleum	6	7	[r e]9	11	7
Ecuador:[e]					
Native	2	5	5	5	4
Byproduct:					
Natural gas	5	5	5	5	5
Petroleum	5	5	5	5	5
Total	12	15	15	15	14
Egypt: Byproduct, petroleum and natural gas	2	2	1	[e]2	2
Finland:					
Pyrites	184	177	224	211	210
Byproduct:					
Metallurgy	[r]268	270	264	265	260
Petroleum	45	40	48	45	45
Total	[r]497	[r]487	536	521	515
France:					
Byproduct:					
Natural gas	1,701	[r]1,690	1,653	1,589	1,424
Petroleum	221	235	157	163	160
Unspecified[e]	120	110	[r]100	110	110
Total	2,042	[r]2,035	1,910	1,862	1,694
German Democratic Republic:[e]					
Pyrites	10	--	--	--	--
Byproduct, all sources	350	360	360	350	330
Total	360	360	360	350	330
Germany, Federal Republic of:					
Pyrites	213	229	--	--	--
Byproduct:					
Metallurgy[e 8]	400	400	400	350	320
Natural gas	834	872	632	[r e]900	1,000
Petroleum[e]	190	220	195	190	200
Unspecified[e]	95	100	95	90	85
Total[e]	1,732	1,821	1,322	[r]1,530	1,605
Greece:					
Pyrites	76	55	67	78	78
Byproduct:					
Natural gas	4	97	[e]115	[e]120	120
Petroleum	7	8	5	[e]5	5
Total	87	160	[r e]187	[r e]203	203
Hungary:[e]					
Pyrites	3	3	3	2	2
Byproduct, all sources	9	9	9	9	9
Total	12	12	12	11	11
India:					
Pyrites	23	22	25	18	20
Byproduct:					
Metallurgy[e]	92	100	110	115	120
Petroleum	4	5	4	[e]5	5
Total[e]	119	127	139	[r]138	145
Indonesia:[7] Native	1	1	3	5	5
Iran:[e]					
Native	50	10	20	30	30
Byproduct, petroleum and natural gas	6	10	25	30	180
Total	56	20	45	60	210

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1981	1982	1983	1984[p]	1985[e]
Iraq:[e]					
Frasch	[5]200	300	300	500	500
Byproduct, petroleum and natural gas	[5]40	40	40	70	70
Total	[5]240	340	340	570	570
Ireland: Pyrites[e]	11	[r]6	(4)	(4)	--
Israel: Byproduct, petroleum and natural gas[e]	10	10	10	10	10
Italy:					
Native	20	10	9	8	[5]1
Pyrites	261	269	271	192	[5]280
Byproduct, all sources[e 9]	230	210	210	200	200
Total[e]	511	489	[r]490	[r]400	481
Japan:					
Pyrites	293	276	272	259	[5]253
Byproduct:					
Metallurgy	1,236	1,268	1,239	1,191	1,192
Petroleum	1,080	1,051	1,102	1,142	1,065
Total	2,609	2,595	2,613	2,592	2,510
Korea, North:[e]					
Pyrites	225	200	200	200	200
Byproduct, metallurgy	30	30	30	30	30
Total	255	230	230	230	230
Korea, Republic of:					
Pyrites	--	--	(10)	(10)	NA
Byproduct:[e]					
Metallurgy	54	54	54	54	55
Petroleum	36	36	36	36	35
Total[e]	90	90	90	90	90
Kuwait: Byproduct, petroleum and natural gas	97	141	145	151	[5]198
Libya: Byproduct, petroleum and natural gas[e]	16	20	20	20	16
Mexico:					
Frasch	1,652	1,391	1,225	1,364	1,555
Byproduct:					
Metallurgy[e]	100	100	100	[r]160	160
Petroleum and natural gas	426	425	377	461	[5]475
Total[e]	2,178	1,916	1,702	[r]1,985	2,190
Morocco: Pyrites	22	--	--	--	--
Namibia: Pyrites	8	58	81	104	100
Netherlands:[e]					
Byproduct:					
Metallurgy	90	100	100	90	85
Petroleum	55	65	105	105	95
Total	145	165	205	195	180
Netherlands Antilles: Byproduct, petroleum	[e]90	[e]90	87	63	25
New Zealand: Byproduct, all sources	(10)	(10)	1	1	1
Norway:					
Pyrites	[r]218	[r]213	179	209	210
Byproduct:					
Metallurgy[e]	[r]37	[r]83	[r]95	[r]58	60
Petroleum	8	8	8	8	[5]8
Total	263	304	282	275	[5]278
Oman: Pyrites[e]	--	--	11	31	31
Pakistan:					
Native	(10)	1	1	1	1
Byproduct, all sources[e]	14	19	26	26	26
Total	14	20	27	27	27
Peru:					
Native	(10)	(10)	(10)	(10)	(10)
Byproduct, all sources[e]	20	58	65	70	70
Total	20	58	65	70	70

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1981	1982	1983	1984[p]	1985[e]
Philippines:					
Pyrites	46	30	29	35	107
Byproduct, metallurgy	--	--	57	95	100
Total	46	30	86	130	207
Poland:[e 11]					
Frasch	4,295	[r]4,428	[r]4,460	4,500	4,386
Native	478	[r]492	500	[r]490	490
Byproduct:					
Metallurgy[12]	[r]180	[r]160	[r]170	[r]170	170
Petroleum	30	30	30	30	30
Gypsum	20	20	20	20	20
Total	[r]5,003	[r]5,130	[r]5,180	[r]5,210	5,096
Portugal:					
Pyrites	[e]135	116	124	140	145
Byproduct, all sources	2	2	5	4	5
Total	137	118	129	144	150
Qatar: Byproduct, natural gas	6	5	5	33	33
Romania:[e]					
Pyrites	300	200	200	200	200
Byproduct, all sources	150	150	150	150	150
Total	450	350	350	350	350
Saudi Arabia: Byproduct, petroleum and natural gas[e]	600	900	695	[5]833	1,100
Singapore: Byproduct, petroleum	([10])	15	4	6	5
South Africa, Republic of:					
Pyrites	502	465	474	464	[5]474
Byproduct:[e]					
Metallurgy	100	135	125	[5]91	[5]85
Petroleum	27	25	32	30	35
Total	629	625	631	585	594
Spain:					
Pyrites	1,118	1,029	1,073	1,094	[5]1,133
Byproduct:					
Coal (lignite) gasification[e]	3	3	3	3	2
Metallurgy	135	[e]125	[e]120	125	115
Petroleum[e]	[5]12	10	8	[r]9	9
Total[e]	1,268	1,167	1,204	[r]1,231	1,259
Sweden:					
Pyrites	202	204	208	[r e]230	225
Byproduct:					
Metallurgy[e]	[r]99	[r]111	[r]125	[r]132	130
Petroleum	37	22	20	25	25
Unspecified	([4])	([4])	([4])	([4])	--
Total	[r]338	[r]337	353	387	380
Switzerland: Byproduct, all sources	3	3	3	3	3
Syria: Byproduct, petroleum and natural gas	6	22	[e]30	[e]35	35
Taiwan:					
Pyrites	([10])	--	--	--	--
Byproduct, all sources	10	20	27	29	[5]43
Total	10	20	27	29	[5]43
Trinidad and Tobago: Byproduct, petroleum	44	13	[e]8	[e]7	5
Turkey:					
Native	[r]29	[e]32	35	41	45
Pyrites[e]	29	[r]2	[r]2	([4])	--
Byproduct, all sources[e]	[r]73	[r]75	[r]75	[r]78	80
Total[e]	[r]131	[r]109	[r]112	[r]119	125
U.S.S.R.:[e]					
Frasch	800	800	800	800	850
Native	2,000	1,900	1,800	1,800	1,700
Pyrites	3,600	3,500	3,400	[r]3,400	3,350

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1981	1982	1983	1984[p]	1985[e]
U.S.S.R.[e] —Continued					
Byproduct:					
Coal	(4)	(4)	(4)	(4)	--
Metallurgy	[r]425	[r]425	[r]450	[r]450	475
Natural gas	[r]2,650	[r]2,700	[r]2,750	[r]2,800	2,900
Petroleum	[r]425	[r]425	[r]450	[r]450	450
Total	[r]9,900	[r]9,750	[r]9,650	[r]9,700	9,725
United Arab Emirates: Abu Dhabi:					
Byproduct:					
Natural gas	--	--	--	--	277
Petroleum	--	[e]5	10	15	15
Total	--	[e]5	10	15	292
United Kingdom:					
Byproduct:					
Metallurgy	55	61	69	71	70
Petroleum	75	59	55	75	80
Spent oxides	4	[r]3	3	1	1
Total	134	123	127	147	151
United States:					
Frasch	6,348	4,210	3,202	4,193	[5]5,011
Pyrites	307	265	W	W	W
Byproduct:					
Metallurgy	1,159	828	831	962	[5]957
Natural gas	1,971	1,960	2,371	2,407	[5]2,373
Petroleum	2,288	2,444	2,584	2,807	[5]2,940
Unspecified	72	80	302	283	[5]328
Total	12,145	9,787	9,290	10,652	[5]11,609
Uruguay: Byproduct, petroleum[e]	2	2	2	2	2
Venezuela: Byproduct, petroleum and natural gas[e]	85	85	85	86	88
Yugoslavia:					
Pyrites and pyrrhotite	[r]286	[r]353	298	301	[5]323
Byproduct:[e]					
Metallurgy	200	200	180	160	170
Petroleum	4	4	3	3	3
Total[e]	[r]490	[r]557	[r]481	[r]464	496
Zaire: Byproduct, metallurgy[e]	25	25	36	[r]37	36
Zambia:					
Pyrites	(10)	1	25	18	25
Byproduct, all sources	90	84	[e]80	[e]80	80
Total	90	85	105	[r e]98	105
Zimbabwe:					
Pyrites	25	25	25	[e]25	26
Byproduct, all sources[e]	5	5	5	5	5
Total	30	30	30	30	31

See footnotes at end of table.

Table 19.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1981	1982	1983	1984[p]	1985[e]
Grand total	[r]53,550	[r]50,870	50,530	52,607	54,856
Of which:					
Frasch	13,295	[r]11,129	9,988	11,358	12,304
Native	[r]2,946	[r]2,800	2,711	2,677	2,698
Pyrites	[r]10,334	[r]9,966	9,941	9,756	10,044
Byproduct:					
Coal and coal gasification	[r]3	[r]3	3	3	2
Metallurgy	[r]5,664	[r]5,320	5,594	5,863	5,870
Natural gas	[r]12,770	[r]12,555	12,921	13,114	13,428
Petroleum	[r]5,018	[r]5,150	5,325	5,589	5,605
Petroleum and natural gas, undifferentiated	1,331	1,703	1,475	1,746	2,219
Spent oxides	4	[r]3	3	1	1
Tar sands	247	259	330	296	392
Unspecified sources	[r]1,893	[r]1,935	2,193	2,158	2,247
Gypsum	45	47	46	46	46

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Byproduct: Unspecified sources."

[1]Table includes data available through June 3, 1986.

[2]In addition to the countries listed, a number of nations may produce limited quantities of either elemental sulfur or compounds (chiefly H_2S or SO_2) as a byproduct of petroleum, natural gas, and/or metallurgical operations, but output, if any, is not quantitatively reported, and no basis is available for the formulation of reliable estimates of output. Countries not listed in this table that may recover byproduct sulfur from oil refining include Albania, Bangladesh, Brunei, Burma, Costa Rica, Guatemala, Honduras, Jamaica, Malaysia, Nicaragua, Paraguay, and the People's Democratic Republic of Yemen. Albania and Burma may also produce byproduct sulfur from crude oil and natural gas extraction. No complete listing of other nations that may produce byproduct sulfur from metallurgical operations (including processing of coal for metallurgical use) can be compiled, but the total of such output is considered as small. Nations listed in this table that may have production from sources other than those listed are identified by individual footnotes.

[3]The term "source" reflects both the means of collecting sulfur and the type of raw material. Sources listed include the following: (1) Frasch recovery; (2) native, comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); (3) pyrites (whether or not the sulfur is recovered in the elemental form or as acid); (4) byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, tar sand cleaning, and processing of spent oxide from stack-gas scrubbers; and (5) recovery from the processing of mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded because to include it would result in double counting. It should be noted that production of Frasch sulfur, other native sulfur, pyrites-derived sulfur, mined gypsum-derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from tar sands are all credited to the country of origin of the extracted raw material; in contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which in some instances is not the original source country of the crude product from which the sulfur is extracted.

[4]Revised to zero.

[5]Reported figure.

[6]Byproduct pyrite and pyrrhotite from the processing of metallic sulfide ores.

[7]In addition, may produce limited quantities of byproduct sulfur from oil refining.

[8]Includes only the elemental sulfur equivalent of sulfuric acid produced as a byproduct from metallurgical furnaces; additional output may be included under "Byproduct: Unspecified sources."

[9]Includes recovery from gypsum, if any.

[10]Less than 1/2 unit.

[11]Official Polish sources report total Frasch and native mined elemental sulfur output annually, undifferentiated; this figure has been divided between Frash and other native sulfur on the basis of information obtained from supplementary sources.

[12]Figures for Polish metallurgy byproduct sulfur have been revised from 1977-84. Revised figures not included in the table are, in thousand metric tons: 1977—235; 1978—225; 1979—210; and 1980—205.

TECHNOLOGY

At the international conference Sulphur 85, 50 papers were presented on sulfur production, trade, forming, handling, acid production systems, new product applications, and/or future sulfur supply and demand.[5]

Conoco Inc. demonstrated that Claus sulfur recovery units can be economically expanded by 60% to 100% with the Claus oxygen-based process expansion technology. Two units at the company's Lake Charles, LA, refinery achieved an 85% increase in capacity by virtue of enriching the process air supply to 55% oxygen.[6]

[1]Physical scientist, Division of Industrial Minerals.

[2]European Chemical News (London). V. 44, No. 1175, 1985, p. 30.

[3]The Oil and Gas Journal. V. 84, No. 5, 1986, p. 29.

[4]Work cited in footnote 2.

[5]The British Sulphur Corp. Ltd. of United Kingdom. Proceedings of Sulphur—85. An International Conference (London, England, Nov. 10-13, 1985). 297 pp.

[6]The Oil and Gas Journal. V. 83, No. 30, 1985, pp. 39-41.

Talc and Pyrophyllite

By Robert L. Virta[1]

Total domestic production of talc and pyrophyllite combined increased 13% from that of 1984, and sales of crude and processed ore increased slightly. Exports of talc decreased 7% in tonnage and 12% in value.

Domestic Data Coverage.—Domestic production and sales data for talc and pyrophyllite are developed by the Bureau of Mines from a voluntary survey of U.S. mines and mills. Of the 98 mines and mills to which a survey request was sent, 80 responded, representing 82% of the U.S. production data shown in table 1. Production for the nonrespondents was estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

Table 1.—Salient talc and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1981	1982	1983	1984	1985
United States:					
Mine production, crude:					
Talc	1,236	1,049	980	[r]1,042	1,188
Pyrophyllite	107	87	87	85	81
Total[1]	1,343	1,135	1,066	[r]1,127	1,269
Value:					
Talc	$21,600	$19,540	$18,998	[r]$21,755	$27,768
Pyrophyllite	1,016	1,131	1,282	1,412	1,420
Total	22,616	20,671	20,280	[r]23,167	29,188
Sold by producers, crude and processed:					
Talc	1,115	915	1,038	[r]1,101	1,067
Pyrophyllite	106	110	125	97	139
Total	1,221	1,025	1,163	[r]1,198	1,206
Value:					
Talc	$95,354	$82,104	$104,739	[r]$112,515	$114,542
Pyrophyllite	3,454	3,557	4,057	3,578	5,101
Total	98,808	85,661	108,796	[r]116,093	119,643
Exports[2] (talc)	311	232	218	256	237
Value	$15,095	$12,957	$12,916	$16,162	$14,282
Imports for consumption (talc)	[3]27	[3]27	44	45	47
Value	[3]$5,834	[3]$6,264	$7,691	$9,156	$9,532
Apparent consumption[4]	937	820	989	1,009	1,079
World: Production	[r]8,012	[r]7,777	7,795	[p]8,351	[e]8,305

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Data may not add to totals shown because of independent rounding.
[2]Excludes powders—talcum (in package), face, and compact.
[3]Does not include imported pyrophyllite.
[4]Production, plus imports, minus exports, plus adjustments in Government and industry stock changes.

Legislation and Government Programs.—On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. Although tier I and II stockpile requirements for talc and pyrophyllite have yet to be evaluated, the stockpile inventory was 1,081 short tons for block or lump talc and 1,089 tons for ground talc at yearend. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The allowable depletion rates established under the Tax Reform Act of 1969 remained at 22% for domestic and 14% for foreign block steatite.

U.S. import duties on talc minerals from most favored nations were crude and unground, 0.02 cent per pound; ground, washed, powdered, and/or pulverized, 3.3% ad valorem; cut, sawed, or in blanks, crayons, cubes, disks, or other forms, free; and other not specifically provided for, 4.8% ad valorem.

DOMESTIC PRODUCTION

Talc.—U.S. mine production of crude talc increased 14% in tonnage and 28% in value. Talc, including soapstone, was produced at 26 mines in 10 States. Eleven mines operated in California. Montana, New York, Texas, and Vermont accounted for 90% of domestic talc production. Montana led all States in the tonnage and value of talc produced.

The largest domestic producers of talc, listed alphabetically, are Cyprus Industrial Minerals Co. and Pfizer Inc., Minerals, Pigments & Metals Div., with mines in California and Montana; R. T. Vanderbilt Co. Inc. in New York; and Windsor Minerals Inc. in Vermont and California.

The Montana Talc Co., a joint venture between NICOR Mineral Ventures and Meridian Land and Minerals Co., began construction of a $12 million mine and mill operation near Ennis, MT.[2] The mine, in the Madison River Valley and adjacent to Cyprus Industrial Minerals' Yellowstone talc mine, had an identified reserve of 1 million tons. Production of 20,000 tons was planned for the first year of operation, gradually increasing to 100,000 tons.

Cyprus Industrial Minerals filed environmental impact statements with the State of Vermont for the construction of an underground talc mine and a processing plant near Chester. The operation would cost $10 to $20 million and employ 50 to 60 workers. The designed annual capacity of the plant would be 40,000 tons.

Pyrophyllite.—Pyrophyllite was mined by four companies operating seven mines in California and North Carolina. Total production decreased slightly from that of 1984.

Piedmont Minerals Co. Inc. increased the andalusite content of its refractory-grade products by adding a second heavy-media separation phase to the beneficiation process.[3] The andalusite content was increased from 40% to 50%, and the alumina content was increased from 29% to 35%. The addition of a flotation stage after the heavy-media separation in a pilot plant increased the andalusite content of the final product to 90%.

R. T. Vanderbilt announced plans to improve its beneficiation facilities at the Robbins and Glendon deposits in North Carolina. The particle size distribution of its products will be controlled more precisely, allowing the company to market more products. Coarse material from the process will be suitable for some ceramic applications and in textured paints. Fine material may be used as filler in plastics.

Table 2.—Crude talc and pyrophyllite produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1984 Quantity	1984 Value	1985 Quantity	1985 Value
California	74	1,642	100	2,493
Georgia (talc)	15	104	16	111
North Carolina	87	1,587	85	1,604
Texas (talc)	r240	r4,125	261	5,245
Other[1] (talc)	711	r15,709	807	19,735
Total	r1,127	r23,167	1,269	29,188

rRevised.
[1]Includes Arkansas, Montana, New York, Oregon, Vermont, and Virginia.

CONSUMPTION AND USES

Apparent domestic consumption of crude and processed talc and pyrophyllite increased 7%. Sales of talc and pyrophyllite increased slightly in tonnage and value.

End-use distribution of ground talc was ceramics, 32%; paint, 16%; paper, 14%; roofing, 11%; plastics, 8%; cosmetics, 5%; rubber, 3%; and insecticides, 1%.

The largest portion, 58%, of domestically produced ground pyrophyllite was used in ceramics; 16% was used in refractories, and 10% in insecticides.

The paint industry is gradually shifting from solvent-based paints to alternative paint formulas because of production costs and environmental and safety problems.[4] Water-based paints are used more extensively, but high-solid paints and powder coatings are promising alternatives to solvent-based paints. All three of these alternatives use extenders to reduce the cost of paint production and to modify the characteristics of the paint. These extenders are selected by chemical composition, refractive index, particle size, particle shape, and particle size distribution. Calcium carbonate, kaolin, and talc are the major extenders used in the United States. Pyrophyllite is a minor extender used only in textured paints.

Approximately 200,000 tons of talc was used by the U.S. paint industry in 1985. Talc is useful as an extender in high-solid paints because it is hydrophobic and disperses well in oleoresinous media, it reduces the amount of solvent required, and it has flatting and antisettling properties. For water-based paints, it is necessary to treat the talc with a deflocculant. Although most talc used is platy, fibrous talc is valuable as an extender because of the high oil absorption properties, good rheological characteristics, and good antisettling properties.

Table 3.—End uses for ground talc and pyrophyllite

(Thousand short tons)

Use	1984			1985		
	Talc	Pyrophyllite	Total	Talc	Pyrophyllite	Total
Ceramics	358	r85	r443	296	72	368
Cosmetics[1]	44	--	44	46	3	49
Insecticides	8	14	22	7	12	19
Paint	189	1	190	144	2	146
Paper	100	--	100	125	--	125
Plastics	67	1	68	70	1	71
Refractories	4	21	25	5	20	25
Roofing	86	6	92	100	2	102
Rubber	29	--	29	27	--	27
Other[2]	85	11	96	101	12	113
Total	970	r139	r1,109	921	124	1,045

rRevised.

[1]Incomplete data. Some cosmetic talc known to be included with "Other."

[2]Includes art sculpture, asphalt filler and coatings, crayons, floor tile, foundry facings, rice polishing, stucco, and uses not specified.

PRICES

Talc prices varied depending on quality and on degree and method of processing.

Prices, quoted by the Engineering and Mining Journal, December 1985, per short ton of domestic ground talc, in carload lots, f.o.b. mine or mill, including containers follow:

New Jersey:	
Mineral pulp, bags extra	$18.50-$20.50
Vermont:	
98% through 325 mesh, bulk	70.00
99.99% through 325 mesh, bags:	
Dry processed	147.00
Water beneficiated	213.00-228.00
New York:	
96% through 200 mesh	62.00- 75.00
98% to 99.25% through 325 mesh	85.00-100.00
100% through 325 mesh, fluid-energy ground	165.00
California:	
Standard	130.00
Fractionated	37.00- 71.00
Micronized	150.00-220.00
Cosmetic steatite	44.00- 65.00
Georgia:	
98% through 200 mesh	50.00
99% through 325 mesh	60.00
100% through 325 mesh, fluid-energy ground	100.00

Approximate equivalents, in dollars per short ton, of price ranges quoted in Industrial Minerals (London), December 1985, for talc, c.i.f. main European ports, follow:

Australian, cosmetic (ex store)	$182-$196
Norwegian:	
Ground (ex store)	126- 140
Micronized (ex store)	154- 224
French, fine-ground	126- 238
Italian, cosmetic-grade	231
Chinese, normal (ex store):	
UK 200 mesh	186
UK 325 mesh	196
New York, paint, minimum 20-ton lot	245

FOREIGN TRADE

Exports.—Talc exports decreased 7%, while their value decreased 12%. Prices ranged from $27 to $440 per ton, averaging $60 per ton.

Mexico was the major importer of U.S. talc, accounting for 46% of the tonnage shipped, followed by Canada, 34%; Japan, 8%; and Belgium-Luxembourg, 3%. Canada led in value of imports with 34% of the total, followed by Mexico with 31%. Fifty-five countries imported U.S. talc.

Imports.—U.S. imports for consumption of talc increased 5%. Imports from Canada increased 20%. Canada was the leading source of imported talc with 63%, followed by Italy with 12% and France with 11%. Canada, Italy, and China accounted for 71% of the value of all imported talc.

Table 4.—U.S. exports of talc[1]

(Thousand short tons and thousand dollars)

Year	Belgium-Luxembourg		Canada[2]		Japan		Mexico		Other[3]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1981	17	1,364	79	4,632	9	500	164	4,256	42	4,343	311	15,095
1982	18	1,263	63	4,208	9	439	102	3,083	40	3,964	232	12,957
1983	1	55	74	4,629	16	1,077	86	2,805	41	4,350	218	12,916
1984	11	722	76	5,265	22	1,518	107	3,696	40	4,961	256	16,162
1985	6	373	81	4,864	18	1,422	108	4,492	24	3,131	237	14,282

[1]Excludes powders—talcum (in package), face, and compact.
[2]Probably includes shipments in transit through Canadian ports.
[3]Includes 51 countries.

Table 5.—U.S. imports for consumption of talc, by country

Country	Crude and unground		Ground, washed, powdered, or pulverized		Cut and sawed		Talc, n.s.p.f.	Total unmanufactured	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983	20,922	2,271	21,701	3,615	1,371	853	952	43,994	7,691
1984:									
Brazil	--	--	116	23	1,215	482	7	1,331	512
Canada	24	1	24,586	3,911	205	208	23	24,815	4,143
China	--	--	--	--	179	169	355	179	524
India	--	--	NA	93	13	36	417	13	546
Italy	9,315	1,706	137	48	--	--	--	9,452	1,754
Korea, Republic of	--	--	2,434	798	104	50	--	2,538	848
Other[1]	5,529	333	705	253	91	85	158	6,325	829
Total	14,868	2,040	27,978	5,126	1,807	1,030	960	44,653	9,156
1985:									
Brazil	--	--	143	23	1,220	464	16	1,363	503
Canada	10	2	29,524	4,111	131	180	29	29,665	4,322
China	--	--	--	--	1,013	889	271	1,013	1,160
France	4,217	240	838	130	--	--	--	5,055	370
Italy	5,511	1,025	84	21	155	251	--	5,750	1,297
Korea, Republic of	437	44	1,672	344	92	54	--	2,201	442
Other[2]	597	39	973	511	278	259	629	1,848	1,438
Total	10,772	1,350	33,234	5,140	2,889	2,097	945	46,895	9,532

NA Not available.
[1]Includes 23 countries.
[2]Includes 15 countries.

Source: Bureau of the Census.

WORLD REVIEW

The United States remained the world's largest talc producer, and Japan remained the largest pyrophyllite producer. The United States, Japan, and China accounted for 48% of the world's talc and pyrophyllite production.

Australia.—Westside Mines Pty. Ltd., which supplied almost 50% of the talc used by the United Kingdom's cosmetic manufacturers, closed its Mount Seabrook talc mine because legal ownership of the mine was being contested.[5]

Thames Mining NL, part of Keywest Investments Group, began exploration of the Livingston talc deposit, 4 miles from the Mount Seabrook deposit.[6] The talc deposit occurs in a deformed quartz-muscovite schist and was believed to be geologically related to the Mount Seabrook deposit. Preliminary drilling indicated substantial reserves of talc.

Brazil.—Mineração Matheus Leme Ltda. began operating its Minas Gerais pyrophyllite processing facility in June.[7] The rated capacity of the plant was 50,000 tons per year of pyrophyllite for use in the paint and rubber industries.

Canada.—Steetley Talc Ltd. began a $3 million expansion at the Timmins plant in Ontario to increase the capacity to 60,000 tons per year and increase the number of talc grades produced.[8] The expansion was phase 2 of a three-phase program to increase production capacity to 120,000 tons per year. The improvements included refurbishing the ball mill, classifiers, drum filters, magnetic separators, and thickeners, and installing a micronizing plant, a Raymond mill, and concentrators.

Talcs de Luzenac S.A., a major French talc producer, acquired a 50% share of Broughton Soapstone and Quarry Co. Ltd. (BSQ).[9] BSQ produced and marketed talc from deposits in the Thetford region of Quebec for roofing materials, the rubber industry, and other construction applications. The company planned a $700,000 expansion to double plant capacity to 50,000 tons per year. High-grade products for the plastics and paper industry will be produced through selective mining.

France.—Talcs de Luzenac, the largest talc-producing group worldwide, increased sales of talc to the British cosmetic industry to approximately 3,500 tons.[10] The increase in sales from France was partly attributed to the closing of Westside Mines' Mount Seabrook Mine, which had supplied almost 50% of the talc for the British cosmetic industry. The company also installed a laser selection process in its plant in the Ariège Pyrenees to supplement hand cobbing.

United Kingdom.—The cosmetic industry consumed approximately 15,000 tons of talc valued at $45 million after sterilization.[11] Talc was selected according to its end use. Properties such as macroscopic and microscopic appearance, chemistry, color, density, odor, and texture were important in this selection. For example, particle size and shape influenced the bulk handling properties of the talc and its softness and absorbency. Chemistry affected the color and the stability of tints and perfumes. Mineral impurities affected abrasiveness and color stability. The properties of talc were frequently enhanced by adding other minerals or chemicals.

Additives such as calcium carbonate, kaolin, metallic stearates, and starch were used to improve absorbency, adhesion, color, density, and bulk powder characteristics.

The comestic manufacturers changed talc suppliers following the shutdown of Westside Mines in May. Westside Mines supplied 45% to 55% of the cosmetic talc to the British cosmetic industry. Belgium, Italy, and Spain were other major suppliers of talc.

Table 6.—Talc and pyrophyllite: World production, by country[1]

(Short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Argentina (talc, steatite, pyrophyllite)	39,925	31,849	32,729	30,629	29,000
Australia	91,476	168,424	204,964	[r] [e]276,000	276,000
Austria (unground talc)	128,336	129,072	134,623	147,722	143,000
Brazil (talc and pyrophyllite)[3]	555,184	446,731	437,025	455,637	468,500
Burma	141	141	141	141	145
Canada (shipments)	[r]91,178	79,567	106,924	138,891	143,000
Chile	733	312	702	465	440
China[e]	990,000	1,050,000	1,050,000	1,050,000	1,100,000
Colombia	6,669	6,878	7,318	7,479	7,400
Egypt	6,309	9,139	4,981	13,463	13,000
Finland	339,418	358,251	351,009	360,976	364,000
France (ground talc)	340,911	304,723	315,812	322,315	331,000
Germany, Federal Republic of (marketable)	17,021	16,789	15,773	[e]15,000	15,000
Greece (steatite)	2,788	2,973	2,388	[r] [e]2,400	2,400
Hungary[e]	19,300	18,700	18,700	19,300	18,700
India (pyrophyllite and steatite)	405,175	379,129	389,162	460,473	441,000
Italy (talc and steatite)	180,106	180,746	175,239	157,329	[4]142,875
Japan[5]	1,703,125	1,644,982	1,615,791	1,652,303	[4]1,580,978
Korea, North[e]	185,000	185,000	185,000	185,000	185,000
Korea, Republic of (talc and pyrophyllite)	622,383	651,594	696,810	935,475	772,000
Mexico	[r]15,138	13,525	12,161	9,811	10,000
Nepal[6]	78	3,310	16,825	8,372	11,000
Norway[e]	[4]93,981	[r]110,000	[r]110,000	[r]110,000	110,000
Pakistan (pyrophyllite)	[r]27,482	[r]22,669	17,588	17,161	20,800
Paraguay	165	165	132	165	140
Peru (talc and pyrophyllite)[e]	10,000	9,500	9,500	9,000	9,000
Philippines	492	1,111	968	442	1,100
Portugal	7,014	5,445	6,018	6,838	6,900
Romania[e]	66,000	66,000	66,000	72,000	72,000
South Africa, Republic of[7]	16,674	15,226	12,337	15,886	[4]15,925
Spain (steatite)	76,134	69,099	76,574	79,628	80,500
Sweden	17,175	19,569	23,210	22,046	22,000
Taiwan	27,309	33,798	29,821	20,591	20,000
Thailand (talc and pyrophyllite)	13,266	24,249	22,209	31,393	32,000
U.S.S.R.[e]	550,000	560,000	560,000	570,000	570,000
United Kingdom[e]	19,800	21,000	17,600	17,600	19,800
United States (talc and pyrophyllite)	1,342,916	1,135,415	1,066,400	1,127,421	[4]1,268,750
Uruguay	[e]1,900	1,262	755	[e]1,300	1,100
Zambia	1,015	299	1,447	405	440
Zimbabwe	425	298	607	314	330
Total	[r]8,012,142	[r]7,776,940	7,795,243	8,351,371	8,305,223

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 27, 1986.
[2]In addition to the countries listed, Czechoslovakia produces talc, but available information is inadequate to make reliable estimates of output levels.
[3]Total of beneficiated and salable direct-shipping production of talc and pyrophyllite.
[4]Reported figure.
[5]Includes talc, pyrophyllite, and pyrophyllite clay.
[6]Data based on Nepalese fiscal year beginning mid-July of year stated.
[7]Includes talc and wonderstone.

TECHNOLOGY

The cost of plastics is reduced by adding talc as a filler.[12] Talc is one of the few minerals used by the plastics industry as a reinforcing filler. The platy nature of the talc provides a rigidity to the composite. Plastics with talc fillers exhibit a higher stiffness and creep resistance at ambient and elevated temperatures compared to plastics with particulate fillers such as calcium carbonate. For example, a polypropylene containing 40% loading of talc filler has a stiffness 3 times that of polypropylene with no filler and 1.5 times that of polypropylene containing a 40% loading of calcium carbonate filler. Talc has additional advantages over other mineral fillers because it is soft, requires less energy to mine, and was less abrasive in processing.

A major problem encountered when using high loadings of fillers is a reduction of impact strength. This is minimized for talc fillers by selecting the proper particle size distribution, treating the surface of the talc particles, and selecting the proper resin formulations. In 1985, the use of surface treatment increased approximately 15%.[13] Particle surfaces were chemically altered using silanes, stearates, and organometallics to improve the bond between the filler and the resins. For siliceous fillers, such as talc, silanes offered an advantage over stearates and organometallics by containing an organic to react with the resin and an inorganic to react with the siliceous filler.

A mineralogical study of a fibrous talc sample from New York examined the phase relationships between the fibrous talc and amphiboles in the sample.[14] Two amphibole phases were present. Nonasbestiform tremolite occurred as a separate phase. Fibrous anthophyllite was intimately intermixed with the fibrous talc within single grains. The intermixing of the anthophyllite and talc within single grains was significant with regard to a provisional transmission electron microscopy (TEM) technique for identifying amphibole asbestos in talc. The provisional technique did not positively identify the anthophyllite because of the crystallographic relationship between the talc and anthophyllite. A more extensive TEM technique employing electron diffraction and energy-dispersive X-ray analysis was recommended.

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[1]Physical scientist, Division of Industrial Minerals.

[2]Rocky Mountain Paydirt. Feb. 1986.

[3]Dickson, T. North American Pyrophyllite-Ceramics Leading the Way. Ind. Miner. (London), No. 218, Nov. 1985, p. 57.

[4]Toon, S. Minerals for Paint. Ind. Miner. (London), No. 219, Dec. 1985, pp. 49-75.

[5]Industrial Minerals (London). Comment. No. 215, Aug. 1985, p. 7.

[6]———. World of Minerals. No. 218, Nov. 1985, p. 9.

[7]———. World of Minerals. No. 215, Aug. 1985, p. 9.

[8]Page 10 of work cited in footnote 7.

[9]Industrial Minerals (London). World of Minerals. No. 209, Feb. 1985, p. 9.

[10]———. Fillers and Extenders. No. 218, Nov. 1985, p. 89.

[11]Robbins, J. UK Cosmetics—Make-Up Minerals. Ind. Miner. (London), No. 216, Sept. 1985, pp. 75-79.

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[13]Harben, P. Fine Particles and Fillers, A Conference Report. Ind. Miner. (London), No. 222, Mar. 1986, pp. 153-157.

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Thorium

By James B. Hedrick[1]

Domestic mine production of monazite, the principal source of thorium, increased in 1985 for the fifth successive year; however, output was exported. Thorium products used domestically were derived from imported materials, existing company stocks, and thorium nitrate released from the National Defense Stockpile (NDS). W. R. Grace & Co.'s Davison Chemical Div. and Rhône-Poulenc Inc., a subsidiary of Rhône-Poulenc S.A. of France, were the principal processors of thorium-containing ores in the United States. Magnesium Elektron Inc. was the principal domestic supplier of thorium alloys from its facilities in the United Kingdom.

Major nonenergy end uses were in aerospace alloys, mantles for incandescent lanterns, welding electrodes, and refractory applications. The only energy use of thorium in the United States was in the high-temperature gas-cooled nuclear reactor at Fort St. Vrain, CO.

Domestic Data Coverage.—Domestic mine production data for thorium-bearing monazite are developed by the Bureau of Mines from a voluntary survey of U.S. operations, the "Rare Earths and Thorium" survey. The one mine to which a survey form was sent responded, representing 100% of total production. Mine production data for thorium contained in monazite are withheld to avoid disclosing company proprietary data.

Table 1.—Salient U.S. thorium statistics

(Metric tons of ThO_2, unless otherwise specified)

	1981	1982	1983	1984	1985
Exports: Ores and metals	6	4	4	11	32
Imports: Compounds, gas mantles, metals	33	23	46	45	69
Shipments from Government stockpile excesses	3	--	--	--	2
Apparent consumption, nonenergy applications[e] [1]	30	19	42	34	39
Prices, yearend, dollars per kilogram, ThO_2:[2]					
Nitrate, mantle-grade	$9.50	$10.60	$10.60	$10.10	$10.10
Oxide, 99% grade	$21.20	$24.50	$31.00	[r]$35.85	$35.85

[e]Estimated. [r]Revised.

[1]All domestically consumed thorium was derived from imported metals, alloys, and compounds; monazite containing 350 to 550 tons of thorium oxide has been imported annually but has not been used to produce thorium products until 1985.

[2]Rhône-Poulenc Inc.

Legislation and Government Programs.—Sales of materials held in the NDS, including thorium nitrate, were suspended in September because the $250 million limit imposed on the General Services Administration's (GSA) transaction fund was reached. Exceptions to the transaction fund limit include authority to sell materials held by GSA in non-NDS stockpiles and to trade NDS materials declared as excess in exchange for upgrading of materials specified under the Presidential Ferroalloy Program. Thorium nitrate from the NDS that had previously been declared as excess to goal was sold in 1985 as authorized by the Department of Defense Authorization Act, 1985 (Public Law 98-525), effective September 30, 1984. A total of 4,536 kilograms (10,000 pounds) of the 22,680 kilograms (50,000 pounds) of thorium nitrate authorized for disposal under this law was sold before the transaction fund limit was reached.

Environmental Impact.—Radioactivity levels at the Bureau of Mines Albany Research Center were reportedly above the Federal limits owing to thorium, radium, and uranium contamination in the soil and the Center's research laboratories. The contamination was discovered in 1983 by officials of the Oregon State Department of Environmental Quality and confirmed by subsequent studies made by Bechtel National Inc., under contract to the Government. The contamination was the result of byproduct waste generated from research conducted during the 1940's related to processing various thorium-bearing ores, metals, and alloys, for the Atomic Energy Commission.[2] Cleanup of the contamination was expected to be completed by fiscal 1988.

Teledyne Wah Chang Albany (TWC) continued to experience problems resulting from environmental concerns over the storage of slightly radioactive process sludge containing thorium, uranium, and radium derived from naturally occurring minerals at its Albany, OR, facilities. TWC reportedly applied for a license to allow it to retain the sludge at its plantsite and strengthen and cover the disposal pond.[3] Removal of the sludge to an out-of-State disposal site would reportedly cost the company an estimated $100 million, according to company sources.

DOMESTIC PRODUCTION

Associated Minerals Ltd. Inc., a subsidiary of the Australian-owned firm Associated Minerals Consolidated Ltd. (AMC), a wholly owned subsidiary of Renison Goldfields Consolidated Ltd. (RGC) of Australia, was the only commercial minerals sands operation in the United States to produce monazite in 1985. Monazite was produced as a byproduct of minerals sands mined for titanium and zirconium minerals at Green Cove Springs, FL. Associated Minerals was engaged in domestic exploration for additional minerals sands to increase its reserves in the United States.

Table 2.—U.S. companies with thorium processing and fabricating capacity

Company	Plant location	Operations and products
Atomergic Chemetals Corp	Plainview, NY	Produces oxide, fluoride, metal.
Bettis Atomic Power Laboratory	West Mifflin, PA	Nuclear fuels; Government research and development.
Cerac Inc	Milwaukee, WI	Produces ceramics.
Ceradyne Inc	Santa Ana, CA	Produces advanced technical ceramics.
Chicago Magnesium Castings Co	Blue Island, IL	Magnesium-thorium alloys.
Coleman Co. Inc	Wichita, KS	Produces thoriated mantles.
Consolidated Aluminum Corp	Madison, IL	Magnesium-thorium alloys.
Controlled Castings Corp	Plainview, NY	Do.
GA Technologies Inc	San Diego, CA	Nuclear fuels.
W. R. Grace & Co., Davison Chemical Div	Chattanooga, TN	Produces thorium-containing residues from monazite.
GTE Sylvania	Towanda, PA	Produces thoriated welding rods.
Hitchcock Industries Inc	South Bloomington, MN	Magnesium-thorium alloys.
NLO Inc.[1]	Cincinnati, OH	Produces compounds and metals; manages DOE thorium stocks.
North American Phillips Lighting Corp	Bloomfield, NJ	Produces thorium-containing lighting and metallic thorium.
Phillips Elmet	Lewiston, ME	Produces thoriated welding rods.
Rhône-Poulenc Inc	Freeport, TX	Produces thorium nitrate from an intermediate compound of monazite.

See footnote at end of table.

Table 2.—U.S. companies with thorium processing and fabricating capacity —Continued

Company	Plant location	Operations and products
Teledyne Cast Products	Pomona, CA	Magnesium-thorium alloys.
Teledyne Wah Chang	Huntsville, AL	Produces thoriated welding rods.
Union Carbide Corp., Nuclear Div	Oak Ridge, TN	Nuclear fuels; test quantities.
Wellman Dynamics Corp	Creston, IA	Magnesium-thorium alloys.

[1]Manager of U.S. Department of Energy stocks; will become Westinghouse Materials Co. of Ohio, effective Jan. 1, 1986.

CONSUMPTION AND USES

Domestic thorium processors reported consumption of an estimated 74 metric tons of thorium oxide equivalent in 1985, an increase of 23 tons above the 1984 level. Nonenergy uses accounted for about 69 tons of the total, and energy uses accounted for the remainder. The approximate distribution of nonenergy thorium consumption by end use, based on information supplied by producers, primary processors, and several consumers, was as follows: refractory applications, 75%; aerospace alloys, 11%; lamp mantles, 8%; welding electrodes, 2%; and other applications, including ceramics and lighting, 4%.

Nearly all of the thorium used in metallurgical applications was alloyed with magnesium. Magnesium-thorium alloys used by the aerospace industry are lightweight and possess high strength and excellent creep resistance at elevated temperatures, properties that are useful in aircraft applications. Small quantities of thorium oxide (thoria) were used in dispersion-hardened alloys for high-strength, high-temperature applications.

Thorium oxide has the highest melting point of all the oxides at 3,300° C, a property that contributed to its use in several refractory applications, including high-strength, high-temperature ceramics; investment molds; crucibles; and research on heat-dissipative core-retention beds for nuclear reactors.

Thorium nitrate was used in the manufacture of mantles for incandescent "camping" lanterns and for oil lamps. Thorium nitrate was also used to produce thoriated tungsten welding electrodes. Thoriated tungsten electrodes were used to join stainless steels, nickel alloys, and other alloys that usually require controlled weld performance.

Thorium was used in electron tubes, in bulbs to light airport runways, in special high-refractivity glass, in radiation detectors, in computer memory components, in catalysts, in photoconductive films, in target materials for X-ray tubes, and in fuel cell elements.

In energy applications, thorium was used as a nuclear fuel in the thorium-232/uranium-233 fuel cycle in one domestic commercial reactor.

STOCKS

Government stocks of thorium nitrate in the NDS were 3,230,400 kilograms (1,544,845 kilograms of equivalent thorium oxide) on December 31, 1985. The NDS goal at yearend was 272,155 kilograms of thorium nitrate (130,153 kilograms of equivalent thorium oxide); remaining stocks have been declared excess to goal. However, the Department of Defense Authorization Act, 1985, authorized for disposal only 22,860 kilograms (50,000 pounds) of the thorium nitrate stocks held in the stockpile. Of this amount, 18,144 kilograms (40,000 pounds) of thorium nitrate remains authorized for disposal, but sales of the material were suspended in September 1985 as a result of a ceiling limit of $250 million placed on receipts in the stockpile transaction fund.

The U.S. Department of Energy's inventory at yearend contained 1,242,868 kilograms of thorium oxide equivalent contained in ore, metal, and various compounds.

PRICES

The average declared value of imported monazite decreased during 1985 to $349 per ton, down $40 from the 1984 value. The price range of Australian monazite, minimum 55% rare-earth oxide including thoria (f.o.b.-f.i.d.[4]), as quoted in Australian dollars (A$) in Metal Bulletin (London), increased sharply from A$410-A$440 per ton at yearend 1984 to A$850-A$900 per ton by yearend 1985. Changes in the foreign exchange rate in 1985, resulting from the continued economic strength of the U.S. dollar against foreign currencies, caused the corresponding U.S. price to rise less sharply from the range of $340-$365 in 1984[5] to $580-$614 in 1985.[6]

The yearend price for monazite, based on a thorium oxide content of 7%, was approximately $8.29 to $8.78 per kilogram of thorium oxide contained.

Rhône-Poulenc Inc. quoted prices for thorium oxide, per kilogram, net 30 days, f.o.b. Freeport, TX, or duty paid at point of entry, effective January 1, 1985, were 99% purity—$37.65 and 99.99% purity—$57.75. Thorium nitrate at 99.5% purity (mantle grade) was quoted at $10.10 per kilogram of thorium oxide equivalent at yearend.

Thorium alloy prices quoted from Magnesium Elektron, Flemington, NJ, were $30.11 per pound for thorium hardener alloy and $4.58 per pound for HZ-type alloy ingot.

FOREIGN TRADE

For the sixth consecutive year, France was the destination of all of the domestic exports of thorium ore, including monazite. Australia has been the principal domestic source of thorium-bearing monazite since 1977. Until 1985, monazite was imported solely for its rare-earth content, and no thorium products had been produced from it. Thorium products processed and manufactured domestically in 1985 were derived mainly from imported materials, primarily thorium compounds and rare-earth concentrates from France and magnesium-thorium alloys from the United Kingdom.

Table 3.—U.S. foreign trade in thorium and thorium-bearing materials

(Quantity in kilograms unless otherwise specified)

	1983 Quantity	1983 Value	1984 Quantity	1984 Value	1985 Quantity	1985 Value	Principal destinations and sources, 1985
EXPORTS							
Thorium ore, monazite	57,139	$51,678	229,983	$157,608	743,103	$415,024	All to France.
Metals[1]	937	48,882	890	46,905	1,440	182,373	United Kingdom 615; France 589; Netherlands 134; other 102.
IMPORTS							
Ore and concentrate:							
Thorium ore, monazite ___ metric tons	4,028	1,517,299	5,661	2,202,377	5,694	1,984,486	All from Australia.
ThO_2 content	284,980	XX	395,760	XX	398,580	XX	
Compounds:							
Nitrate	17,438	191,871	17,957	220,360	16,848	210,910	France 13,699; Canada 3,149.
Oxide	35,844	825,393	35,026	299,994	50,777	841,331	France 47,350; Netherlands 3,427.
Oxide equivalent, in gas mantles[e 2]	1,193	505,589	1,169	426,230	1,877	449,112	Malta 1,417; India 122; Hong Kong 107; Federal Republic of Germany 68; Canada 53; Brazil 51; Italy 38; China 22.
Other	428	100,793	588	195,111	499	171,463	United Kingdom 494; Switzerland 5.
Metals and alloys	30,016	NA	79,990	NA	8,306	NA	All from United Kingdom.
Unwrought, waste, and scrap	--	--	--	--	680	18,334	All from Canada.

[e]Estimated. NA Not available. XX Not applicable.
[1]Unwrought, wrought, waste, and scrap.
[2]Based on the manufacture of 2,205 gas mantles per kilogram of thorium oxide.

Sources: Bureau of the Census and a producer.

WORLD REVIEW

Australia.—RGC announced its bid to takeover control of Allied Eneabba Ltd. Several offers by RGC to gain control of Allied through stock purchases had occurred by yearend. The final takeover offer was to close on January 23, 1986, at which time RGC was expected to have acquired a controlling interest. The corporate takeover, if successful, would make RGC the world's principal minerals sands producer and the world's largest producer of thorium-containing monazite.[7]

Allied, in a joint venture with Asahi Chemical Industry Co. Ltd., was studying the feasibility of building a rare-earth and thorium separation plant at Geraldton, Western Australia, to process monazite. Monazite concentrates produced to date have been exported for further processing and separation, with Australian companies reportedly foregoing the added revenues to be gained through secondary refining.[8] RGC's takeover bid was not expected to affect the proposed Allied-Asahi separation plant venture.

Consolidated Rutile Ltd. (CRL) reportedly began minerals sands production at the Gordon Lease property on the southern end of North Stradbroke Island, Queensland. The property was acquired by CRL from AMC, a wholly owned subsidiary of RGC, in the first quarter of 1985. CRL also completed an agreement with AMC for the acquisition of all of AMC's holdings on the island.[9]

A new company, TiO_2 Corp. NL, owned by Griffiths Bros. Ltd. (80%) and Spunthill Pty. Ltd. (20%), announced plans to mine minerals sands deposits at Jurien Bay and Cooljarloo in Western Australia. These deposits were previously worked by Western Mining Corp. in the mid-1970's. Cooljarloo's reserves were given as 16 million tons proven and 42 million tons probable ore grading 3% to 5% heavy minerals including monazite. The Cooljarloo deposit's monazite content averages about 0.2% of the heavy mineral suite. Reserves at Jurien Bay were listed at 25 million tons proven and 1 million tons probable ore grading 6% to 7% heavy minerals including monazite at 0.7% (12,700 tons of thorium oxide equivalent).[10] Production from Cooljarloo was planned for 1988.

Monazite production capacities for Cooljarloo and Jurien Bay were estimated at 400 tons (28 tons of thorium oxide equivalent) and 1,200 tons (84 tons of thorium oxide equivalent) per year, respectively.[11]

A joint venture by Strategic Minerals Corp. (SMC) and Rutile & Zircon Mines (Newcastle) Ltd. (RZM) was formed to explore and develop SMC's heavy minerals sands deposits at Byfield, Queensland. Reportedly, RZM can earn an 80% equity in the project by either the expenditure of $2.05 million or by completing a final feasibility study leading to a decision to mine.[12]

Bangladesh.—Reportedly, Bangladesh will spend $7 million on a 5-year plan to extract heavy minerals, including thorium-containing monazite from the Cox's Bazaar coastal area. The beach sands, 100 kilometers southeast of Chittagong, along the coast and on nearby islands, contain resources estimated at 5 million tons of heavy minerals.[13]

Brazil.—Minerals sands production began at Cumuruxatiba in Bahia State. Monazite along with ilmenite, rutile, and zircon were recovered at the mine. Concentrates produced at Cumuruxatiba were shipped to the São Paulo processing plant, operated by the state-controlled Nuclebras de Monazita e Associados Ltda., where thorium and rare-earth compounds were produced.[14]

Production of crude monazite ore in 1984 was 530 tons from the State of Espírito Santo, a decrease from the 915 tons produced in 1983, and 3,635 tons from the State of Rio de Janeiro, a decrease from the 1983 production level of 5,015 tons.

According to Anuário Mineral Brasileiro 1985, measured reserves of monazite were 13,705 tons for 1984. Estimated thorium oxide equivalent content based on these reserves was 890 tons. Monazite reserves were in the States of Espírito Santo, Paraná, and Rio de Janeiro.[15]

France.—Rhône-Poulenc S.A. announced it would invest 26.7 million in its two rare earth-thorium plants at La Rochelle, France, and Freeport, TX, in the United States. The additional funding would reportedly be used to increase the existing separation and production capacities.[16] Emphasis on increased separation of neodymium oxide and dysprosium oxide for use in high-strength permanent magnets was reportedly the principal reason for the investment.

Germany, Federal Republic of.—Further studies of heavy minerals sands deposits at Cuxhaven, discovered during a drilling program in 1973-76, were concluded in 1985 by the Federal Ministry for Research & Technology. Reserves were estimated at 10 million tons of heavy minerals sands including ilmenite, rutile, zircon, and possibly monazite. The fossilized beach sands deposits are reportedly similar to those on the east coast of Australia and were deposited during the late Tertiary era. Additional reserves are thought to occur in the area, and further exploration was scheduled.[17]

India.—Indian Rare Earths Ltd.'s dredge and wet concentrator plant began operation at the Orissa Sands Complex in Orissa. The dry mill was also commissioned and trial runs were being conducted.[18] Production of limited amounts of monazite concentrates associated with an initial production of 30,000 tons of ilmenite was reported.

Zaire.—Several tin and gold deposits in the Kivu region also contain monazite. Reserves of monazite in the Obaye mining sector, under the jurisdiction of the Zairian mining company Société Minière et Industrielle de Kivu, occur in two separate deposits. The Kabengelwa deposit contains 1,100 tons of monazite (66 tons of thorium oxide equivalent) in ore grading 2.8 kilograms per cubic meter. The Mashabuto deposit was reported to contain 45 tons of monazite (3 tons of thorium oxide equivalent) in ore grading 3 kilograms per cubic meter.[19]

Table 4.—Monazite concentrate: World production, by country[1]

(Metric tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Australia	13,282	9,562	15,141	16,702	15,000
Brazil	[r]2,460	[r]1,814	5,256	3,622	6,000
India[e 3]	[4]3,704	4,000	4,000	4,000	4,000
Malaysia[5]	320	[r]546	1,051	4,451	6,000
Mozambique	4	3	4	[e]4	4
Sri Lanka	60	304	[e]300	147	200
Thailand	107	162	277	298	250
United States	W	W	W	W	W
Zaire	35	32	15	2	--
Total	[r]19,972	[r]16,423	26,044	29,226	31,454

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1]Table includes data available through Apr. 29, 1986.

[2]In addition to the countries listed, China, Indonesia, North Korea, the Republic of Korea, Nigeria, and the U.S.S.R. may produce monazite, but output, if any, is not reported quantitatively, and available general information is inadequate for formulation of reliable estimates of output levels.

[3]Data are for years beginning Apr. 1 of that stated.

[4]Reported figure.

[5]The 1981-83 figures are exports and the 1984-85 figures are production.

TECHNOLOGY

Researchers at the U.S. Geological Survey continued to study data collected on the Atlantic Continental Shelf to delineate the potentially significant concentrations of heavy minerals sands off the coasts of Georgia and Virginia. Initial analyses indicate placer deposits on the Continental Shelf containing from 3% to 10% heavy minerals sands including thorium-containing monazite. Reportedly, the deposits exist at depths accessible by existing mining technology using floating dredges and concentrators.[20]

An updated study on thorium was published by Roskill's Information Services Ltd. The report gives information on the ores, production, consumption, trade, and uses of thorium on a worldwide basis.[21]

Researchers at General Electric Co.'s Research & Development Center at Schenectady, NY, determined that certain ancient thorium-rich and uranium-rich minerals containing long-lived radioactive isotopes apparently self-anneal, thus completely repairing any damage done by radioactive decay in less than 10,000 years. This would include such isotopes as uranium-234 and thorium-230. The long-term effect of radioactive decay in these minerals is reportedly a reduced rate of dissolution in water; consequently, the concern that solidified nuclear waste and other radioactive materials may eventually breakdown by dissolution in water and be leached out may not be valid under certain geoenvironmental conditions.[22]

[1]Physical scientist, Division of Nonferrous Metals.

[2]Bechtel National Inc., Advanced Technology Div. Radiological Survey of the Albany Research Center, Albany, Oregon. BuMines contract DE-AC0810R20722, Jan. 1985, 75 pp.

[3]The (Portland) Oregonian. New Initiative Takes Aim at Wah Chang Sludge. July 10, 1985.

[4]Free on board-free into container depot.

[5]Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.2070=US$1.00 based on yearend 1984 foreign exchange rates published in the Wall Street Journal.

[6]Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the exchange rate of A$1.4652=US$1.00 based on yearend 1985 foreign exchange rates published in the Wall Street Journal.

[7]Industrial Minerals (London). RGC Increases Offer for Allied Eneabba. No. 219, Dec. 1985, p. 9.

[8]California Mining Journal. Australia To Process Rare Earth Minerals. V. 54, No. 2, Aug. 1985, p. 50.

[9]Bureau of Mineral Resources (Canberra, Australia). Preliminary Summary 1985. Australian Mineral Industry Annual Review. 2 pp.

[10]Mining Journal (London). TiO_2 Mineral Sands Venture. V. 305, No. 7832, Sept. 27, 1985, p. 255.

[11]Industrial Minerals (London). Australia, TiO_2 Corp Launches Mineral Sands Project. No. 217, Oct. 1985, p. 11.

[12]Work cited in footnote 9.

[13]Mining Journal (London). Bangladesh Beach Sands. V. 305, No. 7841, Nov. 29, 1985, p. 415.

[14]Industrial Minerals (London). Brazil, Rare-Earths Progress. No. 217, Oct. 1985, p. 11.

[15]Anuário Mineral Brasileiro 1985. Monazita. Pp. 300-301.

[16]Industrial Minerals (London). France, Rare-Earths Investment for Rhône. No. 215, Aug. 1985, pp. 11-12.

[17]———. Mineral Sands—Towards Self-Sufficiency? No. 219, Dec. 1985, p. 47.

[18]Indian Rare Earths Ltd. 35th Annual Report 1984-85. P. 18.

[19]Morgan, G. A., K. Conner, and B. A. Kornhauser. Zaire. BuMines Mineral Perspectives, Sept. 1985, p. 25.

[20]Grosz, A. (rare-earth specialist). Personal communication, 1985, U.S. Geological Survey, National Ctr., Reston, VA 22092.

[21]Roskill Information Services Ltd. The Economics of Thorium 1985. 4th ed., 1985, 63 pp.

[22]Chemical & Engineering News. Science—Minerals May Repair Radiation Flaws. Apr. 22, 1985, p. 24.

Tin

By James F. Carlin, Jr.[1]

For the fifth consecutive year, there was a substantial world tin excess supply, although world mine production declined and world consumption rose during 1985. In October, the International Tin Council (ITC), which had been buying tin on credit to support the tin price, exhausted its funds for this purpose. This occurrence disrupted the tin industry and caused a suspension of tin from London Metal Exchange (LME) trading for the duration of the year, and tin prices declined markedly during the last 2 months of the year.

Domestic Data Coverage.—Domestic production data for tin are developed by the Bureau of Mines from a voluntary survey of U.S. mines. Of the six mines to which a survey form was sent, all responded. Domestic production, which was negligible, was withheld to avoid disclosing company proprietary data.

Table 1.—Salient tin statistics

(Metric tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production:					
Mine	W	W	W	W	W
Smelter	2,000	3,500	2,500	4,000	e3,000
Secondary	15,438	14,293	14,205	15,417	e14,911
Exports[1]	2,361	5,769	1,340	1,429	1,478
Imports for consumption:					
Metal	45,874	27,939	34,048	41,224	33,830
Ore (tin content)	232	1,961	969	3,272	1,636
Consumption:					
Primary	40,229	33,019	34,301	37,819	37,136
Secondary	14,144	13,276	11,246	11,622	12,590
Stocks, yearend U.S. industry	11,131	10,251	9,859	9,977	12,363
Prices, average cents per pound:					
New York market	648.40	586.85	601.28	567.80	525.90
Metals Week composite[2]	733.05	653.91	654.78	623.80	595.95
London[2]	649.53	580.50	589.19	556.55	556.26
Kuala Lumpur[2] [3]	637.85	587.29	590.78	564.95	540.70
World: Production:					
Mine	r238,008	r219,925	196,902	p198,432	e191,103
Smelter	r235,931	r221,000	199,828	p199,669	e193,715

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data; U.S. mine production for 1981-85 was negligible.
[1]Exports (excluding reexports).
[2]Based on 10 months in 1985.
[3]Beginning in 1985, Kuala Lumpur replaced Penang as the reference market.

Legislation and Government Programs.—The General Services Administration (GSA) continued its daily fixed-price tin sale program through October when it suspended sales for the balance of the year owing to the ITC disruption, since there was no reliable tin price available. A total of 3,005 metric tons was sold in 1985; of that amount, 2,650 tons represented payment material for GSA's Ferroalloy Upgrading Program, which started April 11, 1984.

At yearend, the National Defense Stockpile inventory was 185,220 tons; the stockpile goal was 42,674 tons.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, tin would be categorized in tier II with a goal of 150,000 tons, pending Government review. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The depletion allowance for tin remained at 22% for domestic deposits and 14% for foreign deposits.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.—Two mines, operating in Alaska and Colorado, produced tin concentrates. Domestic mine production data were withheld to avoid disclosing company proprietary data, but total output amounted to only a small fraction of domestic tin requirements.

Smelter Production.—The only domestic tin smelter, Tex Tin Corp., in Texas City, TX, and owned by Gulf Chemical & Metallurgical Corp., a subsidiary of Associated Metals & Minerals Corp., decreased tin metal output to an estimated 3,000 tons. The smelter treated imported and domestic concentrates, secondary tin-bearing materials, and its own stockpile of tin residues and slags. The smelter's major source of tin concentrates was Peru. In August, Tex Tin announced it was ceasing production of refined tin for the balance of the year.

SECONDARY TIN

The United States was believed to be the world's largest producer of secondary tin. Secondary tin from recycled fabricated parts was an important source of material for the solder and the brass and bronze industries.

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1984	1985
Tinplate scrap treated metric tons	492,825	460,105
Tin recovered in the form of:		
Metal do	824	931
Compounds (tin content) do	301	186
Total[1] do	1,125	1,117
Weight of tin compounds produced do	1,498	338
Average quantity of tin recovered per metric ton of tinplate scrap used kilograms	2.24	2.38
Average delivered cost of tinplate scrap per metric ton	$68.01	$53.69

[1]Recovery from tinplate scrap treated only. In addition, detinners recovered 366 metric tons of tin as metal and in compounds from tin-base scrap and residues in 1985.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery

(Metric tons unless otherwise specified)

Form of recovery	1984	1985
Tin metal:		
At detinning plants	1,097	1,292
At other plants	10	10
Total	1,107	1,302
Bronze and brass:		
From copper-base scrap	9,071	e8,800
From lead- and tin-base scrap	75	47
Total	9,146	e8,847
Solder	3,653	3,565
Type metal	142	122
Babbitt	123	88
Antimonial lead	894	791
Chemical compounds	301	186
Miscellaneous[1]	51	10
Total	5,164	4,762
Grand total	15,417	e14,911
Value (thousands)[2]	r$212,021	e$195,907

eEstimated. rRevised.

[1]Includes foil and terne metal.

[2]Based on Metals Week composite price.

CONSUMPTION AND USES

Primary tin consumption remained about the same as that of 1984, and was well below the levels of the 1970's. Solder was the largest application of primary tin, with tinplate a distant second.

Tinplate continued to lose markets to aluminum in container applications. Of the 101.9 billion metal cans shipped, tinplated steel and tin-free steel accounted for 34% and aluminum accounted for 66%, compared with 97.8 billion metal cans shipped in 1984, when steel accounted for 35% and aluminum for 65%. Aluminum held an overwhelming segment of the beverage can market, while steel was still predominant in the food can and the general packaging markets.[2]

Table 4.—U.S. consumption of primary and secondary tin

(Metric tons)

	1981	1982	1983	1984	1985
Stocks, Jan. 1[1]	8,835	8,717	7,549	7,740	8,478
Net receipts during year:					
Primary	41,162	35,843	36,494	39,388	38,936
Secondary	5,692	6,507	5,412	6,096	8,904
Scrap	8,050	7,830	7,435	7,323	7,917
Total receipts	54,904	50,180	49,341	52,807	55,757
Total available	63,739	58,897	56,890	60,547	64,235
Tin consumed in manufactured products:					
Primary	40,229	33,019	34,301	37,819	37,136
Secondary	14,144	13,276	11,246	11,622	12,590
Total	54,373	46,295	45,547	49,441	49,726
Intercompany transactions in scrap	726	274	245	318	214
Total processed	55,099	46,569	45,792	49,759	49,940
Stocks, Dec. 31 (total available less total processed)	8,640	12,328	11,098	10,788	14,295

[1]Includes tin in transit in the United States.

Table 5.—Tin content of tinplate produced in the United States

Year	Tinplate waste (waste, strips, cobbles, etc., gross weight) (metric tons)	Tinplate (all forms) Gross weight (metric tons)	Tin content[1] (metric tons)	Tin per metric ton of plate (kilograms)
1981	284,505	3,288,662	13,306	4.0
1982	208,074	2,712,678	10,936	4.0
1983	166,186	2,586,810	9,328	3.6
1984	152,093	2,500,945	8,659	3.5
1985	146,041	2,215,042	9,322	4.2

[1]Includes small tonnage of secondary tin and tin acquired in chemicals.

Table 6.—U.S. consumption of tin, by finished product

(Metric tons of contained tin)

Product	1984			1985		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)[1]	W	W	W	W	W	W
Babbitt	2,343	341	2,684	1,147	341	1,488
Bar tin	522	4	526	466	W	466
Bronze and brass	1,686	3,312	4,998	1,672	2,657	4,329
Chemicals	W	W	W	W	W	W
Collapsible tubes and foil	W	W	W	W	W	W
Solder	13,450	3,799	17,249	13,301	5,315	18,616
Tinning	1,748	W	1,748	1,511	W	1,511
Tinplate[2]	8,659	166	8,825	9,322	W	9,322
Tin powder	1,057	W	1,057	977	W	977
Type metal	W	W	W	7	W	7
White metal[3]	881	77	958	876	61	937
Other	7,473	3,923	11,396	7,857	4,216	12,073
Total	37,819	11,622	49,441	37,136	12,590	49,726

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes terne metal.
[2]Includes secondary pig tin and tin acquired in chemicals.
[3]Includes pewter, britannia metal, and jewelers' metal.

Table 7.—U.S. industry yearend tin stocks

(Metric tons)

	1981	1982	1983	1984	1985
Plant raw materials:					
Pig tin:					
Virgin[1]	6,857	6,269	6,326	5,480	5,731
Secondary	411	265	732	1,562	2,342
In process[2]	1,449	1,015	682	1,164	1,367
Total	8,717	7,549	7,740	8,206	9,440
Additional pig tin:					
Jobbers-importers	1,943	1,386	608	761	1,642
Afloat to United States	471	1,316	1,511	1,010	1,281
Total	2,414	2,702	2,119	1,771	2,923
Grand total	11,131	10,251	9,859	9,977	12,363

[1]Includes tin in transit in the United States.
[2]Data represent scrap only, tin content.

PRICES

The price of tin metal remained relatively flat during the first 10 months of 1985, at about $6 per pound, as published in Metals Week. However, when the ITC exhausted funds to support the tin price in October and the LME consequently suspended tin trading for the duration of the year, there were no reliable benchmarks to evaluate the tin price. Sporadic price quotations, as published in Metals Week, during November and December, from New York and Asian markets, indicated a price of about $3.50 per pound.

Table 8.—Monthly composite price of Straits tin for delivery in New York

(Cents per pound)

Month	1984			1985		
	High	Low	Average	High	Low	Average
January	625.60	622.20	623.74	586.44	566.26	573.67
February	634.77	622.13	627.88	568.27	552.37	562.62
March	644.90	627.36	626.65	592.27	553.49	565.68
April	638.71	633.65	636.50	612.58	569.33	591.56
May	641.05	632.36	636.32	601.38	561.43	588.61
June	640.12	635.21	638.25	613.74	597.34	604.03
July	635.10	624.86	629.89	637.77	610.51	626.31
August	632.50	619.23	626.00	631.25	617.73	626.49
September	623.70	607.27	618.08	627.36	592.91	610.07
October	607.49	597.45	603.61	614.88	605.61	610.46
November	615.98	600.82	609.94	NA	NA	NA
December	604.30	591.88	598.76	NA	NA	NA
Average[1]	XX	XX	623.80	XX	XX	595.95

NA Not available. XX Not applicable.
[1]Based on 10 months in 1985.

Source: Metals Week.

FOREIGN TRADE

Imports of tin concentrates in 1985 declined sharply, indicating the reduced level of activity at the Tex Tin smelter.

Imports of tin metal declined, with Brazil remaining the major source, followed by Thailand, Indonesia, and China. China has emerged in recent years as an important supplier.

Imports of tin in all forms (ore and concentrate, metal, and waste and scrap) remained free of U.S. duty.

Table 9.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and tin manufactures				Tin compounds	
	Imports			Exports	Imports	
	Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f.	Dross, skimmings, scrap, residues, tin alloys, n.s.p.f.		Tin scrap and other tin-bearing material, except tinplate scrap	Quantity (metric tons)	Value (thousands)
	Value (thousands)	Quantity (metric tons)	Value (thousands)	Value (thousands)		
1983	$10,728	1,193	$1,219	$8,972	642	$4,120
1984	3,292	1,211	1,318	12,494	838	5,301
1985	3,290	877	2,804	18,357	827	5,164

Source: Bureau of the Census.

Table 10.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms; exports of ingots, pigs, bars; imports of tinplate scrap

Year	Ingots, pigs, bars		Tinplate and terneplate				Tinplate scrap	
	Exports		Exports[1]		Imports		Imports	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1983	1,340	$17,305	171,121	$83,827	266,548	$168,413	2,144	$188
1984	1,429	14,409	154,679	93,033	338,630	203,147	4,755	480
1985	1,478	16,744	155,119	85,000	381,137	222,504	3,815	441

[1]Tinplate circles, strips, and cobbles are included with exports of tinplate and terneplate.

Source: Bureau of the Census.

Table 11.—U.S. imports for consumption of tin, by country

Country	1984		1985	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Concentrates (tin content):				
Australia	--	--	(1)	$22
Bolivia	271	$1,782	22	97
Canada	1	1	24	102
Mexico	17	78	32	102
Peru	2,502	14,308	1,506	9,966
Singapore	46	475	--	--
South Africa, Republic of	3	28	32	351
Thailand	403	3,883	20	19
Zaire	29	306	--	--
Total[2]	3,272	20,862	1,636	10,659
Metal:[3]				
Australia	288	4,179	266	3,060
Belgium-Luxembourg	137	1,688	--	--
Bolivia	5,438	67,742	1,815	21,187
Brazil	10,220	126,190	11,021	127,128
Burma	64	776	--	--
Canada	8	66	18	233
Chad	--	--	20	245
Chile	218	3,713	673	7,392
China	1,640	20,596	4,513	60,126
Denmark	40	489	--	--
France	--	--	167	1,803
Germany, Federal Republic of	r(1)	11	147	1,574
Hong Kong	--	--	258	2,954
India	--	--	450	5,012
Indonesia	4,985	62,224	4,586	53,753
Japan	20	242	188	2,131
Korea, Republic of	--	--	3	41
Malaysia	6,622	80,546	379	4,503
Netherlands	140	1,743	45	499
Nigeria	60	788	--	--
Norway	--	--	149	1,838
Paraguay	1	6	--	--
Philippines	20	r258	--	--
Rwanda	30	367	--	--
Singapore	781	4,128	1,886	22,156
South Africa, Republic of	10	121	105	1,282
Sweden	--	--	280	2,948
Switzerland	--	--	50	589
Taiwan	--	--	120	1,423
Thailand	9,531	104,657	6,373	75,423
United Arab Emirates	--	--	129	1,225
United Kingdom	583	7,253	48	600
Zaire	89	787	--	--
Zimbabwe	296	3,462	140	1,283
Total[2]	41,224	492,030	33,830	400,408

rRevised.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.
[3]Bars, blocks, pigs, or granulated.

Source: Bureau of the Census.

WORLD REVIEW

International Tin Agreement.—The Sixth International Tin Agreement (ITA), which commenced on July 1, 1982, continued in effect throughout 1985. The United States was not a member of the agreement.

The ITC continued to be heavily engaged in tin price support actions for most of the year to defend the ITC's floor price by buying tin for its stockpile. The ITC retained the same buffer stock floor price of 29.15 Malaysian dollars (M$) per kilogram and the ceiling price of M$37.89 that were in effect since October 17, 1981. On October 24, 1985, the ITC exhausted funds to support the tin price. This caused severe disruption of the world tin market. The LME and the Kuala Lumpur Tin Market immediately suspended tin trading while the ITC tried to reach financial settlements for debts owed to banks and trading firms for past tin purchases, and while the ITC attempted to reestablish its tin price support program. In the final months of the year, various proposals were considered to enable the ITC to refinance its large debt, but the ITC could not reach agreement among its 22-nation member governments on any plan, and the year ended with the matter unresolved.

Throughout the year, the ITC continued to maintain export controls on producer member countries at a level of 39.6% of the levels of tin exports prevailing before July 1, 1982, which was the commencement date for the export control program. Despite the existence of export controls for over 3 years, industry sources estimated the world tin surplus at about 70,000 tons at yearend 1985.

Tin smuggling in Southeast Asia continued to be a problem, although it declined at yearend with the sharp drop in tin prices. Tin smuggling was counterproductive to export control measures and was viewed as a significant factor in contributing to the world tin surplus. Industry sources indicated that Singapore continued to be the destination for considerable tonnage of smuggled tin concentrates from Indonesia, Malaysia, and Thailand.

The Association of Tin Producing Countries (ATPC), comprised of seven major producer nations—Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand, and Zaire—completed its second year as an organization. ATPC viewed itself as being complementary to, and supportive of, the activities of the ITC, and the organization attempted to persuade non-ITA member countries to restrain tin production.

Australia.—Aberfoyle Ltd. announced plans to halt tin production at its Ardlethan Mine in New South Wales. In recent years, mining at Ardlethan had been mostly from remnant areas that had raised the cost of production. Aberfoyle attributed the closure to depletion of reserves and to the sharp decline in tin prices that occurred late in 1985. Tasmania was the source of about two-thirds of Australia's tin production. The large Renison underground tin mine in western Tasmania accounted for about 40% of the country's total output of tin.

Domestic tin usage was estimated at 2,500 tons, with the tinplate industry being the largest consumer.

There were two primary tin refineries. The Associated Tin Smelters Pty. Ltd. (ATS) in Sydney, which was the larger of the two, obtained its tin concentrate from producers in eastern Australia, including Queensland and New South Wales. The other refinery was operated by Greenbushes Tin Ltd. in Western Australia and smelted the production from its own tin-tantalum mine.

Bolivia.—The Corporación Minera de Bolivia (COMIBOL) was the country's largest tin producer. A significant proportion of mine output was from medium-sized mines. There were also many small mines and some mining cooperatives. The three largest mines were the Huanuni, the La Palca, and the Catavi. Bolivia remained a high-cost tin producer, largely because its mines were the hard-rock underground type and its tin deposits were of relatively low grade. Most of the tin concentrates produced were beneficiated in mills adjoining the mines.

Strikes continued to hamper various production sites throughout the year. The European Economic Community (EEC) displaced the United States as the largest single customer for Bolivian tin.

Brazil.—Brazil was not a member of the ITA and therefore not bound by the ITA's export controls, and Brazilian tin mines significantly increased their output, as they have done in recent years. Brazil ranked as the world's fifth largest tin producer. The three leading private tin mining companies in Brazil were Paranapanema S.A. Mineração, Indústria e Construção, Brascan Recursos Naturais S.A. (BRN), and Mineração Brumadinho S.A.

The leading producer, Paranapanema, accounted for more than one-half of Brazil's total output, operating at least seven tin mines. Paranapanema reported sharply increased output from its new Pitinga operations in the Mapuere region in Amazonas State. The company shipped the entire output of its mines to its Mamoré smelter, near São Paulo, for conversion to refined metal.

BRN, jointly owned by Brascan Ltd. and BP Mineração, was Brazil's second leading tin producer. It operated several mines, all in the State of Rondônia. BRN's tin concentrates were shipped to its Cesbra smelter for refining.

Brumadinho, the third largest tin producer, operated several alluvial tin mines in Rondônia and explored several tin properties in Goiás State. Brumadinho shipped all its tin concentrates to the tin smelter Bera do Brasil S.A., near São Paulo. Bera was 70% owned by Brumadinho and 30% by Paul Bergsoe and Son A/S of Denmark.

St. Joe Minerals Corp. commenced production at its Mocambo Mine, an alluvial deposit situated near São Felix in the Xingu River area of Pará State. Production from the high-grade deposit was expected to be about 1,000 tons per year.

Constructora Andrade Gutierrez S.A. started tin production at its Itaiutuba Mine in Pará State. The firm expected to produce about 500 tons of tin annually.

Canopus S.A. started tin production at its Rhodia-Espeng alluvial tin deposit located in the Iriri River region of Pará State. Production was expected to be about 800 tons per year of tin.

There were at least 10 tin smelters in Brazil, but none, except Mamoré, had sufficient feed to operate at designed capacity.

Canada.—Late in 1985, Rio Algom Ltd. started production at its large open pit tin mine at East Kemptville, Nova Scotia. The operation was expected to produce about 4,500 tons per year of tin concentrate, and rank as the largest tin mine in North America. All tin concentrates were shipped to the Capper Pass tin smelter in North Ferriby, the United Kingdom.

Lac Minerals Ltd. announced the start of a 1-year evaluation project on the Mount Pleasant, New Brunswick tin property owned by Billiton Canada Ltd.

China.—Plans were announced by the Yunnan Provincial government to construct the Wenshan tin complex with the capacity to mine and smelt 3,000 tons of refined tin annually.

Technomin Australia NL formed a joint venture with the Chinese Government's National Nonferrous Metals Industry Corp. to prospect for tin in China. Initial plans were to investigate areas near the recently developed DaChang tin mine, which reported tin grades of almost 1%.

A new tin smelter at Liepan in Guangxi Province was reportedly near completion, with expected annual capacity of about 8,000 tons of refined tin.

India.—India's Mineral Exploration Corp. (MEC) reported the discovery of a tin deposit at Tosham in Haryana Province. Tin grades were about 0.10%. Plans were announced to construct a tinplate facility near the Port of Goa. The London-based Caparo Group Ltd. was expected to provide financing.

Indonesia.—Tin deposits were primarily offshore. P.T. Tambang Timah (P.T. Timah), the national mining firm, was the major producer. P.T. Koba Tin was the second largest producer, with its largest mine situated on Bangka Island. Koba was jointly owned by Kajaura Mining Corp. (Pty.) Ltd., an Australian company, and by P.T. Timah.

Preussag AG (Federal Republic of Germany) purchased the Kelapa Kampit tin mine from The Broken Hill Pty. Co. Ltd. (Australia).

The new P.T. Latinusa electrolytic tinning line facility in Cilegon, West Java, began production. The plant was a joint venture of P.T. Timah and P.T. Krakatan Steel, both Government-owned, and P.T. Nusamba, a local firm. The facility was expected to reach full capacity of 130,000 tons per year of tinplate in 1988 and to raise domestic tin ore consumption to 10% of the country's output.

Malaysia.—Although Malaysia remained the world's leading tin producer, its tin mining activities continued the pattern of decline of recent years. There were 465 mines in 1985, compared with 852 in 1980. The number of dredges declined from 54 in 1980 to 25 in 1985, and the labor force declined from 39,000 people in 1980 to 22,000 in 1985.

Two large smelters continued operating at Penang, refining all of Malaysia's tin concentrates and considerable amounts of imported concentrates. The Malaysia Mining Corp. closed its New York, NY, sales office because of the low level of tin exports to the United States. The major destination for exported tin was Japan, followed by the EEC.

Mexico.—Mexican tin mining occurred sporadically in the three adjoining States of Durango, Zacatecas, and San Luis Potosí in the north-central part of the country. Cía Minera Pizzuto owned Mexico's main tin mine, the El Perro Mine, in San Luis Potosí. The country's main tin smelter was operated by Estãno Electro S.A. de C.V. at Tlalnepantla, near Mexico City, with a capacity of 1,200 tons of refined tin annually. Fundidora de Estãno S.A. operated a tin smelter at San Luis Potosí with a 1,200-ton annual capacity. Both smelters treated mainly imported tin concentrates.

Nigeria.—Five firms mined tin: Amalgamated Tin Mines of Nigeria (Holdings) Ltd., Bisichi-Jantar Nigeria Ltd., Kaduna Prospecting Nigeria Ltd., Ex-Lands Nigeria Ltd., and Gold & Base Metal Mines of Nigeria Ltd. All tin concentrates were smelted domestically by Makeri Smelting Co. Ltd.

Peru.—Tin mine output continued the pattern of steady increases of recent years, and Peru maintained its position as the major supplier of tin concentrates to the United States. The San Rafael Mine, owned by Minsur S.A., was the only tin mine. Situated near Juliaca, the mine was within the northern extension of the Bolivian tin belt. The mine reported tin grades of 1.8%.

South Africa, Republic of.—Gold Fields of South Africa Ltd. was the parent firm of two moderate-sized tin producers, Rooiberg Tin Ltd. and Union Tin Mines Ltd. Both firms reported declining ore grades, currently about 0.4% tin. Zaaiplaats Tin Mining Co. Ltd. was also a producer.

Thailand.—Billiton Thailand Ltd., owned by the Royal Dutch/Shell Group's Billiton B.V., closed its 10-year-old tin dredging operation at midyear. The firm cited dwindling tin reserves in its Government-owned concession block along Thailand's southern coastline and the Government's refusal to grant it new acreage as the reasons for the closure. In recent years, this operation produced about 1,300 tons of tin concentrates annually. Near yearend, the firm considered a proposal from former employees of the defunct operation to purchase it and restart production with the aid of public capitalization.

Throughout the year, Thai miners protested various Government policies, including the high tin royalty system. In response, the Government suspended the issuance of any new tin mining licenses or concessions to lessen competition and reduced some fees and operational charges to aid the miners.

The country's newest smelter, Siam Charoen Tin Smelting Co. expected to start production during the year. Situated near Bangkok, the plant had an expected 360-ton-per-year capacity to supply the domestic solder, pewter, and bronze market. Thai Pioneer Enterprise Co. Ltd., which closed its 3,600-ton-per-year tin smelter in 1982, was negotiating for financing throughout the year, trying to reopen the smelter. The Thailand Smelting and Refining Co. Ltd., a Billiton subsidiary, operated the country's largest tin smelter, at Phuket, with a 38,000-ton-per-year refined tin capacity. Smuggling continued to be a problem, especially in the Andaman Sea region. The Thai Mining Industry Council estimated that 7,000 tons of tin concentrates were smuggled from the country in 1985. The Government introduced several new antismuggling regulations.

U.S.S.R.—Tin was one of only a few major metals for which the Soviet Union was significantly dependent on imports, although it was an important producer. Tin mining was concentrated in remote eastern parts of the country. The Deputatskiy tin mining and benefication complex in Yakutia was scheduled to commission the first stage of a lode mine and concentrator in the 1986-90 period. In Soviet Central Asia, development of the Sary Ozhaz tin mining complex in Kirgiziya was scheduled for the 1986-90 period.

United Kingdom.—The Rio Tinto Zinc Corp. PLC (RTZ) controlled about 80% of the United Kingdom's tin output through its ownership of the Wheal Jane and the South Crofty Mines in Cornwall. A third major producer, Geevor Tin Mines Ltd., also operated a lode mine in Cornwall. Despite optimistic plans during most of the year to expand and modernize these three old mines, the tin price collapse near yearend made the continued survival of these three high-cost mines questionable.

Zaire.—The major tin producer was Société Minière et Industrielle de Kivu (Sominki) in Kivu. The company was 28% Government-owned and 72% owned by Empain-Schneider Group of France. Tin concentrates were shipped to Europe for smelting. The second largest producer was Société Zairetain, with 50% Government ownership and 50% ownership by Geomines Cie. of Belgium. The third largest producer was Société Minière de Goma (SMOG) 20% Government-owned and 80% owned by the Bureau de Recherches Géologiques et Minières.

Table 12.—Tin: World mine production, by country[1]

(Metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina	413	304	291	274	270
Australia	12,267	12,126	[2]9,275	7,699	7,000
Bolivia	29,830	26,773	25,278	19,911	18,000
Brazil	[r]8,297	[r]8,218	13,275	19,957	22,000
Burma	1,438	1,681	1,642	2,028	[3]1,751
Cameroon	[r]21	15	([4])	14	15
Canada	239	135	141	217	250
China[e]	15,000	15,000	15,000	15,000	15,000
Czechoslovakia[e]	[r]300	[r]200	[r]250	[r]250	250
German Democratic Republic[e]	1,600	1,700	1,800	1,800	1,800
Indonesia	35,392	33,806	26,553	23,223	[3]22,115
Japan	561	529	600	485	[3]510
Korea, Republic of	--	--	--	19	--
Laos	255	302	359	430	540
Malaysia	59,938	52,342	41,367	41,307	[3]36,884
Mexico	28	27	334	416	400
Namibia	1,228	1,326	[e]1,400	906	[3]987
Niger	55	36	40	76	50
Nigeria	3,172	2,355	1,560	1,700	1,700
Peru	1,519	1,672	2,368	2,991	[3]3,807
Portugal	506	410	347	[e]350	360
Rwanda	1,790	1,655	1,526	1,561	1,200
South Africa, Republic of	2,811	3,035	2,668	2,301	[3]2,194
Spain	564	518	444	438	[3]465
Tanzania	9	9	6	[r] [e]6	6
Thailand	31,474	26,109	19,943	21,920	20,000
Uganda	([5])	[r]4	[r]25	[r]25	25
U.S.S.R.[e]	[r]21,000	[r]21,000	[r]22,000	[r]23,000	23,000
United Kingdom	3,869	4,208	4,025	5,216	5,300
United States	W	W	W	W	W
Vietnam[e]	[3]380	[r]500	550	500	600
Zaire[6]	[r]2,452	[r]2,320	2,163	2,708	2,870
Zambia[e]	--	10	22	[3]4	4
Zimbabwe[e]	1,600	1,600	1,650	1,700	1,750
Total	[r]238,008	[r]219,925	196,902	198,432	191,103

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Contained tin basis. Data derived in part from the Monthly Statistical Bulletin of the International Tin Council, London. Table includes data available through June 17, 1986.
[2]Excludes tin content of copper-tin cathodes.
[3]Reported figure.
[4]Revised to "Not available" as available general information is inadequate to determine a reliable estimate of output level, if any.
[5]Revised to zero.
[6]Nonduplicated total of content of concentrate plus smelter production.

Table 13.—Tin: World smelter production, by country[1]

(Metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina[e]	200	200	[r]200	[r]200	200
Australia	4,286	3,105	2,913	2,899	[2]2,683
Belgium	65	--	--	--	--
Bolivia	20,005	19,032	14,164	15,842	12,000
Brazil	7,789	9,298	12,950	18,887	21,000
China[e]	15,000	15,000	15,000	15,000	15,000
Czechoslovakia[3]	289	295	307	425	430
German Democratic Republic[e]	[r]1,500	2,000	2,000	2,000	2,000
Germany, Federal Republic of	1,815	608	417	[e]400	400
Indonesia	32,519	29,755	28,390	22,467	21,200
Japan	1,315	1,296	1,260	1,354	[2]1,391
Malaysia[4]	70,326	62,836	53,338	46,911	47,000
Mexico[5]	838	944	1,216	1,531	1,500
Netherlands	3,500	2,800	5,398	6,517	5,500
Nigeria	2,486	2,754	1,190	[e]1,300	1,400
Portugal	900	400	200	[e]180	200
Rwanda	--	908	1,110	[r] [e]1,000	800
South Africa, Republic of	2,602	2,884	2,685	1,592	[2]1,366
Spain	4,400	3,700	3,700	3,500	3,500
Thailand	32,626	25,497	18,467	19,979	19,000

See footnotes at end of table.

Table 13.—Tin: World smelter production, by country[1] —Continued

(Metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
U.S.S.R.[e]	[r]23,000	[r]24,000	[r]24,000	[r]25,000	25,000
United Kingdom	[r]6,863	[r]8,164	6,467	6,830	7,200
United States[6]	2,000	3,500	2,500	4,000	3,000
Vietnam	--	[e]475	520	[e]475	570
Zaire	450	352	201	170	150
Zimbabwe	1,157	1,197	1,235	1,210	1,225
Total	[r]235,931	[r]221,000	199,828	199,669	193,715

[e]Estimated. [p]Preliminary. [r]Revised.

[1]Data derived in part from the Monthly Statistical Bulletin of the International Tin Council, London. Output reported throughout is primary tin only unless otherwise specified. Table includes data available through June 17, 1986.

[2]Reported figure.

[3]May include secondary tin.

[4]Includes small production of tin from smelter in Singapore.

[5]Primarily from imported tin concentrate.

[6]Includes tin content of alloys made directly from ores.

TECHNOLOGY

Advances continued to be made in high-speed, high-quality wave soldering techniques and machinery to meet the rapidly changing needs of the printed circuit board industry. Wave soldering involved carriage of the printed circuit board by linear conveyor through a fluxing stage to ensure solder wetting, a preheating stage to evaporate flux solvent and lessen subsequent thermal shock, and a soldering stage where the board passes over a molten solder wave made by continuously pumping solder up through a slot. Most recent developments occurred in Europe. A significant innovation was the development of a machine that permitted wave soldering of surface-mounted components fixed to the underside of a printed circuit board, by double wave systems.[3]

Because of concerns about the harmful effects of lead, lead-free solders have become increasingly used, especially for plumbing applications. These solders were generally tin-rich solders, such as 97% tin-3% copper or 97% tin-3% silver, utilized as capillary plumbing solders. Studies by the British Association for Brazing and Soldering illustrated that capillary plumbing joint strengths of lead-free solders at ambient temperatures and at 100° C are equal to or greater than those of leaded solders.[4]

A new compact machine was developed that used centrifugal force in combination with room-temperature vulcanizing silicones to create a combination mold making and casting machine. The machine could encourage growth of pewter usage.[5]

The industrial use of sintered stainless steel reportedly was restricted by the poor corrosion resistance of the materials in comparison to the wrought counterpart. A new alloy was developed that utilized 304-L stainless steel powder with additions of either 2% tin or 2% nickel plus 2% copper plus 1% tin. The resulting alloy exhibited significantly improved corrosion resistance.[6]

A technique of electrolytic bronzing of aluminum was developed that used tin electrolytes. The process was reportedly providing harder anodic films and less spalling than conventional bronzing methods.[7]

There are many applications requiring a fast, efficient method of joining copper conductors. A machine was developed to join insulated magnet wire to tinned wire and required no prior removal of the wire's insulation or additional filler metals to form a valid joint.[8]

In the field of tin-canned foods, a new procedure was found to expedite processing. High vacuum flame sterilization of particulate foods was a high temperature, quick-processing method that rolled preheated canned products on tracks over gas burners. Results claimed include better retention of original product quality, providing canned fruits and vegetables with color, taste, and texture very close to those of fresh. In addition, omission of most or all of the traditional covering liquid reduced pack weight, and thus ultimately could lead to smaller cans.[9]

Also in the field of tin cans, a processing innovation called Pressure Fresh was announced. This was a system that combined deoxygenation in the can with the injection of liquid nitrogen to extend shelf life and preserve color and flavor of canned juices. In the process, oxygen levels were reduced from 9 parts per million to less than 1 part per million, and eventually could eliminate the need for tin coating the inside of citrus juice containers.[10]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Can Manufacturer's Institute. Metal Can Shipments Report 1985. Washington, DC, 1985, p. 3.
[3]Tin and Its Uses. No. 148, 1986, pp. 4-9.
[4]Pages 13-15 of work cited in footnote 3.
[5]Pages 15-17 of work cited in footnote 3.
[6]Page 17 of work cited in footnote 3.
[7]Tin and Its Uses. No. 146, 1985, pp. 10-13.
[8]———. No. 145, 1985, pp. 15-16.
[9]Tin News. Tin-Novations. V. 34, No. 7, July 15, 1985, p. 4.
[10]Work cited in footnote 9.

Titanium

By Langtry E. Lynd[1] and Ruth A. Hough[2]

Domestic production of ilmenite, rutile, and synthetic rutile increased in 1985. Consumption of titanium concentrates also increased, and production and consumption of titanium dioxide (TiO_2) pigment reached new record-high levels, reflecting continued strength in the homebuilding industry. Domestic production and consumption of titanium sponge and ingot declined somewhat, but net shipments of mill products were up slightly. During the year, there were a number of changes and proposed changes in the ownership of domestic sponge metal producers. Prices of titanium concentrates generally increased because of the high demand for TiO_2 pigment. Titanium sponge metal prices were lower because of relatively low demand and the availability of considerable excess production capacity in both the United States and Japan. Titanium dioxide pigment prices increased, reaching new high levels by yearend.

Domestic Data Coverage.—Consumption data for titanium raw materials are developed by the Bureau of Mines from a voluntary domestic survey. Of the 38 operations to which a survey request was sent, 95% responded, representing 99.86% of the consumption of ilmenite, rutile, and titanium slag shown in tables 1 and 7. Consumption for the two nonrespondents was estimated using reported prior year consumption levels.

Table 1.—Salient titanium statistics

(Short tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Ilmenite concentrate:					
Mine shipments	523,681	233,063	W	W	W
Value thousands	$37,013	$19,093	W	W	W
Imports for consumption	236,217	348,366	259,328	409,605	506,804
Consumption	856,116	583,250	730,578	783,391	756,071
Titanium slag:					
Imports for consumption	268,825	247,845	138,708	209,839	291,828
Consumption	252,826	225,541	166,401	200,858	252,027
Rutile concentrate, natural and synthetic:					
Imports for consumption	202,373	163,325	111,578	180,508	179,663
Consumption	285,371	238,937	265,558	317,902	305,278
Sponge metal:					
Imports for consumption	6,490	1,354	1,199	[1]2,667	[1]1,717
Consumption[e]	31,599	17,328	16,072	24,713	21,606
Price, Dec. 31, per pound	$7.65	$5.55	$5.55	$5.55	$3.50-$4.00
Titanium dioxide pigment:					
Production	761,190	659,710	760,385	[r]834,889	848,627
Imports for consumption	124,906	138,922	174,857	193,501	196,213
Consumption, apparent[2]	806,040	741,065	853,008	[r]916,198	969,663
Price, Dec. 31, cents per pound:					
Anatase	69.0	69.0	69.0	69.0	72.0
Rutile	75.0	75.0	75.0	75.0	78.0
World: Production:					
Ilmenite concentrate	[r]4,020,733	[r]3,338,674	[3]2,948,100	[p] [3]3,401,503	[e] [3]3,654,210
Rutile concentrate, natural[3]	[r]398,673	[r]373,449	342,081	[p]387,872	[e]401,900
Titaniferous slag	1,244,864	1,157,445	1,160,000	[p]1,260,000	[e]1,410,000

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Excludes sponge imported by the General Services Administration (GSA) for the national stockpile.
[2]Apparent consumption equals production plus imports minus exports minus stock increase.
[3]Excludes U.S. production data to avoid disclosing company proprietary data.

Legislation and Government Programs.—The Government's National Defense Stockpile goal for titanium sponge metal remained at 195,000 tons.[3] The Government stockpile inventory in December contained 25,965 tons of specification metal, including the 4,500 tons of sponge contracted for by the General Services Administration in 1983, of which 139 tons was added to inventory in 1984, and 4,361 tons in 1985. The stockpile also contained 10,866 tons of nonspecification material.

The Government stockpile goal for rutile was unchanged at 106,000 tons. The total rutile stockpile inventory at yearend was 39,186 tons.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, goals for titanium would be 3,900 tons in tier I and 21,100 tons in tier II. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

A final dumping margin of nearly 84% was found by the U.S. Department of Commerce on 150,000 pounds of sponge imported from the U.S.S.R. between August 1, 1982, and July 31, 1983. This decision means that the importers of that sponge will be assessed antidumping duties amounting to 83.96% of the price paid, and that future imports of sponge from the U.S.S.R. will be subject to a deposit equivalent to the antidumping margin, until publication of the findings for the next annual review period, August 1, 1983, to July 31, 1984. No U.S. imports for consumption of titanium sponge from the U.S.S.R. have been reported since the third quarter of 1983.

A U.S. Geological Survey press release on June 28, 1985, reported on potentially significant concentrations of ilmenite and zircon in offshore deposits 5 to 10 miles off the southeastern coast from Georgia to Virginia. Concentrations in some areas were at least 3% to 10% heavy minerals, compared with 3% to 5% heavy minerals in typical commercial onshore deposits. However, more work will be required to determine what commercial potential the deposits may have.

DOMESTIC PRODUCTION

Concentrates.—U.S. producers of ilmenite were Associated Minerals (USA) Ltd. Inc. (AMU) at Green Cove Springs, FL, and E. I. du Pont de Nemours & Co. Inc. at Starke and Highland, FL.

As in 1984, AMU was the only producer of natural rutile concentrate. Kerr-McGee Chemical Corp. continued production of synthetic rutile at its 100,000-ton-per-year Mobile, AL, plant.

Ferrotitanium.—Ferrotitanium was produced by Ashland Chemical Co., Columbus, OH; Reactive Metals and Alloys Corp., West Pittsburg, PA; and Shieldalloy Corp., Newfield, NJ. Most of the production consisted of the 70% titanium grades.

Metal.—RMI Co., Niles, OH, the second largest U.S. titanium producer, built a $4 million welded-tube mill in an effort to expand the sales of its titanium mill products to the nonaerospace market. Tube sales for heat exchangers, water desalination equipment, and chemical processing systems were seen by RMI executives as the largest potential growth area for commercially pure titanium in the next decade. Initial capacity of about 1 million pounds per year of welded tubing was planned.

Wyman-Gordon Co., Worcester, MA, took over management of titanium sponge producer International Titanium Inc. (ITI), Moses Lake, WA, by increasing its holding in ITI to 80% from 41% at an additional cost of $8.4 million after investing $12.3 million in the company in 1984. Nearly all of the remaining shares in ITI are held by Mitsui & Co. Ltd. of Japan. Wyman-Gordon indicated it planned to become an integrated titanium producer and to expand later into titanium mill products, and earlier in the year had offered to purchase all of the shares of ITI held by Mitsui and Ishizuka Research Inc. of Japan; Titanium Industries Inc., Fairfield, NJ; and ITI founder Stephen

Yih.

Oregon Metallurgical Corp. was purchased by Owens-Corning Fiberglas Corp. as part of the sale of Armco Inc.'s aerospace and strategic materials group that included Ladish Co., a maker of forgings for aerospace and other industries, and HITCO Materials Div., a producer of high-performance composite materials for aerospace, defense, marine, and other applications. The sale was part of an Armco plan to sell up to $800 million of assets to reduce debt.

Titech International Inc., Pomona, CA, reportedly was investing $300,000 in a new vacuum annealing furnace and an expansion of its investment casting area, to be in operation by yearend. The company's total sales increased from $7 million to over $10 million in 1985, but growth in sales was expected to level off somewhat, with investment casting demand rising faster than that for rammed graphite castings.

A new company, the ALTA Group, Evans City, PA, was formed by three former employees of the TIMET Div. of Titanium Metals Corp. of America (TMCA), and began commercial production of high-purity titanium, primarily for use in the electronics industry. ALTA uses a molten-salt-bath electrolytic plating process, originally developed by the Bureau of Mines, in producing pure titanium in crystal, powder, or mill product form. The high-purity titanium product may be used in a variety of electronic, prosthetic, or corrosion-resistant applications, where standard titanium is not effective.[4]

Plans for a leveraged buyout of the TIMET Div. of TMCA by a TIMET management group were terminated. Allegheny International Inc. and NL Industries Inc., joint owners of TMCA, said that although the outlook for the titanium metal market is bright, they will continue to seek a buyer for TIMET in accordance with their strategy to divest themselves of companies outside their core businesses. TIMET executives and Kelso & Co., New York, which was arranging financing for the leveraged buyout in return for a share in the company, entered into an agreement to purchase TIMET at yearend 1984, but the management group reportedly was unable to arrange financing, partly because of lower-than-anticipated projected sales volume and profits for the division.

Cabot Corp. announced plans to sell most of its alloys and metal businesses because they were not meeting the company's financial performance objectives. The divestiture included its High Technology Materials Div., which produced titanium flat-rolled products and superalloys at its Kokomo, IN, plant and titanium tubing at its Arcadia, LA, plant. Cabot began producing flat-rolled titanium products at Kokomo in 1982, and had also planned to install titanium melting capacity at that location.

Colt Industries Inc. reportedly planned to sell its Crucible units, including Crucible Specialty Metals Div., which manufactured titanium rod, bar, and wire, as well as high-temperature alloys and other materials. The sale was to be a leveraged buyout by a management and employee group.

Table 2.—Production and mine shipments of ilmenite concentrate[1] from domestic ores in the United States

Year	Production, gross weight (short tons)	Shipments: Gross weight (short tons)	Shipments: TiO_2 content (short tons)	Shipments: Value (thousands)
1981	542,357	523,681	310,854	$37,013
1982	263,391	233,063	145,725	19,093
1983	W	W	W	W
1984	W	W	W	W
1985	W	W	W	W

W Withheld to avoid disclosing company proprietary data.
[1]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

Table 3.—U.S. titanium metal production capacity in 1985

Company	Ownership	Plant location	Capacity (short tons)	
			Sponge	Ingot
Howmet Corp., Titanium Ingot Div.	Pechiney, France	Whitehall, MI	--	5,000
International Light Metals Corp	Martin Marietta Corp., 60%; Nippon Kokan K.K., 40%.	Torrance, CA	--	6,000
International Titanium Inc	Wyman-Gordon Co., 80%; Mitsui & Co. Ltd., Japan, nearly 20%.	Moses Lake, WA	2,500	--
A. Johnson Metals Corp	Axel Johnson Group, Stockholm, Sweden.	Lionville, PA	--	[1]1,500
Lawrence Aviation Industries Inc.	Self	Port Jefferson, NY	--	1,500
Oregon Metallurgical Corp	Owens-Corning Fiberglas Corp., 80%; public, 20%	Albany, OR	4,500	8,000
RMI Co	United States Steel Corp., 50%; National Distillers & Chemical Corp., 50%.	Ashtabula, OH	9,500	--
		Niles, OH	--	18,000
Teledyne Allvac	Teledyne Inc	Monroe, NC	--	4,000
Teledyne Wah Chang Albany	do	Albany, OR	1,500	1,000
Titanium Metals Corp. of America.	NL Industries Inc., 50%; Allegheny International Inc., 50%.	Henderson, NV	14,000	17,000
Viking Metallurgical Corp	Quanex Corp	Verdi, NV	--	[1]5,000
Western Zirconium Inc	Westinghouse Electric Corp	Ogden, UT	500	500
Wyman-Gordon Co	Self	Worcester, MA	--	2,500
Total			32,500	70,000

[1]Single melt only; commercially pure ingot and slab.

Pigment.—Titanium dioxide pigment production increased for the third consecutive year, and in 1985 was about 93% of nominal capacity. Modifications of existing plants were in progress to increase capacity utilization and ease the tight supply situation that has resulted from record-high demand.

Kemira Oy of Finland purchased American Cyanamid Co.'s TiO_2 pigment plant at Savannah, GA, for about $100 million. The purchase brought Kemira's total capacity to nearly 200,000 tons per year, making Kemira the world's fifth largest TiO_2 producer.

Table 4.—Components of U.S. titanium metal supply and demand

(Short tons)

Component	1981	1982	1983	1984	1985
Production:					
Sponge	[1]26,400	[1]15,600	13,966	24,326	23,257
Ingot	46,236	26,536	26,439	39,964	35,902
Exports:					
Sponge	58	36	39	171	51
Other unwrought	257	173	258	204	179
Scrap	3,280	4,287	5,379	4,109	6,760
Ingot, slab, sheet bar, etc	4,203	2,196	1,371	2,071	2,248
Other wrought	1,846	1,404	783	778	1,146
Total	9,644	8,096	7,830	7,333	10,384
Imports:					
Sponge	6,490	1,354	1,199	[2]2,667	[2]1,717
Scrap	3,787	1,277	1,572	1,850	2,134
Ingot and billet	244	212	81	176	179
Mill products	1,116	870	935	840	1,449
Total[3]	11,637	3,713	3,788	5,533	5,478
Stocks, yearend:					
Government: Sponge (total inventory)	32,331	32,331	32,331	32,470	36,831
Industry:					
Sponge[e]	3,720	3,350	3,136	3,147	4,755
Scrap[e]	10,484	11,073	12,635	12,489	11,686
Ingot	3,592	2,534	3,273	4,526	4,000
Other	7	3	22	18	34
Total industry	17,803	16,960	19,066	20,180	20,475

See footnotes at end of table.

Table 4.—Components of U.S. titanium metal supply and demand —Continued

(Short tons)

Component	1981	1982	1983	1984	1985
Reported consumption:					
Sponge[e]	31,599	17,328	16,072	24,713	21,606
Scrap[e]	14,795	8,528	10,467	15,549	14,720
Ingot	[r]43,795	27,580	26,232	39,062	37,174
Mill products (net shipments)[4]	25,492	18,281	15,949	22,808	23,253
Castings (shipments)[4]	209	260	240	268	411

[e]Estimated. [r]Revised.
[1]Calculated sponge metal production equals sponge consumption minus sponge imports plus sponge exports and adjustments for Government and industry stock changes.
[2]Excludes sponge imported by the General Services Administration (GSA) for the national stockpile.
[3]Data may not add to totals shown because of independent rounding.
[4]Bureau of the Census, Current Industrial Reports, Ser. DIB-991 and ITA-991.

Table 5.—Capacities of U.S. titanium dioxide pigment plants on December 31, 1985

Company and plant location	Pigment capacity (short tons per year)	
	Sulfate process	Chloride process
E. I. du Pont de Nemours & Co. Inc.:		
Antioch, CA	--	35,000
De Lisle, MS	--	150,000
Edge Moor, DE	--	110,000
New Johnsonville, TN	--	228,000
Kemira Inc., Savannah, GA	64,000	46,000
Kerr-McGee Chemical Corp., Hamilton, MS	--	63,000
SCM Corp., Glidden Pigments Group:		
Ashtabula, OH	--	98,000
Baltimore, MD	66,000	50,000
Total	130,000	780,000

Table 6.—Components of U.S. titanium dioxide pigment supply and demand

(Short tons unless otherwise specified)

Component	1981 (gross weight)	1982 (gross weight)	1983		1984		1985	
			Gross weight	TiO_2 content	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Production	761,190	659,710	760,385	707,158	[r]834,889	[r]777,031	848,627	788,961
Shipments:[1]								
Quantity	778,116	707,075	813,958	762,818	905,383	844,901	950,637	884,758
Value thousands	$947,881	$927,517	$950,515	$950,515	$1,106,898	$1,106,898	$1,275,131	$1,275,131
Exports	61,104	72,823	91,702	83,372	106,124	96,740	101,954	92,434
Imports for consumption	124,906	138,922	174,857	[e]162,600	193,501	[e]180,091	196,213	182,417
Stocks, yearend	102,189	86,933	77,465	[e]72,035	83,533	[e]77,744	56,756	53,765
Consumption, apparent[2]	806,040	741,065	853,008	[e]791,816	[r]916,198	[e]854,673	969,663	902,923

[e]Estimated. [r]Revised.
[1]Includes interplant transfers.
[2]Apparent consumption equals production plus imports minus exports minus stock increase.

Sources: Bureau of the Census and Bureau of Mines.

CONSUMPTION AND USES

Concentrates.—The total domestic consumption of titanium in concentrates increased about 2%. Slight decreases in consumption of ilmenite and rutile were more than offset by a 25% increase in titanium slag consumption.

Metal.—Demand for titanium was relatively soft for both aerospace and other industrial applications, and consumption of sponge and ingot decreased, although net mill product shipments were up slightly. Mill product shipments were 55% in the form of billet; 30% sheet, strip, plate, tubing, pipe, extrusions, and other; and 15% rod and bar.

Bar and billet were the major forms used for aircraft engines and airframes, while the other forms were used mainly for nonaerospace industrial applications. Mill product usage was estimated to be 75% for aerospace and 25% for other industrial applications.

Current use of titanium in large commercial aircraft represents about 6% of empty aircraft weight. Titanium is utilized where high-strength toughness, heat resistance, and high structural efficiency are required. Typical military aircraft uses are for A-10 ballistic armament; structural forgings and wing skins for F-14 and F-15 aircraft; rotor parts for helicopter blade systems; B-1B fracture-critical forgings and wing support sections; and rotor discs, blades, and compressor blades on various engines. Major nonaerospace industrial uses are those requiring superior resistance to corrosion, such as surface condensers in powerplants, heat exchangers, and chemical industry equipment.

The Titanium Development Association (TDA) continued its efforts on the dissemination of information about titanium applications and potential new markets for titanium. One example of such activities was the production of a 4-foot-high model of an offshore oil rig highlighting current and potential areas of titanium use, including compressor coolers, desalination units, and seawater intake piping and valves. The model was displayed at the Offshore Technology Conference in Houston, TX, in May 1985.

Pigment.—Consumption of TiO_2 pigments rose to a new peak for the third consecutive year, because of continued economic expansion and increased demand from the homebuilding industry. The proportion of shipments used for paper and plastics increased, with corresponding decreases in the remaining categories.

Ferrotitanium.—Consumption of ferrotitanium and titanium scrap in steel and other alloys decreased, mainly because of lower steel production.

Table 7.—U.S. consumption of titanium concentrates

(Short tons)

Year	Ilmenite[1]		Titanium slag		Rutile (natural and synthetic)[2]	
	Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]
1981	856,116	511,022	252,826	186,020	285,371	266,596
1982	583,250	352,393	225,541	168,433	238,937	225,113
1983	730,578	474,285	166,401	127,267	265,558	250,418
1984:						
Alloys and carbide	(3)	(3)	(4)	(4)	--	--
Pigments	775,477	492,658	200,858	152,534	245,927	231,808
Welding-rod coatings and fluxes	(3)	(3)	--	--	4,165	3,911
Miscellaneous[5]	7,914	6,319	--	--	67,810	62,920
Total	783,391	498,977	200,858	152,534	317,902	298,639
1985:						
Alloys and carbide	(3)	(3)	(4)	(4)	--	--
Pigments	747,897	474,561	252,027	199,610	254,837	239,893
Welding-rod coatings and fluxes	(3)	(3)	--	--	5,192	4,881
Miscellaneous[5]	8,174	6,450	--	--	45,249	41,714
Total	756,071	481,011	252,027	199,610	305,278	286,488

[e]Estimated.
[1]Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2]Includes synthetic rutile made in the United States.
[3]Included with "Miscellaneous" to avoid disclosing company proprietary data.
[4]Included with "Pigments" to avoid disclosing company proprietary data.
[5]Includes ceramics, chemicals, glass fibers, and titanium metal.

Table 8.—U.S. distribution of titanium pigment shipments, titanium dioxide content, by industry

(Percent)

Industry	1981[r]	1982[r]	1983[r]	1984[r]	1985
Paint, varnish, lacquer	47.0	48.1	48.9	54.8	54.3
Paper	25.9	27.4	27.3	19.9	20.5
Plastics (except floor covering and vinyl-coated fabrics and textiles)	12.4	12.7	13.2	15.4	16.2
Rubber	2.4	2.6	1.8	2.0	1.7
Printing ink	1.4	1.0	1.1	1.2	1.0
Ceramics	1.5	1.2	1.0	1.0	.7
Other	9.4	7.0	6.7	5.7	5.6
Total	100.0	100.0	100.0	100.0	100.0

[r]Revised.

Table 9.—U.S. consumption of titanium products[1] in steel and other alloys

(Short tons)

	1981	1982	1983	1984	1985
Carbon steel	641	420	744	659	483
Stainless and heat-resisting steel	1,552	1,289	1,748	1,851	2,104
Other alloy steel (includes HSLA)	903	664	749	677	491
Tool steel	W	W	W	W	W
Total steel[2]	3,096	2,373	3,241	3,187	3,078
Cast irons	63	47	38	62	23
Superalloys	645	409	535	622	657
Alloys, other than above	254	200	252	473	357
Miscellaneous and unspecified	26	10	12	18	18
Total consumption	4,084	3,039	4,078	4,362	4,133

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Includes ferrotitanium containing 20% to 70% titanium and titanium metal scrap.
[2]Excludes data withheld and unspecified; included under "Miscellaneous and unspecified."

STOCKS

The total TiO_2 content of industry stocks of concentrates increased 23% from the yearend 1984 level. The largest increase was in stocks of titanium slag, which rose about 31,000 tons, or 60%. The overall increase in concentrate stocks in 1985 followed rather substantial usage from stocks in 1983 and 1984.

Table 10.—U.S. stocks of titanium concentrates and pigment, December 31

(Short tons)

	Gross weight	TiO_2 content[e]
Ilmenite:[1]		
1983	398,884	254,237
1984[r]	201,091	128,507
1985	237,430	147,357
Titanium slag:[1]		
1983	78,378	61,026
1984[r]	66,599	52,397
1985	105,919	83,711
Rutile:[1]		
1983	130,035	122,189
1984[r]	102,128	96,186
1985	115,973	109,319
Titanium pigment:[2]		
1983	77,465	72,000
1984	83,533	77,700
1985	56,756	52,800

[e]Estimated. [r]Revised.
[1]Producer, consumer, and dealer stocks.
[2]Bureau of the Census. Producer stocks only.

PRICES

Concentrates.—Published prices of titanium concentrates were generally higher by the end of 1985. However, published list prices of domestic ilmenite and rutile, in other than bulk lots, were suspended the entire year.

Metal.—Reported sales prices on sponge were lower by yearend. Prices on Japanese sponge under contract and spot prices were not published during 1985.

Pigment.—List prices for titanium dioxide pigment remained unchanged until the fourth quarter of 1985 when they increased 3 cents per pound and closed the year at the higher rate. Because of the high demand, there was very little discounting of list prices.

Table 11.—Published prices of titanium concentrates and products

		1984[1]	1985
Concentrates:			
Ilmenite, f.o.b. eastern U.S. ports	per metric ton	$70.00-$75.00	(2)
Ilmenite, f.o.b. Australian ports	do	36.00- 38.00	$38.00-$42.00
Ilmenite, large lots, bulk, f.o.b. U.S. east coast	do	44.00- 45.00	50.00- 56.00
Rutile, f.o.b. eastern U.S. ports	per short ton	460.00-490.00	(2)
Rutile, bagged, f.o.b. Australian ports	do	339.00-359.00	371.00-386.00
Rutile, bulk, f.o.b. Australian ports	do	319.00-335.00	315.00-328.00
Rutile, large lots, bulk, f.o.b. U.S. east coast	do	320.00-340.00	350.00-360.00
Synthetic rutile, f.o.b. Mobile, AL	do	350.00	350.00
Titanium slag, 80% TiO_2, f.o.b. Sorel, Quebec[e]	per metric ton	185.00	196.00
Titanium slag, 85% TiO_2, f.o.b. Richards Bay, Republic of South Africa[e]	do	200.00	212.00
Metal:			
Sponge, reported sales	per pound	4.00- 4.25	3.50- 4.00
Sponge, Japanese, under contract, c.i.f. U.S. ports, including import duty	do	No quotation	No quotation
Mill products:			
Bar	do	r9.77	9.77
Billet	do	r8.35	8.35
Plate	do	r10.64	10.64
Sheet	do	r12.73	12.73
Strip	do	r13.45	13.45
Pigment:			
Titanium dioxide pigment, f.o.b. U.S. plants, anatase	do	.69	.72- .73
Titanium dioxide pigment, f.o.b. U.S. plants, rutile	do	.75	.78

[e]Estimated. [r]Revised.
[1]Yearend.
[2]List price suspended effective Jan. 1, 1985.

Sources: American Metal Market, Industrial Minerals (London), Metals Week, and industry contacts.

FOREIGN TRADE

Exports of TiO_2 pigments decreased for the first time since 1980, while imports of pigment continued the upward trend that began in 1981.

Substantial increases in exports of most titanium metal categories occurred during 1985. Exports of sponge metal decreased 70%, and imports of sponge dropped 36%.

Imports of ilmenite, slag, and synthetic rutile increased 24% to 50%, much more than offsetting the 7% decrease in imports of natural rutile.

Table 12.—U.S. exports of titanium products, by class

Class	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Concentrates:						
Ilmenite	865	$26	3,807	$151	--	--
Rutile	3,526	980	4,844	1,784	27,759	$6,953
Total	4,391	1,006	8,651	[1]1,936	27,759	6,953
Metal:						
Sponge	39	203	171	967	51	338
Other unwrought	258	1,896	204	1,224	181	2,604
Scrap	5,379	7,074	4,109	7,168	6,760	14,533
Ingots, billets, slabs, etc	1,371	29,232	2,071	40,993	2,248	40,942
Other wrought	783	22,965	778	20,509	1,147	29,481
Total	7,830	61,370	7,333	70,861	[1]10,388	87,898
Pigment and oxides:						
Titanium dioxide pigments	91,702	86,900	106,124	97,804	101,954	108,384
Titanium compounds, except pigment-grade	1,819	5,232	2,123	5,024	1,247	4,486
Total	93,521	92,132	108,247	102,828	103,201	112,870

[1]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 13.—U.S. imports for consumption of titanium concentrates, by country

Concentrate and country	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Ilmenite:						
Australia	259,328	$9,262	409,605	$11,063	506,539	$14,060
Indonesia	--	--	--	--	265	530
Total	259,328	9,262	409,605	11,063	506,804	14,590
Titanium slag:						
Canada	127,691	18,533	160,155	25,081	195,230	36,350
South Africa, Republic of	11,016	1,628	49,685	7,702	96,598	15,881
Total[1]	138,708	20,161	209,839	32,783	291,828	52,231
Rutile, natural:						
Australia	80,096	16,450	93,871	25,046	66,055	19,062
Canada	--	--	219	55	258	43
Sierra Leone	--	--	48,436	13,326	32,994	10,822
South Africa, Republic of	10,817	3,365	15,939	2,674	44,146	10,094
Other	79	21	--	--	3,150	488
Total[1]	90,992	19,836	158,465	41,100	146,602	40,509
Rutile, synthetic:						
Australia	11,118	1,767	22,043	3,810	33,061	3,458
France	127	111	--	--	--	--
Japan	617	235	--	--	--	--
Taiwan	8,723	1,583	--	--	--	--
Total[1]	20,586	3,696	22,043	3,810	33,061	3,458
Titaniferous iron ore:[2]						
Canada	2,124	107	1,966	77	858	38

[1]Data may not add to totals shown because of independent rounding.
[2]Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel furnace flux.

Source: Bureau of the Census. Data adjusted by the Bureau of Mines.

Table 14.—U.S. imports for consumption of titanium dioxide pigments, by country

Country	1983		1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	5,591	$5,824	5,277	$5,398	5,285	$5,967
Belgium-Luxembourg	14,456	11,287	10,840	9,824	16,459	15,508
Canada	25,563	27,396	26,212	29,388	26,658	30,019
Finland	4,829	4,678	6,079	5,954	5,799	6,200
France	31,195	30,032	47,801	45,107	39,379	42,167
Germany, Federal Republic of	36,659	35,804	34,980	34,156	39,723	38,955
Italy	1,223	1,082	1,078	1,032	1,520	1,855
Japan	4,888	4,870	4,546	4,900	5,378	6,267
Mexico	67	61	1,668	1,201	3,289	4,050
Netherlands	254	211	189	198	1,238	1,120
Norway	6,428	5,638	6,931	6,304	6,978	5,968
South Africa, Republic of	--	--	--	--	551	634
Spain	23,006	18,784	22,129	20,863	21,283	23,659
United Kingdom	19,761	19,135	22,847	20,857	21,242	22,880
Yugoslavia	155	115	2,597	1,447	516	508
Other[1]	r781	r577	r329	r322	913	1,054
Total[2]	174,857	165,495	193,501	186,952	196,213	206,809

rRevised.
[1]Includes Algeria, Austria, Brazil, China, Denmark, Dominican Republic, Hong Kong, India, Ireland, the Republic of Korea, Macao, Poland, Singapore, Sweden, Switzerland, and Taiwan, in one or more of these years.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 15.—U.S. imports for consumption of titanium metal, by class and country

Class and country	1983		1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Unwrought: Sponge:						
China	1	$4	--	--	--	--
Japan	976	6,761	[1]2,662	$15,789	[1]1,689	$10,007
Korea, Republic of	--	--	--	--	28	156
U.S.S.R	193	913	--	--	--	--
United Kingdom	30	177	[1]5	26	([2])	1
Total[3]	1,199	7,856	[1]2,667	15,815	[1]1,717	10,164
Ingot and billet:						
Canada	7	102	6	62	29	247
China	--	--	([2])	1	--	--
France	--	--	38	162	([2])	15
Germany, Federal Republic of	19	405	30	561	46	844
Japan	44	546	77	1,327	101	950
U.S.S.R	4	38	--	--	--	--
United Kingdom	6	133	26	328	2	49
Other	([2])	4	([2])	5	([2])	26
Total[3]	81	1,228	176	2,447	179	2,131
Waste and scrap:						
Austria	39	55	217	390	--	--
Belgium	66	89	28	11	47	61
Canada	451	2,240	190	320	117	155
China	22	19	68	168	372	839
France	62	95	149	451	122	498
Germany, Federal Republic of	166	365	294	851	87	316
Japan	44	130	117	522	352	1,175
Sweden	90	168	100	301	90	311
Switzerland	117	184	--	--	162	318
U.S.S.R	--	--	90	270	78	194
United Kingdom	463	1,036	544	2,215	595	2,001
Other	52	80	53	202	111	207
Total[3]	1,572	4,461	1,850	5,703	2,134	6,075

See footnotes at end of table.

Table 15.—U.S. imports for consumption of titanium metal, by class and country —Continued

Class and country	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Wrought titanium:						
Canada	317	$5,219	212	$3,701	390	$6,293
Germany, Federal Republic of	(2)	2	6	140	(2)	18
Japan	605	8,842	529	6,091	987	13,128
United Kingdom	8	258	68	1,130	55	1,254
Other	5	33	25	441	18	345
Total[3]	935	14,354	840	11,504	1,449	21,038

[1]Excludes sponge imported by GSA for the national stockpile.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

World production of titanium concentrates rose for the second consecutive year because of the continued increase in TiO_2 pigment production and demand. World prices of concentrates and pigment increased in response to the high demand. World demand for TiO_2 pigment in 1985 was about 2.6 million tons.

Titanium sponge metal production in the market economy countries rose to about 49,000 tons because of increased production in Japan, despite somewhat reduced output in the United States and the United Kingdom.

Australia.—Australia again was the largest producer of titanium minerals with exports of ilmenite, in order of decreasing volume, mainly to the United States, the United Kingdom, Spain, the U.S.S.R., Japan, Brazil, and France, and exports of rutile, in order of decreasing volume, mainly to the United States, the United Kingdom, and Japan.

Because of strong demand for ilmenite, rutile, monazite, and zircon, the Australian mineral sands industry planned to increase its production capacity of mineral sands and synthetic rutile. Mineral Deposits Ltd. planned to begin a new operation in August that would bring its production rate to 33,000 tons per year each of rutile and zircon by early 1986. In August-September 1985, TiO_2 Corp. was introduced as a major new mineral sands operator on Australia's west coast and by 1988, planned to exploit deposits acquired from Western Mining Corp. at Cooljarloo and Jurien Bay north of Perth. Westralian Sands Ltd. planned to build a 110,000-ton-per-year synthetic rutile plant at Capel, Western Australia, by mid-1987. Associated Minerals Consolidated Ltd. (AMC) was to add to its existing synthetic rutile capacity of 66,000 tons per year, at Capel, by building a 120,000-ton-per-year plant near Geraldton, Western Australia, also to be completed in 1987. Total Australian synthetic rutile capacity by 1987 was thus expected to increase from the current level of 66,000 tons per year to about 300,000 tons per year.

Du Pont reportedly agreed to sell its 50% share in Allied Eneabba Ltd., a producer of ilmenite and zircon in Western Australia, to Renison Goldfields Consolidated Ltd. Renison's subsidiary, AMC, is Australia's largest producer of ilmenite, with mining and processing operations in the Eneabba and Perth areas.

Belgium.—Inco Ltd. reportedly reached an agreement for Inco Alloy Products Ltd. (IAPL) to acquire a $2.5 million share in Titech Europe, a titanium castings company that was in receivership following the withdrawal of the parent company, Titech International Inc. A new company was to be formed, jointly owned by IAPL (60%) and the Walloon regional development authority, known as the Société Regionale d'Investissement de Wallonie (40%), according to reports. An extensive program of capital investment and research and development was planned to increase the product range of the new company, to be known as the Société de Technologie du Titane et des Alliages Speciau.

Brazil.—Du Pont was considering a joint venture with Cia. Vale do Rio Doce (CVRD), owned by the Government of Brazil, to construct a 66,000-ton-per-year TiO_2 pigment plant in Brazil. CVRD would supply Du Pont with 220,000 tons per year of anatase concentrates from a $100 million plant that CVRD was to begin building in 1985 in the State of Minas Gerais, and Du Pont would supply technology for producing TiO_2 pigment from the anatase concentrates. The TiO_2 plant would also cost about $100 million and begin production in 1989. CVRD reportedly began operation of a 15,000-ton-per-year pilot plant to produce anatase concentrates in 1983.[5]

International Minerals & Chemical Corp. (IMC), Northbrook, IL, reportedly signed a letter of intent with the Goiás State government indicating the company's interest in investing in a titanium concentrate plant that would be built in Catalao, Goiás, in the next 2 years. The proposed agreement tentatively called for IMC to invest up to $200 million in a plant with an estimated capacity of 330,000 tons per year of anatase concentrate containing up to 90% TiO_2. The project would be in a new market area for IMC, which is a major worldwide supplier of fertilizers, ferroalloys, and industrial minerals. Anatase ore reserves are controlled by a Brazilian State company, Metais de Goiás S.A., and would be leased to IMC for 25 years.[6]

Canada.—NL Industries planned to build a 40,000-ton-per-year chloride-process TiO_2 plant at Varennes, Quebec, to be completed by mid-1987 at a cost of $50 million. NL Industries' subsidiary, NL Chem Canada Ltd., operates a 40,000-ton-per-year sulfate-process TiO_2 plant at Varennes.

Chemetics International Co., North York, Ontario, announced a project for recovering spent acid from sulfate-process TiO_2 production. Chemetics, Tioxide Canada Inc. (Dorval, Quebec), NL Chem Canada, and QIT-Fer et Titane Inc. (Sorel, Quebec) agreed in principle to build a unit for processing 110 tons per day of waste acid at Tioxide Canada's Tracy, Quebec, TiO_2 plant. The process, reportedly patented by Chemetics, involves total evaporation of sulfuric acid in strong acid waste, followed by separation of the solid metal sulfates from the vapor phase, and production of 93% to 96% sulfuric acid by partial condensation.[7]

China.—China reportedly contracted to buy a vacuum arc melting furnace for the manufacture of titanium ingots. The furnace was to be installed in the Baoji metal plant in Shaanxi Province, to improve quality as well as increasing output to 1,300 tons per year.

Finland.—The Otanmaki underground mine, operated by Rautaruukki Oy, was closed in April 1985 because of high operating costs. Besides ilmenite, the mine produced magnetite, pyrite, and vanadium pentoxide.

Germany, Federal Republic of.—NL Industries began operation of its new 44,000-ton-per-year chloride-process TiO_2 plant at Leverkusen, which replaces some of its older sulfate-process capacity at that location. NL Industries' total annual TiO_2 production capacity in the Federal Republic of Germany was about 88,000 tons of chloride-process and 40,000 tons of sulfate-process capacity at Leverkusen, and 66,000 tons of sulfate-process capacity at Nordenham. The company planned to build acid recycling plants for both the Nordenham and Leverkusen facilities by 1989, the year permission was scheduled to end for dumping waste acid into the North Sea.

India.—Mining was scheduled to begin in 1985 at the Orissa Sands Complex. Indian Rare Earths Ltd. planned to mine 3.2 million tons of raw sand annually to provide 240,000 tons of ilmenite, 33,000 tons of sillimanite, 11,000 tons of rutile, 4,000 tons of monazite, and 2,000 tons of zircon.[8]

Italy.—Elettrochimica Marco Ginatta (EMG) reportedly was building a 1,300-ton-per-year electrolytic process titanium sponge, crystals, and powder plant in Trieste, in partnership with Instituto par la Reconstruzione Industriale, the state holding company that owns the major steel company, Finanziaria Siderurgica S.p.A. EMG hoped to have the plant in production by early 1987 and was also seeking partners for a 10,000-ton-per-year titanium sponge plant elsewhere in Europe.[9]

Japan.—Toho Titanium Co. Ltd. expanded its ingot capacity to about 9,000 tons per year from 3,300 tons per year, through the purchase of a new vacuum arc melting furnace from Consarc Corp., Rancocas, NJ. In December 1985, Toho was planning to start deliveries of titanium ingots weighing 16.5 tons.

Total annual Japanese sponge production capacity at yearend was about 34,800 tons, distributed among the four producers as follows: Osaka Titanium Co. Ltd., 17,000 tons; Toho, 13,200 tons; Nippon Soda Co. Ltd., 2,400 tons; and Showa Titanium Co. Ltd., 2,200 tons.

In November, Osaka and Nippon Soda reportedly reduced their production rates because of lower-than-expected demand from the aerospace industry and a drop in sales prices of about 20% caused by the increased strength of the Japanese yen relative to the U.S. dollar. However, Toho and Showa continued to operate at levels reached earlier in the year, so that overall utilization of Japan's sponge capacity in the fourth quarter was about 62%. Total 1985 titanium sponge production in Japan was 24,500 tons.

Norway.—The Central Bureau of Statistics estimated Norway's titanium reserves to be sufficient for 60 years of operation at the current production rate, indicating total reserves of 49 million tons of ilmenite concentrate containing about 22 million tons of TiO_2. The K/S Ilmenittsmelteverket A/S (KSI) plant, being built in Tyssedal to smelt 385,000 tons per year of ilmenite and recover 220,000 tons per year of 75% TiO_2 slag, was expected to start trial runs in September 1986 and be in full production in 1987. KSI is a limited partnership between state-owned DNN Industries A/S (83.3%), Kronos Titan A/S (7.5%), Titania A/S (7.5%), and shipowner Atle Jebsen (1.67%). Estimated total cost of the project was about $160 million.[10]

Saudi Arabia.—A private sector Saudi industrial group, IDI Ltd., was planning to build a 55,000-ton-per-year TiO_2 plant at Al-Jubail on the Persian Gulf. The plant probably would use chloride-process technology and would cost about $140 million. The plant would supply domestic and export markets.[11]

South Africa, Republic of.—Richards Bay Minerals planned to spend about $68 million over the next 2 years to expand its heavy minerals mining and smelting operations in the Republic of South Africa. The smelter capacity reportedly will be increased 50% to about 720,000 tons per year of 85% TiO_2 slag by building a third furnace.

Taiwan.—Du Pont obtained permission from the Government of Taiwan to build a 66,000-ton-per-year TiO_2 pigment plant. Estimated cost of the plant was about $150 million, with a 1988 startup date. Du Pont estimated that worldwide TiO_2 demand was growing at 1.5% per year, but that demand in the Asian-Pacific and Latin American regions was growing at double that rate.

U.S.S.R.—Production of titanium sponge metal was estimated to be 47,000 tons. Annual production capacity was estimated to be about 53,000 tons. Imports of ilmenite from Australia declined 40% to 69,000 tons.

United Kingdom.—In September, Billiton (UK) Ltd. sold its 62.5% share of Deeside Titanium Ltd. to Rolls Royce Ltd., bringing Rolls Royce's share in Deeside to 82.5%. IMI Titanium Ltd. owns the remaining 17.5%. Deeside was reportedly operating its 5,500-ton-per-year sponge plant at a 1,500-ton-per-year rate, the estimated level required to supply the needs of Rolls Royce.

Table 16.—Titanium: World production of concentrates (ilmenite, leucoxene, rutile, and titaniferous slag), by country[1]

(Short tons)

Concentrate type and country	1981	1982	1983	1984[p]	1985[e]
Ilmenite and leucoxene:[2]					
Australia:					
Ilmenite	1,456,303	1,266,788	987,900	1,260,224	1,380,000
Leucoxene	21,232	21,758	14,725	17,509	19,000
Brazil	[r]17,478	[r]12,480	33,568	45,134	50,000
China[e]	150,000	150,000	154,000	154,000	154,000
Finland	178,023	184,968	180,669	[e]184,000	150,000
India[3]	179,141	[r]168,585	148,234	154,323	187,000
Malaysia[4]	190,432	111,556	245,509	259,025	303,000
Norway	[r]727,088	608,215	612,826	729,027	810,500
Portugal	[r]441	[r]645	298	181	160
Sri Lanka	88,197	75,268	90,145	112,489	110,000
Thailand	41	20	226	591	550
U.S.S.R.[e]	470,000	475,000	480,000	485,000	490,000
United States[5]	542,357	263,391	W	W	W
Total	[r]4,020,733	[r]3,338,674	2,948,100	3,401,503	3,654,210
Rutile:					
Australia	254,432	243,277	174,404	200,048	225,000
Brazil	[r]190	[r]258	510	454	500
India[3]	7,397	[r]6,374	[r] [e]6,100	[r] [e]6,600	7,700
Sierra Leone[6]	55,992	52,590	79,146	100,641	89,000
South Africa, Republic of[e]	55,000	52,000	62,000	62,000	61,000
Sri Lanka	14,662	7,950	8,921	7,129	7,700

See footnotes at end of table.

Table 16.—Titanium: World production of concentrates (ilmenite, leucoxene, rutile, and titaniferous slag), by country[1] —Continued

(Short tons)

Concentrate type and country	1981	1982	1983	1984[p]	1985[e]
Rutile —Continued					
U.S.S.R.[e]	11,000	11,000	11,000	11,000	11,000
United States	W	W	W	W	W
Total	[r]398,673	[r]373,449	342,081	387,872	401,900
Titaniferous slag:					
Canada[7]	836,864	737,445	700,000	800,000	930,000
South Africa, Republic of[e 8]	408,000	420,000	460,000	460,000	480,000
Total	1,244,864	1,157,445	1,160,000	1,260,000	1,410,000

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Table excludes production of unbeneficiated anatase ore in Brazil, in short tons, as follows: 1981—3,208,185; 1982—3,136,054; 1983—2,610,028; 1984—2,943,538; and 1985—3,000,000 (estimated). This material reportedly contains 20% TiO_2. Table includes data available through June 24, 1986.

[2]Ilmenite is also produced in Canada and in the Republic of South Africa, but this output is not included here because an estimated 90% of it is duplicative of output reported under "Titaniferous slag," and the rest is used for purposes other than production of titanium commodities, principally as steel furnace flux and heavy aggregate.

[3]Data are for fiscal year beginning Apr. 1 of year stated.

[4]Exports.

[5]Includes a mixed product containing ilmenite, leucoxene, and rutile.

[6]Contains 96% TiO_2.

[7]Contained 72% TiO_2 in 1981-82, 74% TiO_2 in 1983, and 80% TiO_2 in 1984-85.

[8]Contains 85% TiO_2.

TECHNOLOGY

The Bureau of Mines issued a report on contract research in which engineering profiles and cost data were obtained on foreign titanium mineral properties. Capital and operating costs were estimated for all reported currently operating and potential future projects in market economy countries.[12] The Bureau also investigated the recovery of titanium from perovskite ($CaTiO_3$) concentrates by using sulfuric acid-$CaTiO_3$ reactions at atmospheric pressure. Under some conditions, over 98% of the titanium was rapidly converted to water-soluble sulfates.[13] A U.S. patent was developed based on this work.[14] In other Bureau research, titanium diboride (TiB_2) was used as a 0% to 12% stoichiometric constituent of an iron-base alloy system being investigated as a potential replacement for cobalt-base alloys for some uses. A range of TiB_2 contents resulting in most promising properties was determined for further research.[15]

New evidence was published indicating that the Trail Ridge mineral sands deposit in Florida formed mainly as a great sand dune or dune complex, rather than as a beach deposit, as previously thought. The new evidence, consisting of high-angle crossbeds diagnostic of an aeolian dune environment, was revealed in 1968 and again in 1985 when the dredge pond at Du Pont's mining operation was lowered to reach some deep ore. The high water table had previously prevented direct examination of the ore structure. Since exploration for heavy minerals in the Southeastern United States has been aimed almost entirely at ancient shoreline placers, some dune deposits may have been overlooked.[16]

The role of titanium minerals and pigments in welding fluxes was discussed in an article examining the industrial minerals used for coated electrodes, flux-cored wires, and granular fluxes. A description of relevant welding processes was included.[17]

U.S. Navy officials reported that the *Sea Cliff*, one of the Navy's three Turtle class deep-diving submarines, had made an ocean dive of 20,000 feet off the coast of Central America. The 31-foot *Sea Cliff* had been refitted with a special titanium hull and silver-zinc batteries, allowing independent operation at 20,000 feet for more than 16 hours. The original design of the Turtle class submarines specified a standard operating depth of 6,500 feet.[18]

Recognizing the need for a single, comprehensive, concise, up-to-date source book on titanium, TDA published in book form a compilation of articles on various aspects of titanium technology. Most of these articles have already appeared in print, mainly in the "Journal of Metals." However, a major new chapter was included on the history of titanium, written especially for this book.[19]

In response to a need for improved performance of gas turbine aircraft engines, the U.S. Air Force worked on projects that could result in radically new materials for engine components. An important part of the Air Force Wright Aeronautical Materials Laboratory program at Wright-Patterson Air Force Base, Dayton, OH, is to develop low-density, high-strength, and high-temperature titanium alloys, using rapid solidification technology. Significant quantities of rapidly solidified titanium may be produced by a melt spinning technique by the end of 1986. Low density may be achieved by alloying with lithium, beryllium, or silicon, and the Air Force applied for a patent on such a process. An Air Force objective is to use new high-temperature alloys in a new fighter aircraft engine in 1992.[20] Development of such improved alloys is expected to increase titanium demand in the 1990's.

The properties and advantages of patented Lockheed Missiles and Space Co. titanium alloys Transage 175, (2.7Al-13V-7Zn-2Zr) and Transage 134 (2.5Al-12V-2Sn-6Zr) were described. In aerospace applications tests, Transage 175, a high-temperature alloy, was used to produce jet engine components that were found to be structurally superior to components made with the standard Ti-6Al-4V alloy and were lower cost. Transage 134 is a high-strength alloy that can be press forged at temperatures as low as 1,200° F, compared with 1,650° F to 1,800° F for the Ti-6Al-4V alloy.[21]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Mineral data assistant, Division of Nonferrous Metals.
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Tungsten

By Philip T. Stafford[1]

Consumption of tungsten concentrate decreased 20% and imports fell 18% from those of 1984. Mine shipments decreased 16% from those of 1984, remaining lower than those of any year since 1934. Prices of concentrate from domestic mines remained at a relatively low level, decreasing 19% from those of 1984.

More than 95% of domestic production came from three mining operations in California and Colorado. Most mines, mills, and ammonium paratungstate (APT) plants were closed all or part of the year.

Domestic Data Coverage.—Domestic production data for tungsten are developed by the Bureau of Mines by means of three separate, voluntary surveys. These surveys are "Tungsten Ore and Concentrate," "Tungsten Concentrate and Tungsten Products," and "Tungsten Concentrate." Of the 43 operations to which surveys were sent, all responded, representing 100% of the total production shown in table 1.

Table 1.—Salient tungsten statistics

(Metric tons of tungsten content unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Concentrate:					
Mine production	3,605	1,521	980	1,203	996
Mine shipments	3,545	1,575	1,016	1,173	983
Value thousands	$62,231	$22,062	$10,528	$13,409	$9,143
Consumption	9,839	4,506	5,181	8,577	6,838
Shipments from Government stocks	958	344	259	1,368	902
Exports	79	305	1	129	124
Imports for consumption	5,331	3,528	2,861	5,807	4,746
Stocks, Dec. 31:					
Producer	108	54	47	46	60
Consumer	671	1,765	1,085	959	1,077
Ammonium paratungstate:					
Production	8,855	4,914	5,021	7,339	6,527
Consumption	9,165	5,873	5,655	8,808	7,941
Stocks, Dec. 31: Producer and consumer	699	748	970	1,191	1,056
Primary products:					
Production	9,960	6,441	6,020	9,799	8,219
Consumption	9,613	6,349	6,523	10,216	8,096
Stocks, Dec. 31:					
Producer	1,472	1,477	1,433	1,850	1,968
Consumer	936	933	1,446	1,585	1,206
World: Concentrate:					
Production	r50,269	r46,921	40,821	p46,478	e46,989
Consumption	r47,986	r42,170	42,705	p50,072	e47,298

eEstimated. pPreliminary. rRevised.

Legislation and Government Programs.—The General Services Administration (GSA) Office of Stockpile Transactions continued to sell excess stockpiled tungsten concentrate on the basis of monthly sealed bids. Regular offerings of excess concentrate were made at the disposal rate of 136,078 kilograms of tungsten content per month, of which 102,058 kilograms was for domestic use and 34,020 kilograms was for export. Additionally, supplemental offerings were made at the rate of 90,719 kilograms per month, of which 68,039 kilograms was for domestic use and 22,680 kilograms was for export. As a result of the regular and supplemental offerings, concentrate sales totaled 694,370 kilograms of tungsten, of which 611,587 kilograms was for domestic use and 82,783 kilograms was for export.

Actual shipment of excess concentrate from the stockpile totaled 902,401 kilograms of tungsten content in concentrate.

All stockpile sales of tungsten concentrate were discontinued as of October 1 until further notice because the transaction fund had reached its legal limit ceiling of $250 million. Hence, no sales were made after September.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, tungsten would be categorized in tier II, and the goal would be 23,682 metric tons of tungsten metal equivalent. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

Table 2.—U.S. Government tungsten stockpile material inventories and goals

(Metric tons of tungsten content)

Material	Goals	Inventory by program, Dec. 31, 1985		
		National stockpile	DPA[1] inventory	Total
Tungsten concentrate:				
Stockpile grade	25,152	24,670	72	24,742
Nonstockpile grade	--	11,846	46	11,892
Total	25,152	36,516	118	36,634
Ferrotungsten:				
Stockpile grade	--	381	--	381
Nonstockpile grade	--	537	--	537
Total[2]	--	919	--	919
Tungsten metal powder:				
Stockpile grade	726	711	--	711
Nonstockpile grade	--	150	--	150
Total	726	861	--	861
Tungsten carbide powder:				
Stockpile grade	907	871	--	871
Nonstockpile grade	--	51	--	51
Total	907	922	--	922

[1]Defense Production Act (DPA) of 1950.
[2]Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

Mine production and shipments decreased 17% and 16%, respectively, compared with those of 1984. Production totaled 996 metric tons of tungsten content in 1984, the smallest amount since 1934, except for 1983. Shipments totaled 983 tons, the smallest amount since 1934. Although four mines in two Western States reported production, three mines provided more than 95% of the domestic tungsten production. No mine operated continuously. However, the Strawberry Mine and mill of Teledyne Tungsten, a subsidiary of Telédyne Inc., near North Fork, Madera County, CA, produced tungsten concentrate except during the winter, when it was closed owing to weather conditions.

The Climax Mine and mill of Climax Molybdenum Co., a division of AMAX Inc., at Climax, CO, produced tungsten at one-quarter capacity for most of the year. The Climax Mine, in Lake County, principally produces molybdenum.

The Pine Creek Mine and APT plant of Umetco Minerals Corp., a subsidiary of Union Carbide Corp., near Bishop, CA, was closed or operated at a reduced capacity during most of the year.

Table 3.—Tungsten concentrate shipped from mines in the United States

Year	Quantity		Reported value, f.o.b. mine[1]		
	Metric ton units of WO_3[2]	Tungsten content (metric tons)	Total (thousands)	Average per unit of WO_3	Average per kilogram of tungsten
1981	447,028	3,545	$62,231	$139.21	$17.55
1982	198,652	1,575	22,062	111.06	14.00
1983	128,130	1,016	10,528	82.17	10.36
1984	147,958	1,173	13,409	90.63	11.43
1985	123,944	983	9,143	73.77	9.30

[1]Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2]A metric ton unit equals 10 kilograms of tungsten trioxide (WO_3) and contains 7.93 kilograms of tungsten.

Table 4.—Major producers of tungsten concentrate and principal tungsten processors in the United States in 1985

Company	Location of mine, mill, or processing plant
Producers of tungsten concentrate:	
Climax Molybdenum Co., a division of AMAX Inc	Climax, CO.
Teledyne Tungsten	North Fork, CA.
Umetco Minerals Corp., a subsidiary of Union Carbide Corp	Bishop, CA.
Processors of tungsten:	
AMAX Inc., AMAX Metals Group	Fort Madison, IA.
Fansteel Inc	North Chicago, IL.
General Electric Co	Euclid, OH, and Detroit, MI.
GTE Products Corp	Towanda, PA.
Kennametal Inc	Latrobe, PA, and Fallon, NV.
North American Philips Lighting Corp	Bloomfield, NJ.
Teledyne Firth Sterling	Pittsburgh, PA.
Teledyne Wah Chang Huntsville	Huntsville, AL.

CONSUMPTION

Domestic consumption of tungsten in primary products decreased 20% from that of 1984. The major end use, 62% of the total, continued to be in cutting and wear-resistant materials, primarily as tungsten carbide. Other end uses were mill products, 23%; specialty steels, 5%; and miscellaneous, including superalloys, welding and hard-facing rods, chemical and ceramic uses, and other tungsten materials, 10%.

Consumption of tungsten products used directly to make end-use items was distributed as follows: tungsten carbide powder, 63%; tungsten metal powder, 24%; scheelite, 5%; tungsten scrap, 3%; ferrotungsten, 2%; and other, 3%.

Table 5.—Production, disposition, and stocks of tungsten products in the United States in 1985

(Metric tons of tungsten content)

	Hydrogen-reduced metal powder	Tungsten carbide powder		Chemicals	Other[1]	Total
		Made from metal powder	Crushed and crystalline			
Gross production during year	7,269	3,883	800	2,413	65	14,430
Used to make other products listed here	3,911	6	126	2,168	--	6,211
Net production	3,358	3,877	674	245	65	8,219
Producer stocks, Dec. 31	839	622	362	120	25	1,968

[1]Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, and self-reducing oxide pellets.

Table 6.—Consumption and stocks of tungsten products in the United States in 1985, by end use

(Metric tons of tungsten content)

End use	Ferro-tungsten	Tungsten metal powder	Tungsten carbide powder	Scheelite (natural, synthetic)	Tungsten scrap[1]	Other tungsten materials[2]	Total
Steel:							
Stainless and heat-resisting	34	--	--	42	W	W	76
Alloy	19	--	--	W	W	W	19
Tool	122	--	--	204	W	W	326
Superalloys	W	W	W	W	W	13	13
Alloys (excludes steels and superalloys):							
Cutting and wear-resistant materials	--	W	5,033	--	W	W	5,033
Other alloys[3]	W	7	W	--	5	W	12
Mill products made from metal powder	--	1,858	W	--	--	W	1,858
Chemical and ceramic uses	--	--	--	--	--	85	85
Miscellaneous and unspecified	4	86	55	125	276	128	674
Total	179	1,951	5,088	371	281	226	8,096
Consumer stocks, Dec. 31, 1985	36	31	990	28	61	60	1,206

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Does not include that used in making primary tungsten products.
[2]Includes melting base, self-reducing tungsten, tungsten chemicals, and others.
[3]Includes welding and hard-facing rods and materials and nonferrous alloys.

PRICES

The average value of tungsten concentrate shipped from domestic mines and mills, as reported to the Bureau of Mines, decreased 19% to $73.77 per metric ton unit of WO_3, compared with the 1984 value. Excess tungsten concentrate was purchased from GSA during the year at prices ranging from $56.24 to $76.35 per metric ton unit for domestic use and from $61.16 to $67.52 per metric ton unit for export.

The following price quotations showed similar price trends: European prices of tungsten concentrate as reported in Metal Bulletin of London, the U.S. spot quotations as reported in Metals Week, and the International Tungsten Indicator. Differences in the monthly and annual averages resulted from differences between the scheelite and wolframite concentrate prices for the same period of time. For 1985, prices decreased 17%, compared with those for 1984.

Prices for intermediate products were not announced because of their competitiveness.

Table 7.—Monthly price quotations of tungsten concentrate in 1985

Month	Metal Bulletin (London), scheelite, European market, 70% WO_3 basis[1]				Metal Bulletin (London), wolframite, European market, 65% WO_3 basis[2]				Metals Week, U.S. spot quotations, 65% WO_3 basis, c.i.f. U.S. ports[3]				International Tungsten Indicator, weighted average price,[4] 60% to 79% WO_3	
	Dollars per metric ton unit			Dollars per short ton unit	Dollars per metric ton unit			Dollars per short ton unit	Dollars per short ton unit			Dollars per metric ton unit		
	Low	High	Average	Average	Low	High	Average	Average	Low	High	Average	Average	Dollars per metric ton unit	Dollars per short ton unit
January	79.63	82.63	81.13	73.60	66.38	71.38	68.88	62.49	60.00	70.00	65.38	72.06	80.61	73.13
February	79.00	82.00	80.50	73.03	71.00	75.00	73.00	66.22	61.00	69.50	66.50	73.30	76.16	69.09
March	79.00	82.00	80.50	73.03	73.78	77.67	75.73	68.70	66.00	70.00	67.75	74.68	77.70	70.49
April	77.50	80.50	79.00	71.67	72.63	76.13	74.38	67.48	63.50	69.00	67.13	73.99	76.86	69.73
May	74.88	78.13	76.51	69.40	65.75	70.25	68.00	61.69	57.00	66.00	62.20	68.56	77.57	70.37
June	69.38	73.75	71.57	64.92	59.75	66.13	62.94	57.10	55.00	63.00	59.00	65.04	73.16	66.37
July	69.00	74.00	71.50	64.86	60.33	68.78	64.56	58.56	52.50	59.00	55.75	61.45	69.79	63.31
August	69.00	75.00	72.00	65.32	64.50	70.63	67.57	61.29	54.00	66.00	61.40	67.68	69.68	63.21
September	69.00	75.00	72.00	65.32	66.13	72.25	69.19	62.77	59.00	67.50	64.06	70.62	68.29	61.95
October	67.89	74.00	70.94	64.36	62.56	69.89	66.22	60.08	56.00	62.50	59.25	65.31	70.28	63.76
November	65.56	71.67	68.62	62.25	58.67	66.56	66.62	56.80	53.00	61.50	57.45	63.33	68.99	62.59
December	62.00	70.00	66.00	59.87	55.86	63.86	59.86	54.30	48.00	59.00	53.88	59.39	68.60	62.23

[1]Low and high prices are reported semiweekly. Monthly averages are arithmetic averages of semiweekly low and high prices. The average price per metric ton unit of WO_3, which is an average of all semiweekly low and high prices, was $74.03 for 1985. The average equivalent price per short ton unit of WO_3 was $67.16 for 1985.

[2]Low and high prices are reported semiweekly. Monthly averages are arithmetic averages for semiweekly low and high prices. The average price per metric ton unit of WO_3, which is an average of all semiweekly low and high prices, was $67.61 for 1985. The average equivalent price per short ton unit of WO_3 was $61.33 for 1985.

[3]Low and high prices are reported weekly. Monthly averages are arithmetic averages of weekly low and high prices. The average price per short ton unit of WO_3, which is an average of all weekly low and high prices, excluding duty, was $61.69 for 1985. The average equivalent price per metric ton unit of WO_3 was $68.00 for 1985.

[4]Weighted average price per metric ton unit of WO_3 was $73.10 for 1985. The equivalent weighted average price per short ton unit of WO_3 was $66.31 for 1985.

FOREIGN TRADE

Exports of tungsten in concentrate and primary products increased 58% from 1,700 tons in 1984 to 2,692 tons in 1985. Imports decreased 12%, from 8,092 tons in 1984 to 7,118 tons in 1985. Tungsten in concentrate had a net import decrease of 19%, from 5,678 to 4,622 tons, but tungsten in ammonium tungstate had a net import increase of 10%, from 1,164 to 1,279 tons. Other tungsten intermediate products had a net export increase of 229%, from 451 to 1,485 ounces.

Table 8.—U.S. exports of tungsten ore and concentrate, by country

	1984		1985	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Austria	29	$279	1	$15
Brazil	25	161	--	--
France	6	93	--	--
Germany, Federal Republic of	48	571	10	85
Ireland	(1)	3	--	--
Japan	--	--	40	290
Mexico	21	133	18	108
Netherlands	--	--	54	323
U.S.S.R.	--	--	1	9
United Kingdom	--	--	(1)	1
Total	129	1,240	124	831

[1]Less than 1/2 unit.

Source: Bureau of the Census.

Table 9.—U.S. exports of ammonium paratungstate, by country

Country	1984			1985		
	Gross weight (metric tons)	Tungsten content[1] (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content[1] (metric tons)	Value (thousands)
Australia	(2)	(2)	$1	--	--	--
Belgium-Luxembourg	--	--	--	37	26	$411
Canada	3	2	39	12	8	133
France	2	1	9	1	1	9
Germany, Federal Republic of	1	1	9	1	1	25
Japan	(2)	(2)	5	--	--	--
Mexico	--	--	--	5	4	51
Netherlands	--	--	--	22	15	251
Singapore	--	--	--	(2)	(2)	1
South Africa, Republic of	5	4	56	--	--	--
United Kingdom	--	--	--	24	17	278
Total	11	8	119	102	72	1,159

[1]Tungsten content estimated by multiplying gross weight by 0.7066.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

Table 10.—U.S. exports of tungsten carbide powder, by country

Country	1984 Tungsten content (metric tons)	1984 Value (thousands)	1985 Tungsten content (metric tons)	1985 Value (thousands)
Argentina	8	$285	(1)	$11
Australia	2	161	3	87
Austria	48	973	32	787
Belgium-Luxembourg	15	396	25	511
Brazil	7	198	14	451
Canada	121	2,671	143	3,437
Denmark	8	205	8	297
Finland	1	27	10	174
Germany, Federal Republic of	38	902	71	1,629
India	1	48	5	117
Ireland	11	1,185	5	337
Israel	(1)	4	135	2,246
Italy	48	1,715	40	1,524
Japan	61	1,193	18	346
Mexico	14	439	17	627
Netherlands	6	367	15	640
Peru	--	--	1	15
Philippines	6	18	--	--
Singapore	2	47	--	23
South Africa, Republic of	--	--	19	428
Sweden	(1)	1	3	38
Switzerland	--	--	10	189
United Kingdom	49	1,496	63	1,299
Venezuela	2	54	1	17
Other	(1)	r30	23	504
Total	448	12,415	661	15,734

rRevised.
[1]Less than 1/2 unit.

Source: Bureau of the Census.

Table 11.—U.S. exports of tungsten and tungsten alloy powder, by country

Country	1984 Gross weight (metric tons)	1984 Tungsten content[1] (metric tons)	1984 Value (thousands)	1985 Gross weight (metric tons)	1985 Tungsten content[1] (metric tons)	1985 Value (thousands)
Australia	7	6	$121	--	--	--
Austria	23	19	400	23	19	$525
Belgium-Luxembourg	5	4	109	6	5	135
Brazil	3	2	67	5	4	129
Canada	20	16	497	17	14	486
Finland	4	3	69	6	5	112
Germany, Federal Republic of	98	78	2,471	121	97	3,071
Ireland	4	3	104	1	1	27
Israel	520	416	8,880	1,172	937	21,567
Italy	(2)	(2)	1	4	3	260
Japan	61	49	1,834	12	10	496
Mexico	2	2	56	7	5	179
Netherlands	242	193	2,218	338	270	4,443
Singapore	3	3	64	6	4	101
Switzerland	1	1	62	21	17	222
United Kingdom	23	18	279	15	12	385
Other	r4	r3	r97	57	46	1,193
Total	1,020	816	17,329	1,811	1,449	33,331

rRevised.
[1]Tungsten content estimated by multiplying gross weight by 0.80.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials

Product and country	1984		1985	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Tungsten and tungsten alloy wire:				
Argentina	1	$369	(1)	$209
Brazil	7	1,161	5	879
Canada	19	3,179	22	3,561
France	2	356	1	238
Germany, Federal Republic of	7	1,462	6	1,601
Hong Kong	1	108	1	209
India	3	261	3	355
Italy	2	431	2	339
Japan	9	1,229	4	916
Korea, Republic of	2	297	3	339
Mexico	10	1,258	6	1,248
Poland	3	201	1	118
Taiwan	1	155	2	181
U.S.S.R.	6	446	--	--
United Kingdom	2	505	3	689
Other	2	r1,019	3	1,106
Total	77	12,437	62	11,988
Unwrought tungsten and alloy in crude form, waste, and scrap:				
Australia	7	55	--	--
Austria	77	347	61	487
Belgium-Luxembourg	128	1,106	56	451
Canada	28	422	33	550
Finland	1	19	(1)	4
Germany, Federal Republic of	219	1,611	287	2,099
Ireland	1	30	--	--
Israel	50	987	1	20
Italy	7	130	2	44
Japan	--	--	13	16
Mexico	1	11	(1)	18
Netherlands	28	227	37	303
Saudi Arabia	1	14	1	21
South Africa, Republic of	26	602	--	--
Sweden	2	20	3	83
United Kingdom	29	296	19	222
Other	1	r22	1	12
Total	606	5,899	514	4,330
Other tungsten metal:				
Australia	2	202	1	183
Austria	1	17	(1)	9
Canada	28	1,692	29	2,008
France	5	626	2	668
Germany, Federal Republic of	30	1,178	15	1,275
Italy	2	227	(1)	89
Japan	10	1,679	9	2,584
Mexico	3	260	4	627
Netherlands	--	--	9	177
Singapore	3	106	(1)	6
South Africa, Republic of	--	--	8	41
Sweden	1	49	(1)	4
Switzerland	6	305	1	207
Taiwan	2	150	1	103
United Kingdom	16	1,277	9	1,273
Venezuela	1	31	(1)	3
Other	2	309	1	536
Total	112	8,108	89	9,793
Other tungsten compounds:				
Austria	2	77	(1)	21
Belgium-Luxembourg	(1)	(1)	3	68
Brazil	2	34	4	185
Canada	8	280	7	280
China	--	--	4	52
France	6	152	21	148
Germany, Federal Republic of	4	78	2	126
Haiti	19	60	--	--
Hong Kong	(1)	16	1	42
Ireland	6	148	2	87
Israel	75	1,340	1	52
Italy	2	91	2	107
Japan	10	201	5	179

See footnotes at end of table.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials —Continued

Product and country	1984		1985	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Other tungsten compounds —Continued				
Korea, Republic of	(1)	$2	54	$117
Mexico	13	243	84	605
Netherlands	58	790	33	548
Singapore	11	323	8	299
Sweden	1	21	--	--
United Kingdom	1	25	1	172
Venezuela	1	24	--	--
Other	1	r72	3	110
Total	220	3,977	235	3,198

rRevised.
1Less than 1/2 unit.

Source: Bureau of the Census.

Table 13.—U.S. imports for consumption of tungsten ore and concentrate, by country

Country	1984		1985	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Australia	133	$1,166	414	$3,107
Bolivia	1,302	12,694	627	5,270
Brazil	149	1,309	69	503
Burma	341	2,545	55	643
Canada	1,464	12,645	1,371	10,364
Chile	9	161	--	--
China	31	221	558	3,391
France	16	140	4	36
Germany, Federal Republic of	--	--	24	213
India	7	56	--	--
Japan	10	92	--	--
Korea, Republic of	16	98	--	--
Malaysia	25	214	12	167
Mexico	196	1,610	183	1,325
Peru	605	5,258	282	2,093
Portugal	606	5,504	555	4,525
Rwanda	6	55	9	76
Singapore	13	90	87	797
Spain	22	220	11	124
Thailand	774	7,038	472	3,948
Turkey	51	422	--	--
United Kingdom	25	114	--	--
Zaire	--	--	13	124
Zimbabwe	6	63	--	--
Total	5,807	51,715	4,746	36,706

Source: Bureau of the Census.

Table 14.—U.S. imports for consumption of ammonium tungstate, by country

Country	1984		1985	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Australia	44	$466	--	--
China	720	8,275	1,126	$13,229
Germany, Federal Republic of	26	397	33	449
Hong Kong	24	235	63	1,240
Korea, Republic of	356	3,999	116	1,391
Netherlands	2	42	--	--
Taiwan	--	--	12	132
United Kingdom	(1)	(1)	1	19
Total	1,172	13,414	1,351	16,460

1 Less than 1/2 unit.

Source: Bureau of the Census.

Table 15.—U.S. imports for consumption of ferrotungsten, by country

Country	1984		1985	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Austria	93	$1,135	27	$263
Brazil	26	319	--	--
China	8	90	22	219
France	10	115	--	--
Germany, Federal Republic of	38	425	1	12
Netherlands	8	92	--	--
Portugal	65	803	41	435
Sweden	32	369	2	22
United Kingdom	5	72	--	--
Total	285	3,420	93	951

Source: Bureau of the Census.

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials

Product and country	1984 Tungsten content (metric tons)	1984 Value (thousands)	1985 Tungsten content (metric tons)	1985 Value (thousands)
Other metal-bearing materials in chief value of tungsten:				
Brazil	--	--	4	$24
China	--	--	32	220
Total	--	--	36	244
Waste and scrap containing not over 50% tungsten:				
Canada	1	$5	1	5
France	3	30	(1)	8
Portugal	9	44	--	--
United Kingdom	13	135	--	--
Other	(1)	3	1	7
Total	26	217	2	20
Waste and scrap containing over 50% tungsten:				
Australia	2	23	(1)	5
Belgium-Luxembourg	4	35	2	24
Canada	35	359	23	253
China	18	206	21	231
France	14	148	5	44
Germany, Federal Republic of	240	2,526	27	378
Israel	496	5,716	331	3,550
Japan	6	102	15	237
Mexico	1	9	10	106
Netherlands	131	782	125	617
Singapore	29	636	19	394
South Africa, Republic of	12	122	15	166
Sweden	48	518	12	142
Switzerland	2	31	6	82
Thailand	18	101	--	--
United Arab Emirates	2	17	--	--
United Kingdom	104	898	20	242
Total	1,162	12,229	631	6,471
Unwrought tungsten, except alloys, in lumps, grains, and powders:				
Belgium-Luxembourg	4	50	1	42
China	--	--	5	45
Germany, Federal Republic of	14	431	17	461
Japan	3	79	3	122
Korea, Republic of	3	47	9	174
United Kingdom	2	40	5	37
Other	(1)	21	2	44
Total	26	668	42	925
Unwrought tungsten, ingots, and shot	(1)	5	2	45
Unwrought tungsten, other[2]	(1)	25	1	45
Unwrought tungsten, alloys:				
Austria	14	190	(1)	17
Canada	6	368	2	149
China	38	760	7	184
Germany, Federal Republic of	19	425	17	365
Korea, Republic of	1	25	--	--
Other	(1)	31	(1)	12
Total	78	1,799	26	727
Wrought tungsten:[2]				
Austria	7	542	9	987
Belgium-Luxembourg	12	932	6	501
France	4	28	(1)	110
Israel	--	--	11	390
Japan	9	1,788	25	2,853
United Kingdom	1	61	2	171
Other	r5	r402	3	222
Total	38	3,753	56	5,234
Tungstic acid:				
China	192	1,742	158	1,148
Other	1	10	(1)	1
Total	193	1,752	158	1,149

See footnotes at end of table.

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials —Continued

Product and country	1984 Tungsten content (metric tons)	1984 Value (thousands)	1985 Tungsten content (metric tons)	1985 Value (thousands)
Calcium tungstate:				
Germany, Federal Republic of	6	$236	5	$155
Japan	1	31	(1)	27
Total	7	267	5	182
Potassium tungstate	--	--	2	4
Sodium tungstate:				
China	--	--	131	1,181
Germany, Federal Republic of	(1)	4	2	24
Japan	--	--	17	26
Total	(1)	4	150	1,231
Tungsten carbide:				
Australia	2	24	(1)	7
Austria	1	31	4	115
Belgium-Luxembourg	33	921	37	1,075
Canada	2	74	1	29
China	4	98	50	1,020
Germany, Federal Republic of	317	6,551	257	5,726
Japan	2	53	(1)	6
Korea, Republic of	47	779	39	707
South Africa, Republic of	1	1	--	--
United Kingdom	42	695	31	495
Other	(1)	6	3	75
Total	451	9,233	422	9,255
Other tungsten compounds:				
Canada	1	33	(1)	13
China	--	--	20	256
Other	(1)	18	(1)	33
Total	1	51	20	302
Mixtures, organic compounds, chief value in tungsten:				
Italy	28	51	--	--
Other	r4	r118	7	227
Total	32	169	7	227

rRevised.
1Less than 1/2 unit.
2Estimated from reported gross weight.

Source: Bureau of the Census.

Table 17.—U.S. import duties on tungsten

TSUS No.	Item	Rate of duty effective Jan. 1, 1985	
		Most favored nation (MFN)	Non-MFN
601.54	Tungsten ore	17 cents per pound on tungsten content.	50 cents per pound on tungsten content.
603.45	Other metal-bearing materials in chief value of tungsten.	10 cents per pound on tungsten content and 4.8% ad valorem.	60 cents per pound on tungsten content and 40% ad valorem.
606.48	Ferrotungsten and ferrosilicon tungsten	6.9% ad valorem	35% ad valorem.
629.25	Waste and scrap containing by weight not over 50% tungsten.	5.6% ad valorem	50% ad valorem.
629.26	Waste and scrap containing by weight over 50% tungsten.	4.2% ad valorem	Do.
629.28	Unwrought tungsten, except alloys, in lumps, grains, and powders.	12.1% ad valorem	58% ad valorem.
629.29	Unwrought tungsten, ingots, and shot	7.5% ad valorem	50% ad valorem.
629.30	Unwrought tungsten, other	8.6% ad valorem	60% ad valorem.
629.32	Unwrought tungsten, alloys, containing by weight not over 50% tungsten.	5.3% ad valorem	35.5% ad valorem.
629.33	Unwrought tungsten, alloys, containing by weight over 50% tungsten.	8.6% ad valorem	60% ad valorem.
629.35	Wrought tungsten	8.0% ad valorem	Do.
416.40	Tungstic acid	11.6% ad valorem	55% ad valorem.
417.40	Ammonium tungstate	10.8% ad valorem	49.5% ad valorem.
418.30	Calcium tungstate	10.3% ad valorem	43.5% ad valorem.
420.32	Potassium tungstate	13.8% ad valorem	50.5% ad valorem.
421.56	Sodium tungstate	10.7% ad valorem	46.5% ad valorem.
422.40	Tungsten carbide	11.5% ad valorem	55.5% ad valorem.
422.42	Other tungsten compounds	10.5% ad valorem	45.5% ad valorem.
423.92	Mixtures of two or more inorganic compounds in chief value of tungsten.	do	Do.

WORLD REVIEW

The Committee on Tungsten (COT) of the United Nations Conference on Trade and Development held a meeting in Geneva, Switzerland, during November in an effort to resolve a 22-year deadlock between producing and consuming countries concerning the stabilization of the world tungsten market. No agreement was reached by COT, but a sessional working group reviewed and assessed the current market situation and short-term outlook. Recommendations were made to complete studies of the scrap recycling industry in Japan and the United States, and to update previous studies on pricing indicators and trade in intermediate products.

Australia.—The two main mines in Australia, the King Island scheelite mine of Peko-Wallsend Ltd. and the Mount Carbine Mine of Wolfram Pty. Ltd., produced at about 50% of capacity each because of depressed world tungsten prices. Five of the six smaller Australian mines remained closed.

Canada.—The mine and mill operated by Canada Tungsten Mining Corp. Ltd. at Tungsten, Northwest Territories, produced 2,949 tons of tungsten in concentrate, the most from the mine since 1980 and the most of any mine in the market economy countries during 1985. Its shipments were 2,740 tons. Production capacity is 3,500 tons per year. Ore reserves at a grade of 1.24% totaled 14,000 tons at yearend. A large amount of lower grade ore is also present.

The Mount Pleasant tungsten-molybdenum mine and mill, in Charlotte County, New Brunswick, operated at a reduced capacity until it was forced to close in July because of depressed tungsten prices. The joint venture between Billiton Canada Ltd. and Brunswick Tin Mines Ltd. had an annual production capacity of 1,500 tons of tungsten in concentrate and 600 tons of molybdenite (MoS_2) from a 2,000-ton-per-day mill. Minable ore reserves were placed at 25,000 tons of tungsten in ore, grading 0.39% WO_3 and 0.204% MoS_2.

At yearend, AMAX through its subsidiary, AMAX of Canada Ltd., continued to delay development of the MacTung tungsten deposit near MacMillan Pass along the Yukon-Northwest Territories boundary until world tungsten market conditions improved. Reserves were placed at 57 million tons of ore, grading 0.95% WO_3 or 430,000 tons of tungsten, the largest known deposit in the market economy countries.

[1]Physical scientist, Division of Ferrous Metals.

Table 18.—Tungsten: World concentrate production, by country[1]

(Metric tons of tungsten content)

Country	1981	1982	1983	1984[p]	1985[p]
Argentina	11	17	41	37	36
Australia	3,517	2,618	2,015	1,772	1,912
Austria	[r]1,616	[r]1,465	1,408	1,632	1,565
Bolivia	2,779	2,534	2,449	1,893	1,551
Brazil	1,576	[r]1,524	1,026	1,037	1,175
Burma	825	844	930	1,096	945
Canada	1,993	2,842	328	3,715	3,100
China[e]	13,500	12,500	12,500	13,500	15,000
Czechoslovakia[e]	50	50	50	50	50
France	591	727	832	796	[e]700
India	18	25	15	21	28
Japan	631	604	475	477	526
Korea, North[e]	2,200	2,200	500	1,000	1,000
Korea, Republic of	2,739	2,420	2,480	2,702	2,572
Malaysia	35	43	31	25	[e]20
Mexico	263	194	186	274	291
Mongolia[e]	1,000	1,500	1,500	1,500	1,500
New Zealand	10	7	6	6	5
Peru	521	[r]692	723	754	870
Portugal	1,395	1,358	1,183	1,493	1,751
Rwanda	281	324	231	291	310
Spain	437	545	517	565	530
Sweden	312	268	365	385	388
Thailand	1,209	855	562	741	586
Turkey[e]	153	150	325	350	350
Uganda	1	4	4	[e]4	[e]4
U.S.S.R.[e]	8,850	9,000	9,100	9,100	9,200
United Kingdom	50	--	--	--	--
United States	3,605	1,521	980	1,203	996
Zaire	46	38	44	30	18
Zimbabwe	[e]55	52	15	29	10
Total	[r]50,269	[r]46,921	40,821	46,478	46,989

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Aug. 8, 1986.

Table 19.—Tungsten: World concentrate consumption, by country[1]

(Metric tons of tungsten content)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Reported consumption:					
Australia	100	145	160	[e]100	100
Austria	1,850	1,304	1,629	2,096	2,000
Canada[e 3]	21	18	15	12	12
France	[r]663	[r]653	520	730	500
Japan	2,238	1,826	1,977	2,302	2,500
Korea, Republic of	[r]1,898	[r]1,742	1,555	2,070	[4]2,048
Mexico	[e]40	19	22	[e]61	50
Portugal	227	183	174	159	150
Sweden	1,432	994	774	784	800
United Kingdom	879	[r]660	560	610	600
United States	9,839	4,506	5,181	8,577	[4]6,838
Apparent consumption:[5]					
Argentina	20	29	41	[e]30	30
Belgium-Luxembourg	9	[e]9	[e]10	142	200
Brazil	480	454	450	593	550
Bulgaria[e 3]	100	100	100	100	100
China[e 3]	[r]5,500	[r]6,000	6,500	7,000	7,500
Czechoslovakia[e]	1,300	1,300	1,300	1,300	1,300
German Democratic Republic[e]	270	270	250	270	270
Germany, Federal Republic of	1,348	1,541	2,030	3,934	2,000
Hungary[e]	600	[r]400	400	500	500
India	459	454	[e]400	[e]400	400
Italy	[e]40	[e]40	27	78	100
Korea, North[e 3]	1,600	1,600	1,000	1,000	1,000
Netherlands[e]	400	300	300	300	400
Poland	427	1,312	1,073	594	1,000
South Africa, Republic of[e]	250	250	250	250	250
Spain	[r]96	161	107	80	100
U.S.S.R.[e 3]	15,900	15,900	15,900	16,000	16,000
Total	[r]47,986	[r]42,170	42,705	50,072	47,298

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Source, unless otherwise specified, is the Quarterly Bulletin of the UNCTAD Committee on Tungsten: Tungsten Statistics. V. 20, No. 1, Jan. 1986.
[2]In addition to the countries listed, Denmark, Finland, Israel, Norway, Romania, Switzerland, and Yugoslavia may consume small amounts of tungsten concentrate, but consumption levels are not reported, and available general information is inadequate to permit formulation of reliable estimates of consumption levels.
[3]Estimated by the Bureau of Mines.
[4]Reported figure.
[5]Production plus imports minus exports. For a few countries where data were available, variations in stocks were used in determining consumption.

Vanadium

By Peter H. Kuck[1]

For much of the vanadium industry in the market economy countries, 1985 was a difficult year. The industry continued to be hurt by its dependence on world steel production. Steel producers have been frustrated by a worldwide overcapacity situation since 1980. More than 85% of the vanadium sold on the world market was consumed in steelmaking as ferrovanadium or related vanadium-carbon ferroalloys. Numerous consumers of vanadium and several producers were affected by mergers or corporate restructuring. Rautaruukki Oy closed both of its vanadiferous magnetite mines in Finland because of unprofitability. Continued low prices for vanadium pentoxide (V_2O_5) forced prospective and past producers to delay or shelve plans for new mines and extraction facilities in North America and Oceania. The sharp decline of the South African rand against the U.S. dollar permitted Highveld Steel and Vanadium Corp. Ltd. and Transvaal Alloys Pty. Ltd. to escape most of the upheaval. Highveld commissioned its second iron plant in July and strengthened its position as the leading producer of vanadium in the face of domestic economic and political difficulties.

In July 1984, Union Carbide Corp. announced that it wanted to sell its Umetco Minerals Corp. subsidiary as part of its corporate restructuring program but was unable to find anyone willing to buy the entire operation. At the end of 1985, Union Carbide, faced with a hostile takeover bid from GAF Corp., decided to sell Umetco in parts. General Mining Union Corp. Ltd. (Gencor) agreed to purchase Umetco's chromium interests in the Republic of South Africa, while a Umetco employee group

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium[1]	5,126	4,098	2,171	1,617	W
Value ... thousands	$71,496	$52,577	$30,675	$24,551	W
Vanadium oxides recovered from ore[2]	6,368	4,867	2,433	2,620	W
Vanadium oxides recovered from petroleum residue[3]	1,900	1,513	893	[r]1,701	2,695
Consumption	6,863	3,496	3,277	4,761	4,883
Exports:					
Ferrovanadium (gross weight)	435	326	775	469	454
Ore and concentrate	56	57	59	12	3
Vanadium pentoxide, anhydride (gross weight)	346	1,582	2,648	3,712	1,527
Other compounds (gross weight)	61	361	95	305	322
Imports (general):					
Ferrovanadium (gross weight)	1,236	855	846	1,461	977
Ores, slags, residues	2,435	1,112	58	633	303
Vanadium pentoxide, anhydride	354	129	408	149	63
World: Production from ores, concentrates, slags	38,562	[r]36,124	30,924	[p]34,291	[e] [4]33,665

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.
[2]Produced directly from all domestic ores and ferrophosphorus; includes metavanadates.
[3]Includes vanadium recovered from ashes and spent catalysts.
[4]Excludes U.S. production.

took steps to acquire the subsidiary's vanadium and tungsten assets in the United States. These latter assets included the vanadium mill and open pit mine at Hot Springs, AR; the underground tungsten mines at Bishop, CA, and Tempiute, NV; and the vanadium and tungsten processing facility at Niagara Falls, NY. The employee group also wanted to purchase the vanadium mine and mill near Brits in the South African Transvaal Province. Gencor, Union Carbide's joint venture partner in Tubatse Ferrochrome (Pty.) Ltd., would acquire Umetco's 49% interest in Jagdlust Chrome Co. (Pty.) Ltd., Chrometco Minerals (Pty.) Ltd., and Chrome Corp. (South Africa) (Pty.) Ltd. The purchase of these South African operations would make Gencor a major force in the international ferroalloys industry, rivaling Middleburg Steel & Alloys Holdings (Pty.) Ltd. as one of the world's major ferrochromium producers. Union Carbide was negotiating with other organizations for the purchase of Umetco's tungsten interests in Brazil and Portugal, as well as its chromium mines and smelter in Zimbabwe.

In the United States, the beleaguered vanadium industry was completing a major restructuring in order to better compete in international markets against products derived from Chinese and South African magnetite (Fe_3O_4) ores. The restructuring was triggered by (1) the sharp decline in ferrovanadium consumption by U.S. steel producers during the 1982-83 recession, and (2) continuing depressed prices for coproduct uranium oxide. Umetco resumed full production of vanadium oxides at its Hot Springs mill in Arkansas to compensate for the shutdown of its uranium-vanadium operations on the Colorado Plateau. Atlas Corp., however, kept its Moab uranium-vanadium mill in Utah on standby and switched resources to the company's gold operations in Nevada. The uranium-vanadium industry was at a complete standstill throughout the first 8 months of 1985 because of the lowest spot market prices for yellowcake (natural U_3O_8 concentrate) in more than a decade. Only 43 uranium mines on the Colorado Plateau reported activity in 1985, compared with 198 mines in 1980. Several of the larger shippers in 1985 mined high-grade uraninite deposits with no significant vanadium mineralization.

The weak and slow recovery of the U.S. steel industry gave only minimal encouragement to the remaining hard-pressed producers and converters of vanadium oxides. The decelerating rise in ferrovanadium consumption represented a modest recovery from the 20-year low of 1983, rather than an overly optimistic outlook for the vanadium industry. Some ferrovanadium consumers remained concerned about the deteriorating sociopolitical situation in the Republic of South Africa. The first purchases of vanadium materials since 1961 for the National Defense Stockpile (NDS) were completed in August 1985.

Domestic Data Coverage.—Domestic production data for vanadium are developed by the Bureau of Mines from four voluntary surveys of U.S. mills and processing facilities. Of the 18 plants or mills canvassed in 1985, 17 responded. Supplemental information was provided by two power-generating stations. Data on uranium-vanadium mining operations are obtained from an independent survey conducted by the U.S. Department of Energy (DOE). Only 10 mines in the United States reported production or shipments of vanadium-bearing ores in 1984, compared with 35 in 1983 and more than 55 in 1982. In 1984, 26 uranium-vanadium mines on the Colorado Plateau permanently closed or were placed on standby because of the depressed market for yellowcake.

Legislation and Government Programs.—The program undertaken by the General Services Administration (GSA) in 1983 to upgrade and increase the stocks of vanadium materials held in the NDS was slowed by growing budgetary restrictions. The NDS goals of 1,000 short tons of vanadium contained in ferrovanadium and 7,700 tons of vanadium contained in V_2O_5 remained in effect throughout the year. These goals were established by GSA on May 1, 1980.

Contracts for a total of 180 tons of vanadium contained in pentoxide meeting Grade A purchase specifications were awarded to Gulf Chemical & Metallurgical Co. in 1983 and to Umetco in 1984. Grade A material must contain at least 98.0% V_2O_5 by weight on a dry basis and have a total alkali content of less than 0.75%. The grade is intended to be used as feed material for ferrovanadium conversion plants. The last lots, which contained 79 tons of vanadium, were accepted by GSA in August, bringing total receipts for 1985 to 112 tons. This completed the first large-scale acquisition of vanadium materials by the U.S. Government since the former Atomic Energy Commission halted its vanadium credits program in 1962.

As of December 31, 1985, the U.S. Government inventory consisted of 721 tons of contained vanadium in the form of V_2O_5. However, the 541 tons in the inventory that were purchased between 1947 and 1955 contain excessive amounts of alkali and may require upgrading prior to use. Because of recent advances in smelting and improvements in alloy quality, converters must now start with chemically purer grades of pentoxide.

The Interagency Working Group was established in 1982 to undertake quality assessment studies mandated by the National Materials and Minerals Policy, Research and Development Act of 1980. Both the National Academy of Sciences and the American Society for Metals (ASM) were advising the group. All of the stockpile purchase specifications and special instructions pertaining to vanadium were still being reviewed in 1985 by the Interagency Working Group. A joint industry and Government panel was formed by the U.S. Department of Commerce and ASM in December 1984 to specifically assess the quality of the V_2O_5 held in the NDS and recommend other suitable forms of vanadium for future acquisition.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, vanadium would be categorized in tier II and the existing goal would be lowered to 721 tons of vanadium metal equivalent. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

On September 25, the Secretary of Energy made a formal finding that the domestic uranium mining and milling industry was not viable in 1984. A significant fraction of the vanadium produced in the United States since 1950 has been a coproduct or byproduct of the uranium mined on the Colorado Plateau. Some analysts warned that continued closure of the plateau mines could increase this country's dependence on imports of vanadium from China and the Republic of South Africa. In conjunction with this finding, the Secretary (1) authorized the DOE to offer its enrichment customers a free variable tails assay option that, if exercised, would effectively spur domestic U_3O_8 sales, (2) postponed for 1 year a DOE plan to feed some of its own stockpiled uranium into the enrichment plants, and (3) asked the U.S. Trade Representative to carry out a 3-month study of uranium imports and their effect on the domestic uranium industry. According to the DOE Energy Information Administration, uranium imports totaled 16.4 million pounds of U_3O_8 in 1985, compared with 12.5 million pounds in 1984 and only 8.2 million pounds in 1983. Reported utility enrichment feed deliveries in 1984 were 20.6 million pounds of U_3O_8.[2] Unless current trends are reversed, uranium imports could account for more than 65% of all U.S. requirements by 1990. The U.S. Trade Representative's study was still in progress at the end of 1985.

Environmental concerns about the stabilization and long-term control of uranium-vanadium mill tailings continued to attract public attention in the Rocky Mountain States. At least three Federal agencies, a variety of State regulatory agencies, and most mill operators on the Colorado Plateau were involved in tailings stabilization projects, environmental hearings, and/or lengthy litigation.

The Environmental Protection Agency (EPA), the American Mining Congress, and the Environmental Defense Fund remained locked in litigation over EPA's final standards governing the long-term disposal of uranium mill tailings. EPA issued the standards in late 1983 under the authority of the Uranium Mill Tailings Radiation Control Act of 1978 (Public Law 95-604). To help alleviate this situation, the Nuclear Regulatory Commission (NRC) amended its existing regulations governing the disposal of uranium mill tailings so that they now conform with the 1983 standards (40 CFR, part 192) issued by the EPA. Under the revised regulations (10 CFR, parts 40 and 50), the earlier requirement for a minimum of 3 meters of cover over mill tailings to limit dispersal of radon has been replaced by the EPA's more stringent standards for longevity and radon control. The new NRC rules require that permanent mill tailings and waste disposal areas be designed so that they provide reasonable assurance of control of radiological hazards for 1,000 years, to the extent reasonably achievable, and, in any case, for at least 200 years. The design must also provide reasonable assurance that releases of radon from the tailings to the atmosphere will not exceed an average of 20 picocuries per square meter per second. The new regulations, which took effect on November 15, should eliminate some of the legal inconsistencies and jurisdictional conflicts that have handicapped uranium-vanadium mill operators on the Colorado Plateau and should simplify long-range planning for the hard-pressed industry.

In early February, the families of 24 miners who developed cancer after working in southern Utah uranium mines were awarded almost $2 million in partial settlement of a court suit against Foote Mineral Co. of Exton, PA. The miners worked at the Vanadium Corp. of America (VCA) operations near Marysvale, UT, from 1949 to 1968. VCA was merged into Foote Mineral in 1967. Negligence claims were also brought against the Federal Government, which inspected the mines where high levels of radon-222 gas and its radioactive daughter products were observed. The plaintiffs held that the Government failed to warn the miners of the radiation dangers in the poorly ventilated uranium mines. However, a U.S. District Court judge ruled on July 1, 1985, that the Federal Government was immune from the claims of the Marysvale miners.

As of December 31, the Colorado Department of Health was still considering whether to grant Umetco a license permitting construction of a new tailings impoundment and disposal facility for the company's uranium-vanadium mill at Uravan, CO. The proposed disposal site would be on Spring Creek Mesa along the eastern side of the San Miguel River opposite Uravan. The licensing process has been complicated by an environmental suit brought by the State of Colorado against Umetco under the Resource Conservation and Recovery Act of 1976 (Public Law 94-580). Under an agreement signed with the Colorado Water Control Division in 1981, Umetco was required to halt its mill discharges into the existing ponds at Uravan by July 1, 1985. Extensive hearings on the tailings pond license and related environmental matters were held during the fourth quarter of 1984 in the neighboring towns of Montrose and Nucla. Approval reportedly has been blocked by concerns over (1) the thickness of the proposed clay lining for the new disposal facility, (2) protection of an apparently isolated pod of ground water beneath Spring Creek Mesa, and (3) the future reclamation of existing tailings piles at Uravan, some of which date back to the 1930's. Umetco was considering submitting a revised plan to the Colorado Department of Health that would allay specific concerns about potential ground water contamination. Umetco and the State of Colorado were exploring remedial action to permanently stabilize and control the existing tailings sites.

The Uravan mill was placed on standby in November 1984 because of the depressed uranium market. A month later, Umetco was forced to suspend vanadium recovery operations at its Rifle plant in Garfield County, CO. The Rifle plant depends upon the Uravan mill for its feedstocks of vanadium liquor.

DOMESTIC PRODUCTION

Domestic production, expressed in terms of recovered vanadium, dropped back to the depressed level of 1983, the worst year for vanadium mining and milling operations since 1951. However, recoverable production, which represents receipts of ore and vanadium-bearing ferrophosphorus, was significantly higher than that of 1984. Arkansas was the leading producing State followed by Idaho. For the first time since 1907, no vanadium was recovered from the uraniferous sandstone ores of the Colorado Plateau. All five mills in Colorado and Utah that had coproduct vanadium recovery circuits were on standby during the first 8 months of 1985 because of the continuing depressed price for yellowcake and increased imports of uranium, both natural and enriched. Increased recovery of vanadium from petroleum residues, utility ash, and spent refinery catalysts partially compensated for the abnormally low level of domestic mine production.

During the first half of 1985, Umetco expanded operations at its mine and mill complex in Garland County, AR, to compensate for the closure of most of its smaller uranium-vanadium mines in Colorado and Utah. The Hot Springs mill, which has an annual capacity of approximately 7,500 tons of V_2O_5 equivalent, has traditionally used vanadiferous micaceous clays as its major feed material. The clays are mined from four open pits in the Wilson Springs carbonatite-alkalic igneous complex. In December, Umetco laid off 150 of 220 workers at the facility and suspended operations for at least 10 months because of high inventories. About 70 workers were retained to perform maintenance and upgrade the capabilities of the mill.

V_2O_5 and ammonium metavanadate (NH_4VO_3) were produced from vanadium-rich ferrophosphorus by Kerr-McGee Chemical Corp. at Soda Springs in Caribou County, ID. Vanadium-rich ferrophosphorus is a byproduct of two elemental phosphorus plants in Idaho and one in Montana. Increased demand for elemental phosphorus during the first half of 1985 led to a buildup of ferrophosphorus stocks in the two States.

FMC Corp. and the Shoshone Bannock Indian Tribes agreed in August to expand the Gay phosphate mine in Bingham County, ID, after 2-1/2 years of negotiations. The open pit mine, jointly operated by the J. R. Simplot Co. and FMC, is on the Fort Hall Indian Reservation about 30 miles northeast of Pocatello. The joint venture will be allowed to expand its mining operations into a 2,300-acre tract south of the present minesite in exchange for increased royalty payments to the tribes. Vanadium-bearing, furnace-grade phosphatic shale is being mined from the Meade Peak Member of the Permian Phosphoria Formation and shipped to FMC's electric furnaces west of Pocatello, where it is converted into elemental phosphorus. The ferrophosphorus slags made at FMC's elemental phosphorus operation have been a significant source of byproduct vanadium in recent years.

Phosphatic shale for the electric furnaces operated by the Monsanto Industrial Chemicals Co. at Soda Springs, ID, came from the company's nearby Henry Mine. Stauffer Chemical Co. shipped shale on the Union Pacific Railroad from its Wooley Valley Mine in Caribou County, ID, to its phosphorus plant at Silver Bow, MT.

Almost all of the uranium-vanadium mines in the Uravan Mineral Belt of western Colorado have been closed permanently or placed on standby as a result of the 1981-84 collapse of the domestic uranium ore market. Continued world overproduction of U_3O_8, the downturn in nuclear powerplant construction, and the discovery of high-grade uraninite deposits in the Canadian Province of Saskatchewan and South Australia all helped drag the price of natural uranium to a 12-year low in terms of constant dollars. The spot price of uranium concentrate (represented by Nuclear Exchange Corp.'s exchange value) bottomed out in April at $14.25 per pound of U_3O_8, a drop of $26.50 from the early 1980 price of $40.75. By yearend 1985, the spot price of uranium concentrate had partially recovered, returning to $17.00 per pound. This partial recovery encouraged two mills to reopen.

Cotter Corp. reopened its uranium-vanadium mill at Canon City, CO, in September, recalling 64 employees. The facility had been closed since January 1985 because of the depressed price for yellowcake. Approximately 33 employees were retained at that time to maintain the mill in standby condition, bringing present total employment to about 100. The mill has begun processing vanadium-poor, high-grade uraninite ore from the company's Schwartzwalder Mine, 9 miles northwest of Golden in Jefferson County. However, Cotter has no immediate plans to reactivate its vanadium recovery circuit at Canon City. In the past, feed liquors for the circuit have been produced from carnotite and tyuyamunite ores mined in the Uravan Mineral Belt.

In Garfield County, Umetco continued to ship V_2O_5 and NH_4VO_3 from stocks at its Rifle upgrading plant. Vanadium recovery operations were suspended at Rifle in December 1984 when vanadium liquor feedstocks supplied by the company's uranium-vanadium mill at Uravan were exhausted. The Uravan mill has been on standby since November 1984.

The White Mesa mill, a joint venture of Umetco (70%) and Energy Fuels Nuclear Inc. (30%), resumed operations on October 1. The 2,000-ton-per-day facility, 6 miles south of Blanding, UT, had been on standby since January 1983. Energy Fuels is supplying the mill with high-grade uraninite ore from its Hacks Canyon No. 2, Hacks Canyon No. 3, and Pigeon Mines in the Arizona Strip. The three mines produced a total of 175,000 tons of ore in 1985, averaging 0.60% U_3O_8. A few small independent mining operations in the Monticello, UT-Dove Creek, CO, area have also been shipping toll ores to White Mesa. Umetco is responsible for operation of the mill and currently employs 103 people, most of whom worked previously at either Blanding or the neighboring Umetco mill at Uravan, CO, which is still closed. White Mesa was scheduled to operate three full shifts per day, 7 days per week, until at least early 1987. The mill was expected to recover 5.7 million pounds of uranium and 2.5 million pounds of vanadium from 638,000 tons of ore between October 1985 and January 1987.

In a related action, Energy Fuels has agreed to supply the British Civilian Uranium Procurement Organization with more than 3 million pounds of yellowcake over a 10-year period starting in 1987. The new Kanab North Mine being developed by Energy Fuels in the Arizona Strip and the proposed Canyon Mine, south of the Grand Canyon near Tusayan, could provide White Mesa with additional uraninite.

Atlas sold 1,028,000 pounds of V_2O_5 in the 12 months preceding June 30, 1985, exhausting its vanadium inventory. The company kept its uranium-vanadium mill near Moab, UT, and its last three operating mines in San Juan County—the Pandora, the Velvet, and the Rim Columbus—on standby throughout all of 1985. However, the company stated that the mill and mines could be brought back into production within 6 to 8 weeks if the market for U_3O_8 improved. Atlas postponed development of its new uranium-vanadium mine near Ticaboo in Garfield County, UT, and instead sought financing to bring its newly discovered Gold Bar gold deposit in Eureka County, NV, into production. The expected profits from the Gold Bar property, which has an estimated 300,000 ounces of economically recoverable gold, could enable Atlas to keep its uranium-vanadium operations on standby for several years.[3]

On April 4, Homestake Mining Co. suspended conventional underground mining operations at its Section 23 uranium property near Ambrosia Lake, NM, laying off about 100 of its 275 employees. An additional 130 employees were released later in the year when the company's nearby Milan mill was placed on indefinite standby. The 3,400-ton-per-day mill had just reopened on January 2 with a throughput of 550 tons per day after a 4-month shutdown for inventory adjustment. The company continued to leach its abandoned stopes throughout the year. The Ambrosia Lake uranium operations were a significant source of byproduct vanadium sludge prior to 1982 when V_2O_5 prices were considerably higher in terms of constant dollars. At the peak of the 1980 uranium boom, Homestake's uranium operations had a total work force of 825 in New Mexico.

In recent years, vanadium-bearing feed materials of foreign origin have included iron slags from Chile, China, and the Republic of South Africa as well as utility ashes, spent catalysts from refineries, and a variety of petroleum residues. U.S. production from petroliferous materials in 1985 totaled 2,695 tons of contained vanadium, 58% more than the 1,701 tons (revised) for 1984.

Vanadium oxide concentrates were produced as a byproduct of the burning of Venezuelan and other Caribbean residual oils at a number of power-generating stations in the Eastern United States. Long Island Lighting Co. (LILCO) recovered high-grade ash containing 510 tons of V_2O_5, compared with 794 tons (revised) in 1984. The New York utility operated two oil-fired power stations in Suffolk County, one at Northport and the other at Port Jefferson. Recently, LILCO also has been supplying processors with an ash sludge recovered from its wastewater treatment plants that averages 15% to 16% V_2O_5 when dried. The lower grade material recovered in 1985 contained 403 tons of V_2O_5 and was 33% greater in gross weight than the 1984 material, which contained 314 tons of V_2O_5.

In January, Société d'Applications de la Chimie, de l'Electricité et des Métaux SA (SADACEM) and Société Européenne des Dérives du Manganese SA, two subsidiaries of the Société Générale de Belgique SA, acquired the spent catalyst processing facility of Gulf Chemical at Freeport, TX. The Texas plant recovers vanadium and molybdenum from spent hydroprocessing catalysts generated largely by oil refining and petrochemical industries in the Southern United States. The plant's products include fused flake V_2O_5, granular V_2O_5, various alkali vanadates, and purified molybdic oxide (MoO_3). The selling parent company, Associated Metals & Minerals Corp., retained Gulf Chemical's tin smelter at Texas City, TX, and a second catalyst processing facility at Ironton, OH, that has been idle for several years. The SADACI Div. of SADACEM produces approximately 1,300 tons (gross weight) per year of an 80% V grade of ferrovanadium as well as ferromolybdenum at its Langerbruggekaai ferroalloys plant near Ghent, Belgium.

The Freeport, TX, plant was a recent supplier of V_2O_5 to the NDS and is one of only three such reclamation facilities operating in the country. The facility, which employs 130 people, began operations in 1973 and is currently being expanded. The first phase of the expansion was completed in 1982, enabling the plant to treat up to 30,000 tons of catalysts per year. The new management plans to double this capacity by 1990 and eventually recover several million pounds of cobalt and nickel left in stockpiled catalyst residues.

At Freeport, TX, the spent catalysts are roasted with sodium carbonate (Na_2CO_3) in multiple-hearth furnaces for about 2 hours. The roasting is carried out under oxidizing conditions at temperatures ranging from 650° to 900° C. During the roasting, the vanadium and molybdenum react with the Na_2CO_3 to form soluble sodium salts. The resulting calcine is then quenched in water, ground, and leached. The pregnant leach liquor is separated from the insolubles with a counter-current decantation circuit. The pregnant leach liquor is next purified to remove phosphorus and alumina. The vanadium can then be separated from the molybdenum by precipitating the vanadium from solution with ammonium chloride. The NH_4VO_3 precipitate is later calcined and fused to produce V_2O_5. The residual molybdenum-laden liquor is finally heated to 80° to 85° C and acidified, with the molybdenum precipitated as molybdic acid ($H_2MoO_4 \cdot H_2O$). The $H_2MoO_4 \cdot H_2O$ precipitate is then calcined to produce MoO_3.[4]

In the second quarter, Hall Chemical Co. of Wickliffe, OH, awarded a preliminary engineering contract to Brown & Root U.S.A. for a similar plant that would recover vanadium and three other strategic metals from spent hydroprocessing catalysts. A feasibility study of the project was completed in late 1984 by the Chemical Engineering Div. of Brown & Root. For the past 5 years, pilot plant operations have been under way at Hall's inorganic chemical plant near Arab, AL. The new facility would have sufficient capacity to recover annually, in metal equivalent units, 3 million pounds of vanadium, 5 million pounds of molybdenum, 2.3 million pounds of nickel, and 650,000 pounds of cobalt.

The dismal situation of U.S. producers of ferrovanadium and proprietary vanadium-iron-carbon alloys improved somewhat in 1985. Although demand for ferrovanadium was essentially unchanged from that of 1984, U.S. imports of the ferroalloy declined by one-third. The three traditional producers of ferrovanadium—Foote Mineral, Shieldalloy Corp., and Umetco—also profited to some extent from the closure and sale in early 1984 of Engelhard Corp.'s aluminothermic reduction plant at Strasburg, VA. Affiliated Metals and Minerals Inc. attained full production capability at its new specialty ferroalloys plant in Newcastle, PA. The Newcastle plant is currently producing low-aluminum, high-purity 80%, standard 80%, 60%, and 42% grades of ferrovanadium as well as ferromolybdenum, molybdenum briquets, and ferroboron.

On October 16, Cabot Corp. announced plans to restructure its business groups and sell most of its specialty metals and alloying operations in order to improve the company's financial performance. The proposed divestiture would include a titanium rolling mill and superalloy production facilities at Kokomo, IN; a titanium tubing plant at Arcadia, LA; beryllium-copper alloy production facilities at Elkhart, IN, and Reading, PA; and the aluminum master alloy plants at Henderson, KY, and Wenatchee, WA. However, the company would retain its integrated tantalum and columbium production facilities in Pennsylvania. The divestiture would reduce Cabot's present work force from 7,700 to less than 5,700. Cabot produces 2.5% vanadium aluminum, 5% vanadium aluminum, and 3% zirconium-2% vanadium aluminum at the Henderson and Wenatchee plants.

Producers of primary vanadium chemicals included Foote Mineral, Cambridge, OH; Stauffer, Weston, MI; and Umetco, Niagara Falls, NY. Vanadium oxytrichloride ($VOCl_3$) and vanadium tetrachloride (VCl_4) were the two ranking chemicals after pentoxide.

In March, Chesebrough-Pond's Inc., a diversified consumer products company, acquired Stauffer for $1.25 billion through a cash tender offer of $28 per share for Stauffer common stock. Stauffer's 14 operating divisions were consolidated into 4 divisions, which form the nucleus of Chesebrough-Pond's new Chemical Products Group. Stauffer's basic research capability was expected to complement Chesebrough-Pond's marketing skills and organization. Stauffer, a producer of basic, agricultural, and specialty chemicals, synthesizes vanadium catalysts as a sideline at its Weston, MI, plant. Products include vanadium trichloride (VCl_3), VCl_4, $VOCl_3$, and vanadium tris-acetylacetonate ($V(C_5H_7O_2)_3$). Stauffer also operates the elemental phosphorus plant at Silver Bow, MT, which produces a byproduct vanadium-rich ferrophosphorus.

Table 2.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons of contained vanadium)

Year	Mine production[1]	Recoverable vanadium[2]
1981	5,852	5,126
1982	4,093	4,098
1983	W	2,171
1984	W	1,617
1985	W	W

W Withheld to avoid disclosing company proprietary data.
[1]Measured by receipts of uranium and vanadium ores and concentrates at mills, vanadium content.
[2]Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

Table 3.—U.S. production of vanadium oxides[1]

(Short tons)

Year	Gross weight	Oxide content[2]
1981	11,366	11,367
1982	8,850	8,689
1983	4,590	4,344
1984	4,688	4,678
1985	W	W

W Withheld to avoid disclosing company proprietary data.
[1]Produced directly from all domestic ores and ferrophosphorus; includes metavanadates.
[2]Expressed as equivalent V_2O_5.

CONSUMPTION, USES, AND STOCKS

Reported domestic consumption of vanadium in 1985 was only about 3% higher than that of 1984. This meager rise in consumption represented a slowing of the recovery from the 20-year low of 1983 and gave little hope for substantial improvement in the immediate future. The primary cause of the recovery to date has been increased domestic production of vanadium-bearing, high-strength, low-alloy (HSLA) steels for the construction and automotive industries. The steel industry as a whole showed an overall decline of 4.6% in raw steel output from the encouraging level of 1984, and remained in an uphill battle against near-record-high imports of major iron and steel products, a still strong but weakening dollar, and low profitability. Import penetration of steel mill products again exceeded 25% despite voluntary restraint agreements between the United States and 15 of its larger trading partners.

Approximately 83% of the vanadium was consumed by the domestic iron and steel industry as ferrovanadium, related vanadium-carbon ferroalloys, or a new proprietary product called Vanox. Vanox, a specially processed form of vanadium trioxide introduced by Umetco in 1984, is designed primarily for addition to tool steel and can be added directly to the argon-oxygen-decarburization vessel. V_2O_5 cannot be substituted for the trioxide because the melting point of the pentoxide (690° C) is lower than that of either the steel (1,550° to 1,650° C) or the trioxide (1,970° C). The trioxide is easier to reduce than the pentoxide and is more homogeneously distributed throughout the melt. At least eight domestic specialty steel producers were using or evaluating Vanox.

The dependence of the vanadium industry on the struggling iron and steel industry continued to create marketing problems for the five domestic producers of ferrovanadium. Ferrovanadium imports slackened from the record high of 1984, but remained a serious problem for the hard-pressed producers. Converters in Austria and Belgium-Luxembourg increased their share of the U.S. ferrovanadium market at the expense of Canada. Marketing was complicated further because the South African producers resumed shipments of the ferroalloy after a hiatus of 7 years. A significant increase in consumption of ferrovanadium and other vanadium-iron-carbon additives by producers of carbon steel offset decreased consumption in HSLA steel. A large part of the decrease in the HSLA steel category between 1984 and 1985 reflected the depressed conditions in the oil country tubular goods market. Demand for ferrovanadium by tool steel producers also deteriorated significantly. Total shipments of sheet steel and strip to the automotive industry and other consumer goods sectors were essentially unchanged. However, shipments of structural shapes did improve significantly.

The restructuring of the U.S. steel industry continued throughout 1985. The loss of over $6 billion between 1982 and 1984 triggered a string of steel company mergers, modernization programs, and permanent closures of obsolete plants. Production costs have been cut more than 10% since 1982, and labor productivity has improved dramatically. The two giants, United States Steel Corp. (USS) and Bethlehem Steel Corp., have discarded more than one-third of their 1979 capacities. According to the American Iron and Steel Institute, domestic steel producers have shut down more than 600 steelworks and fabrication plants since 1974.

Despite all these changes, the industry lost an additional $1.7 billion in 1985. USS and Armco Inc. were the only two of the six leading integrated steelmakers to make a profit during the year. These new losses led to another round of plant closures and sales. Inland Steel Co., for example, announced plans to close seven outdated open-hearth furnaces at its Indiana Harbor Works in East Chicago, IN. LTV Steel Co. idled indefinitely numerous facilities at Aliquippa, PA, Chicago, IL, Gulfport, MS, and Pittsburgh, PA. This radical restructuring, coupled with recent investments in continuous casters, continuous annealing lines, and other new equipment should lead to a smaller, more productive industry. At least seven continuous casters were being planned or installed. One of the highlights of the year was the startup of The Timken Co.'s new $500 million alloy steel plant at Faircrest, OH. The technological changes accompanying these modernization programs should have a positive effect on the long-term outlook for vanadium.

Demand for vanadium in titanium alloys was about 12% lower than that of 1984. The B-1B bomber program and increased production of other military aerospace products have helped initiate perhaps the most stable period in the 35-year history of the titanium industry. The U.S. aerospace industry currently depends on Government orders for approximately two-thirds of its total business. However, all of the budgeted bombers have now been ordered, with the 100th bomber scheduled for delivery in June 1988. Shipments of titanium mill products to domestic aircraft manufacturing plants slowed considerably toward the end of the year despite a surge in commercial aircraft orders. The Boeing Co. alone booked orders for 364 airliners, the highest figure since it won 461 orders in 1978. The total value of Boeing's 364 orders was about $14 billion. According to the Aerospace Industries Association, Boeing, Lockheed Corp., and McDonnell Douglas Corp. together shipped a total of 271 civil jet transport aircraft in 1985, compared with only 182 in 1984 and 257 in 1983.

Ti-6Al-4V alloy, which has been used in jet engines, airframes, and other aircraft parts for more than two decades, accounted for more than one-half of the titanium-based alloy market in 1985. Relatively small amounts of Ti-8Al-1V-1Mo and Ti-3Al-2.5V were being used for some jet engine components, while two newer alloys, Ti-15V-3Cr-3Al-3Sn and Ti-10V-2Fe-3Al, were being extensively evaluated for the next generation of commercial airliners. Forgings of Ti-10V-2Fe-3Al have already been used in some components of the Boeing 757 and 737-300 jetliners. The forgeability characteristics of Ti-10V-2Fe-3Al are reportedly superior to those of any other known titanium alloy. The newly formed Titanium Development Association has been focusing a large part of its initial efforts on developing new markets for titanium alloys in the oil, gas, and petrochemical industries. Ti-3Al-8V-6Cr-4Mo-4Zr, for example, has excellent corrosion resistance to saltwater saturated with hydrogen sulfide and may be superior to the nickel-based alloys that are currently used when a sour gas environment is encountered in oilfield operations. The association has also identified potential markets for titanium mill products in the shipbuilding, automotive, paper, and medical equipment industries.

In August, Armco agreed to sell its Aerospace and Strategic Materials Group to Owens-Corning Fiberglas Corp. of Toledo, OH, for $415 million in cash. Armco, a major steelmaker with headquarters in Middletown, OH, had been forced earlier to halt its diversification efforts and adopt a retrenchment strategy because of setbacks in its once highly profitable seamless pipe business. The sale of the aerospace group was completed in September, giving Owens-Corning control of the Hitco Fabricated Composites Div., the Hitco Materials Div., and the Ladish Co., as well as an 80% stake in the Oregon Metallurgical Corp. (Oremet). The other 20% of Oremet is publicly held.

Oremet is the third largest titanium sponge producer in the United States and a major consumer of vanadium-aluminum master alloys. Oremet currently employs 365 workers at its Albany, OR, metallurgical complex and has been making titanium-aluminum-vanadium alloys for over 20 years. Ladish, of Cudahy, WI, produces custom aerospace and high-performance industrial forgings along with stainless steel piping components for the power generation and petrochemical industries. According to analysts, Owens-Corning bought Armco's aerospace group primarily to acquire the two Hitco divisions, which are leading suppliers of carbon fibers, epoxy resins, and preimpregnated fabrics for advanced composites.

Plans for a leveraged buyout of the Timet Div. of Titanium Metals Corp. of America (TMCA) by a Timet management group were shelved in late November. Timet is the largest producer of titanium alloys and metal in the United States and operates a 14,000-ton-per-year sponge plant at Henderson, NV. Allegheny International Inc. and NL Industries Inc., joint owners of TMCA, said that although the outlook for the titanium metal market was favorable, they would continue to seek a buyer for the Timet Div. as part of their new divestiture strategy. Top Timet executives and Kelso & Co., a New York management consulting firm, which was arranging financing in return for a share in the company, had agreed in January to purchase the division. However, the management group was unable to arrange financing, partly because of lower-than-anticipated projected sales volume and profits for the division.

Consumption of NH_4VO_3, granular pentoxide, and other vanadium chemicals for catalysts dropped back to the depressed levels of 1983, and remained far below the average of the last decade. Sulfuric acid production, a major end use for vanadium oxidation catalysts, approximated that of 1984. More than 80% of the sulfuric acid currently being produced in the United States is synthesized by the contact process, which uses an 8% V_2O_5 catalyst on a silica support to convert the sulfur dioxide to sulfur trioxide. Vanadium catalysts are also used in the commercial synthesis of three key organic intermediates: maleic anhydride, adipic acid, and phthalic anhydride. Production of maleic anhydride increased only 4% in 1985, while production of adipic acid and phthalic anhydride declined 7% and 4%, respectively. In November, Monsanto Industrial Chemicals permanently closed its 110-million-pound-per-year benzene-based maleic anhydride unit in St. Louis, MO, after raising the capacity of its new butane-based unit at Pensacola, FL, from 130 million to 190 million pounds per year. The butane process employs a new proprietary vanadium catalyst that has a higher V_2O_5 content than the previous $2V_2O_5 \cdot MoO_3$ benzene catalyst.

In addition to the consumers' stocks, producers' stocks of vanadium as fused oxide, precipitated oxide, vanadates, metal, alloys, and chemicals totaled 2,849 tons of contained vanadium at yearend 1985, compared with 3,321 tons at yearend 1984.

Table 4.—Producers of vanadium alloys or metal in the United States in 1985

Producer	Plant location	Products[1]
Affiliated Metals and Minerals Inc	New Castle, PA	FeV.
Cabot Corp., Engineered Products Group	Henderson, KY	VAl and ZrVAl.
Do	Wenatchee, WA	Do.
Foote Mineral Co., Ferroalloys Div	Cambridge, OH	FeV and Ferovan.[2]
Metallurg Inc., Shieldalloy Corp	Newfield, NJ	FeV.
Reading Alloys Inc	Robesonia, PA	FeV and VAl.
Teledyne Inc., Teledyne Wah Chang Albany Div	Albany, OR	V.
Union Carbide Corp., Umetco Minerals Corp	Marietta, OH[3]	Carvan[2] and Nitrovan.[2]
Do	Niagara Falls, NY	FeV and VAl.

[1]FeV, ferrovanadium; V, vanadium metal; VAl, vanadium aluminum; ZrVAl, zirconium vanadium aluminum.
[2]Registered trademarks for proprietary products.
[3]Elkem Metals Co. has been toll converting vanadium oxide at Marietta for Union Carbide since 1981.

Table 5.—U.S. consumption and consumer stocks of vanadium materials, by type

(Short tons of contained vanadium)

Type	1984 Consumption	1984 Ending stocks	1985 Consumption	1985 Ending stocks
Ferrovanadium[1]	3,826	334	4,071	248
Oxide	26	W	18	5
Ammonium metavanadate	W	W	W	W
Other[2]	909	115	794	107
Total	4,761	449	4,883	360

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes other vanadium-iron-carbon alloys as well as vanadium oxides added directly to steel.
[2]Consists principally of vanadium-aluminum alloy, plus relatively small quantities of other vanadium alloys and vanadium metal.

Table 6.—U.S. consumption of vanadium in 1985, by end use

(Short tons of contained vanadium)

End use	Quantity
Steel:	
Carbon	1,135
Stainless and heat-resisting	35
Full alloy	944
High-strength, low-alloy	1,383
Tool	522
Unspecified	W
Total	4,019
Cast irons	22
Superalloys	16
Alloys (excluding steels and superalloys):	
Cutting and wear-resistant materials	W
Welding and alloy hard-facing rods and materials	5
Nonferrous alloys	788
Other alloys[1]	W
Chemicals and ceramics:	
Catalysts	14
Other[2]	W
Miscellaneous and unspecified	19
Grand total	4,883

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Includes magnetic alloys.
[2]Includes pigments.

PRICES

The Metals Week price quotation for domestic 98% fused V_2O_5 (metallurgical-grade) at the beginning of 1985 was $3.35 to $3.65 per pound of V_2O_5, f.o.b. mill. This price spread was established on May 15, 1981, and remained in effect throughout all of 1985. The slowing of demand for ferrovanadium gave little encouragement to domestic pentoxide producers, struggling to recover from the 1982-83 recession. Some discounting of metallurgical-grade material continued throughout 1985 because of the strong but weakening dollar and downstream pressure from imports of ferrovanadium.

Prices for metallurgical-grade pentoxide in Japan and Western Europe firmed during the first half of 1985 owing to increased production of ferrovanadium by major converters and production constraints on exports of pentoxide from China. Throughout the year, Highveld maintained its list price of $2.41 per pound of V_2O_5 c.i.f. for 98% minimum fused pentoxide from the Republic of South Africa. The European spot price for metallurgical-grade material increased from $2.30 to $2.35 per pound in early January to a high in March and April of $2.37 to $2.42. The spot price weakened during the second half of the year, reaching a low of $2.05 to $2.15 in November and eventually closed at $2.15 to $2.20.

The Metals Week price spread for technical air-dried V_2O_5 (chemical-grade) of $4.10

to \$4.94 per pound of V_2O_5 was set on April 1, 1982, and remained unchanged throughout 1985.

On July 8, Umetco, facing probable divestiture and under pressure from continuing high imports of ferrovanadium, lowered prices for its 60% and 80% standard grades of ferrovanadium as well as Carvan to \$5.00 per pound of contained vanadium, f.o.b. Niagara Falls, NY. This move to maintain market share triggered a series of price reductions between July 12 and August 1 by other domestic producers. The end results of the price reductions are presented in the following tabulation:

Company and product	Price per pound of contained vanadium	
	Jan. 1, 1985	Dec. 31, 1985
Foote Mineral Co.:		
Ferovan	\$6.25	\$5.00
70% to 80% FeV	6.50	5.00
Shieldalloy Corp.:		
Standard 60% to 70% FeV	6.25	5.00
Umetco Minerals Corp.:		
Carvan	6.00	5.00
UCAR 80% FeV	6.50	5.00

The \$5 domestic price effectively undercut spot dealer quotes for imported ferrovanadium, which reportedly ranged from \$5.20 to \$5.50 during the third quarter, and encouraged several traders to seek more profitable markets in Europe.

Previously, in mid-1984, Umetco took action to protect its market share against imported ferrovanadium with the introduction of Vanox. The new proprietary oxide product was priced initially at \$5.05 per pound of contained vanadium, f.o.b. Niagara Falls, NY, and was expected to compete in the tool steel additive market against the more expensive, imported ferrovanadium. The July 8 price reductions necessitated a lowering of the Vanox price. At yearend 1985, Vanox was being quoted at \$4.50 per pound of contained vanadium, to be effective with January 2, 1986, shipments.

FOREIGN TRADE

The U.S. trade pattern for vanadium products has changed dramatically since 1981. The United States is no longer a net exporter of ferrovanadium and has begun to purchase substantial amounts of the 80% grade from the European Communities and Austria. At the same time, U.S. exports of V_2O_5 have increased more than threefold, while imports of the oxide have plummeted. This shift in the pentoxide trade pattern has been magnified because imports of vanadium trioxide from the Republic of South Africa have replaced some of the more conventional pentoxide imports. It is also important to note that significant amounts of exported pentoxide were apparently in the form of oxidation catalysts.

The strong dollar and stiff competition from European converters continued to hurt U.S. export sales of vanadium-iron-carbon alloys. Exports of ferrovanadium totaled 454 tons gross weight, compared with 469 tons for 1984 and 775 tons for 1983. The average declared value of the ferrovanadium was \$5.28 per pound of alloy, a 5% decrease from the \$5.55 value for 1984. The modest increase in domestic ferrovanadium production from the highly depressed levels of 1982 and 1983 gave little encouragement to beleaguered U.S. pentoxide producers. This frustrating situation coupled with the effects of a falling South African rand[5] kept the pressure on U.S. producers to compete agressively against South African material in Western Europe, Canada, and Japan. In the fourth quarter, the decline of the dollar against the deutsche mark and a temporary reduction in sales of Chinese pentoxide to Europe offered some relief to U.S. exporters of both pentoxide and ferrovanadium. Exports of anhydride and catalysts containing pentoxide totaled only 1,527 tons gross weight, a 59% decrease from the 3,712 tons for 1984. According to the Bureau of the Census, VCl_4 was one of the principal unspecified chemicals exported in 1985.

U.S. imports for consumption of ferrovanadium dropped to 779 tons of contained vanadium from a historical high of 1,171 tons in 1984. The material averaged 80.6% vanadium and had a mean Customs value of $4.98 per pound of contained vanadium. This decrease in imports reversed, at least temporarily, a long-term trend in which European converters have been gradually capturing a larger share of the U.S. ferrovanadium market. Imports accounted for 19% of reported consumption of vanadium-iron-carbon alloys, compared with less than 4% in 1973. The Belgium-Luxembourg Economic Union replaced Canada as the principal source of imported ferrovanadium and accounted for 27% of the imported alloy in terms of contained weight. Imports of Canadian ferrovanadium fell from a record high in 1984 to their lowest level in 7 years.

Only 20 tons gross weight of pentoxide was imported in 1985. More than 90% of this material came from the Federal Republic of Germany. For the second year in a row, there were no imports of pentoxide reported for consumption from the Republic of South Africa. Between 1978 and 1983, annual imports of South African pentoxide steadily declined from 1,152 tons to 56 tons.

Imports of vanadium contained in ores, slags, and residues totaled only 303 tons, compared with 633 tons in 1984. At least 45% of this vanadium came directly or indirectly from the refining operations of Petróleos de Venezuela S.A. (PDVSA), the state oil monopoly of Venezuela. The remaining 55% was contained in other assorted petroleum refinery residues and utility ashes from, in order of decreasing tonnage, Italy, the Netherlands Antilles, Mexico, Suriname, Jamaica, and Barbados. Part of the Caribbean material also may have been recovered from Venezuelan crude. For only the second time in 18 years, there were no imports of vanadiferous iron slag from Highveld's Witbank steelworks in the Transvaal, Republic of South Africa.

Potassium vanadate imports amounted to 57 tons gross weight, of which 38 tons came from the Republic of South Africa and 19 tons came from the Federal Republic of Germany. In addition, 15 tons of NH_4VO_3 was received from the United Kingdom. Imports of vanadium carbide and unwrought vanadium metal were less than 1 ton each. Imports classified as "Other vanadium compounds" totaled 807 tons gross weight, compared with 831 tons in 1984. As mentioned earlier, 97% of this material was vanadium trioxide from the Republic of South Africa. Nearly all of the remaining 23 tons was unspecified chemicals from the United Kingdom.

Table 7.—U.S. exports of vanadium in 1985, by country

(Thousand pounds and thousand dollars)

Country	Ferrovanadium (gross weight)		Vanadium ore and concentrate (vanadium content)		Vanadium compounds (gross weight)			
					Pentoxide (anhydride)[1]		Other[2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	--	--	2	13	--	--
Australia	--	--	--	--	74	108	(3)	7
Austria	--	--	--	--	120	250	--	--
Belgium-Luxembourg	86	507	--	--	751	1,219	--	--
Brazil	--	--	--	--	401	666	38	48
Canada	313	1,572	--	--	91	244	84	1,168
Chile	--	--	--	--	71	88	58	65
Colombia	--	--	--	--	3	4	--	--
Ecuador	--	--	--	--	(3)	2	--	--
France	--	--	--	--	--	--	316	15,284
Germany, Federal Republic of	29	169	--	--	--	--	(3)	8
Hong Kong	--	--	--	--	--	--	36	147
India	--	--	--	--	11	19	--	--
Indonesia	--	--	--	--	77	261	--	--
Israel	--	--	--	--	1	216	--	--
Italy	--	--	--	--	53	67	--	--
Japan	--	--	--	--	291	423	(3)	2
Kenya	--	--	--	--	17	28	--	--
Korea, Republic of	--	--	--	--	55	101	16	19
Malaysia	3	15	--	--	--	--	--	--
Mexico	29	127	5	9	712	1,987	90	257
Netherlands	38	160	--	--	106	226	--	--
Pakistan	--	--	--	--	6	8	--	--
Peru	--	--	--	--	3	3	2	5
Philippines	1	4	--	--	10	21	--	--
Singapore	--	--	--	--	18	42	--	--
South Africa, Republic of	--	--	--	--	134	237	(3)	2

See footnotes at end of table.

Table 7.—U.S. exports of vanadium in 1985, by country —Continued

(Thousand pounds and thousand dollars)

Country	Ferrovanadium (gross weight)		Vanadium ore and concentrate (vanadium content)		Vanadium compounds (gross weight)			
					Pentoxide (anhydride)[1]		Other[2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Spain	--	--	--	--	--	--	(3)	3
Sweden	167	997	--	--	--	--	(3)	10
Taiwan	--	--	--	--	17	27	--	--
Trinidad and Tobago	22	89	--	--	--	--	--	--
Tunisia	--	--	--	--	28	36	--	--
Venezuela	221	1,151	--	--	(3)	4	1	8
Total[4]	908	4,791	5	9	3,053	6,300	643	17,032

[1]May include catalysts containing vanadium pentoxide.
[2]Excludes vanadates.
[3]Less than 1/2 unit.
[4]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census, adjusted by the Bureau of Mines.

Table 8.—U.S. imports of ferrovanadium, by country

(Thousand pounds and thousand dollars)

Country	1984			1985		
	Gross weight	Vanadium content	Value	Gross weight	Vanadium content	Value
General imports:						
Austria	445	363	2,022	461	380	1,994
Belgium-Luxembourg	412	331	1,598	487	400	1,887
Brazil	1	1	16	(1)	(1)	5
Canada	1,138	923	4,745	418	339	1,775
China	--	--	--	44	36	199
France	99	80	416	--	--	--
Germany, Federal Republic of	558	444	2,077	334	252	1,238
Japan	114	91	493	--	--	--
South Africa, Republic of	--	--	--	168	137	614
United Kingdom	156	126	565	40	31	149
Total[2]	2,921	2,359	11,934	1,953	1,574	7,861
Imports for consumption:						
Austria	445	363	2,022	461	380	1,994
Belgium-Luxembourg	390	313	1,504	509	418	1,982
Brazil	1	1	16	(1)	(1)	5
Canada	1,138	923	4,745	418	339	1,775
France	99	80	416	--	--	--
Germany, Federal Republic of	558	444	2,077	334	252	1,238
Japan	114	91	493	--	--	--
South Africa, Republic of	--	--	--	168	137	614
United Kingdom	156	126	565	40	31	149
Total[2]	2,899	2,341	11,839	1,931	1,557	7,757

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census, adjusted by the Bureau of Mines.

Table 9.—U.S. imports of vanadium pentoxide (anhydride), by country

Country	1984			1985		
	Gross weight (pounds)	Vanadium content (pounds)	Value	Gross weight (pounds)	Vanadium content (pounds)	Value
General imports:						
Belgium-Luxembourg[1]	33,660	18,855	$40,598	--	--	--
Finland	494,953	277,256	1,218,749	--	--	--
Germany, Federal Republic of	2,000	1,120	8,643	35,554	19,916	$169,721
Japan	--	--	--	1,200	672	5,829
Netherlands Antilles[2]	--	--	--	2,641	1,479	3,960
South Africa, Republic of	--	--	--	186,285	104,351	396,683
United Kingdom	14	8	1,134	--	--	--
Total	530,627	297,239	1,269,124	225,680	126,418	576,193
Imports for consumption:						
Belgium-Luxembourg[1]	33,660	18,855	40,598	--	--	--
Finland	494,953	277,256	1,218,749	--	--	--
Germany, Federal Republic of	2,000	1,120	8,643	35,554	19,916	169,721
Japan	--	--	--	1,200	672	5,829
Netherlands Antilles[2]	--	--	--	2,641	1,479	3,960
United Kingdom	14	8	1,134	--	--	--
Total	530,627	297,239	1,269,124	39,395	22,067	179,510

[1]Queried by the Bureau of Mines.
[2]Used pentoxide received for recycling.

Source: Bureau of the Census, adjusted by the Bureau of Mines.

WORLD REVIEW

Ferrovanadium consumption in the Western World was estimated to be 21,000 tons of contained vanadium in 1985, a level essentially unchanged from that of 1984. The estimates for these 2 years represented a partial recovery from the depressed levels of 1982-83, but were significantly below the record high of 24,000 tons in 1981. This relatively stable situation mirrored raw steel production, its predominant end use. The International Iron and Steel Institute reported only a 0.6% increase in total raw steel production over that of 1984 for its 30 member countries. During the second half of 1985, monthly raw steel production in Japan and the United States began to decline below the projected seasonal dip, indicating a slowdown in the recovery. Vanadium consumption by producers of oil country tubular goods was abnormally low. The worldwide oil surplus discouraged sales of seamless tubes, such as drill pipe, well casing, and large-diameter line pipe, that contain vanadium to strengthen the steel.

In the Republic of South Africa, at least three companies were either expanding existing vanadium production capacity or planning construction of entirely new extraction and processing facilities. Highveld continued to strengthen its position as the world's largest supplier of vanadium slags and oxides. The commissioning of a second vanadium-bearing pig iron plant at the company's Witbank iron and steel complex in the Transvaal partially offset the permanent closure of Rautaruukki's two mines in Finland and the deterioration of the uranium-vanadium mining industry of the Colorado Plateau. Vanadiferous slag production facilities were also under construction at the Glenbrook steel plant on the North Island of New Zealand. In Canada, large-scale equipment was under development for extracting vanadium from fly ash generated by commercial oil sands plants.

Brazil.—The Brazilian ferroalloys industry has been systematically increasing production of ferrovanadium, ferrocolumbium, and other specialty ferroalloys since the worldwide collapse of ferroalloy prices in 1982. Production of ferrovanadium reached a record high of 998 tons gross weight in 1985, almost double the 503 tons (revised) reported for 1984 and more than eight times the 112 tons of 1983.[6] Approximately 70% of the ferrovanadium produced in 1985 came from the aluminothermic reduction plant of Centroligas-Produtos Siderúrgicos Ltda. in the State of São Paulo. Installed capacity in December 1985 totaled 2,877 tons per year, and was divided between Centroligas-Produtos and four other producers: Cia. Paulista de Ferro-Ligas, Eletrometalur S.A. Indústria e Comércio, Polisinter Indústria e Comércio Ltda., and Termoligas Mineração e Metalurgia S.A. Most of the pentoxide feed was being imported from the Federal Republic of Germany and the Republic of South Africa.

Centro de Pesquisa e Desenvolvimento da Bahia has been evaluating the vanadiferous magnetite deposit at Maracas in the State of Bahia. The Maracas ores reportedly contain 1.0% to 2.2% V_2O_5.[7]

Canada.—Renzy Mines Ltd., a Toronto-based company, was still planning to construct a vanadium extraction plant near Fort McMurray, Alberta. The Canadian plant would use fly ash from the nearby oil-sands operations of Suncor Inc. as feed, and was one of at least three such extraction plants under development in Alberta. The Renzy Mines operation could become the first Canadian facility to produce vanadium commercially from domestic raw materials. The plant would treat 100 tons of syncrude fly ash per day containing about 4.5% V_2O_5 and was expected to have an annual output of 1,300 tons of V_2O_5. The facility could begin production as early as mid-1987 and would cost between $4 and $5 million. Renzy Mines was also considering the extraction of scandium, gallium, nickel, and molybdenum from the fly ash.[8]

In a related action, Esso Resources Canada Ltd. of Calgary was contemplating a $290 million expansion of its oil-sands operation at Cold Lake on the Saskatchewan border. The existing 240 wells have been producing a total of 19,000 barrels per day of bitumen from a depth of 500 meters. Steam is injected into the wells to reduce the viscosity of the bitumen so that it can be pumped to the surface. The proposed expansion would raise Esso's output to 95,000 barrels per day. To date, no steps have been taken to recover any of the vanadium contained in the Cold Lake bitumen prior to upgrading.[9]

China.—China was expanding the iron and steel complexes at Panzhihua near Dukou in Sichuan Province and at Maanshan in Anhui as part of its seventh 5-year plan (1986-90). Construction of new steelmaking facilities and modernization of existing plants have already begun at the two sites and were expected to be completed by 1995. Panzhihua and Maanshan both have their own titaniferous magnetite mines and are major producers of vanadiferous slag. These slags may assay from 13% to 21% V_2O_5 but average about 17%.

The Panzhihua complex would have an annual production capacity of 3.1 million tons of pig iron when the new 1,350-cubic-meter blast furnace is completed. The present plant reportedly was producing 1.7 million tons of pig iron annually with its three existing blast furnaces. According to Xinhua, an official Chinese news agency, the Panzhihua deposit contains more than 10 billion tons of ore and accounts for 87% of the country's vanadium reserves. An earlier report stated that the iron mine had only 1.05 billion tons of ore grading 33.2% Fe, 11.6% titanium dioxide (TiO_2), and 0.3% V_2O_5.

A new 2,500-cubic-meter blast furnace and a new sinter plant would also be installed at Maanshan. Existing plans called for the 30% to 50% iron ore at Maanshan to be blended with Australian ore as feed for the new sinter plant.

Finland.—Rautaruukki underwent a major restructuring in 1985, substantially scaling down its mining and prospecting activities while simultaneously expanding its downstream engineering and manufacturing operations. The state-controlled steel conglomerate discontinued all production of V_2O_5, giving up roughly 10% of the world vanadium market. Both the Otanmäki and Mustavaara vanadiferous magnetite mines were closed because of unprofitability, leaving only the Rautuvaara copper-iron mine still in operation. In December, Rautaruukki also sold its mineral rights to the Sokli phosphorus deposit at Savukoski to Kemira Oy.

Ore hoisting was halted at the Otanmäki underground mine in May. Otanmäki had been in continuous production since the startup of byproduct vanadium recovery operations in the summer of 1956. Excavation at the Mustavaara surface mine was phased down during November and terminated in December. The two mines produced a total of 4,850 tons of V_2O_5, a drop of 20% from the 6,029 tons of 1984. At the beginning of 1985, 468 workers were employed at Otanmäki and 174 at Mustavaara. Most of the mine workers had been receiving retraining and were transferred to the new Otanmäki and Taivalkoski Works, where railcar manufacturing was inaugurated in August. The two former mining centers have begun fabricating freight cars for the timber, mineral fertilizer, and wine industries of Europe and the U.S.S.R.[10]

France.—Pechiney, the French state metals group, was in the second year of a major modernization and consolidation program that could affect the vanadium market to a limited degree over the next 5 years. The group's ferroalloy subsidiary, Pechiney Électrometallurgie (formerly Société Française d'Électrometallurgie), began upgrading silicon metal and other bulk ferroalloy operations at its Anglefort plant southwest of Lake Geneva. Pechiney Électrometallurgie continued to produce ferrovanadium by aluminothermic reduction at Chedde in Savoie. A second subsidiary, Métaux Speciaux S.A., was producing catalytic-grade $VOCl_3$ for the Western European rubber industry at nearby Pombliere.

In early April, the group established a 50-50 joint venture between Pechiney Électrometallurgie and the Brandeis Intsel Group for the marketing of both bulk and specialty ferroalloys, including ferrovanadium. Brandeis, a British company acquired by Pechiney in June 1981, reportedly is the third largest ferroalloy trading company of the market economy countries. Brandeis also acts as an agent for Transvaal Alloys Pty. Ltd., a South African producer of V_2O_5.

Howmet Turbine Components Corp., the North American subsidiary of Pechiney, initiated a $16.2 million program in May to expand its casting division at Hampton, VA. Howmet was also spending $3 million on a new addition to its New England Aircraft Products plant at Farmington, CT. The company is a major supplier of investment cast components for gas turbine engines, and consumes sizable amounts of ferrovanadium and other vanadium materials.

In 1984, France imported 2,756 tons of V_2O_5 and 689 tons of ferrovanadium. Finland supplied 1,455 tons, or 53%, of the pentoxide, while the bulk of the ferrovanadium came from Belgium-Luxembourg and Austria. Part of the pentoxide was used to produce 1,377 tons of ferrovanadium for export.[11]

India.—Work continued at the Regional Research Laboratory in Bhubaneswar to develop an economical method for recovering vanadium from the titaniferous magnetite ores of Orissa and Bihar. Metallurgists at the laboratory have built a coal-fired, five-step furnace for evaluating, on a pilot plant scale, different techniques of salt-roasting the magnetite ores. The five-step furnace uses an inexpensive noncoking coal from the Talcher region of Orissa to generate the hot flue gases needed for roasting.

The ore initially used in the Bhubaneswar studies contained 0.89% V_2O_5, 15.26% TiO_2, and 81.94% Fe_3O_4. The ore was ground to minus 200 mesh, pulverized in a ball mill, mixed with sodium chloride, and then pelletized. Both 5% and 10% NaCl pellets, 12 to 18 millimeters in diameter, were evaluated. The pellets were charged from the furnace roof onto the highest step, and moved to successively lower steps while the hot flue gases passed counter-currently to the charge. The steps allowed the pellets to be roasted at different temperatures ranging from 800° to 1,100° C. The roasted pellets were removed from the lowermost step at prescribed time intervals and then leached with water to produce a sodium vanadate solution. The Bhubaneswar investigators were able to recover as much as 90% of the vanadium after 7 to 8 hours of roasting at temperatures of 950° to 1,000° C.[12]

Japan.—Demand for ferrovanadium in Japan deteriorated slightly in 1985 despite a 4.6% increase in annual production of structural steel, tool steel, and other specialty steels. The steel industry consumed only 4,451 tons of ferrovanadium, compared with 4,782 tons (revised) in 1984. There were five producers of ferrovanadium in 1985: Nippon Denko Co. Ltd., Taiyo Mining and Industrial Co. Ltd., Awamura Metal Industry Co. Ltd., Japan Metals and Chemicals Co. Ltd., and Nippon Kokan K.K. Together, they produced 3,696 tons of the ferroalloy, a 10% decrease from the 4,115 tons of 1984.[13] The newest producer, Nippon Kokan, has a plant in Toyama Prefecture and has only been making ferrovanadium since 1983.

Because Japan has no vanadium mines and only a limited processing capability for vanadium-bearing ash and spent catalysts, more than four-fifths of the ferrovanadium produced since 1979 has been made from imported V_2O_5. Pentoxide imports fell 18% from 5,072 tons gross weight in 1984 to 4,173 tons in 1985. The Republic of South Africa was the principal supplier of pentoxide to Japan and accounted for 86% of the total gross weight. Ferrovanadium imports continued to decline, dropping from 817 tons gross weight in 1983 to 624 tons in 1984 and then to 504 tons in 1985. All of the imported ferrovanadium in the last 2 years has come from either Austria or the European Communities. Japan exported 11 tons of ferrovanadium to North Korea and less than 0.5 ton to New Zealand.[14]

Netherlands.—Exxon Corp. spent more than $800 million to modernize its 25-year-old refinery at Rotterdam. The rebuilt refinery was being equipped with a 32,000-barrel-per-day FLEXICOKING unit that would use thermal cracking rather than traditional catalytic cracking to convert inferior heavy feedstocks into high-quality liquid and gaseous fuels. The new process, under development by Exxon for more than

15 years, would produce only a relatively small amount of vanadium and nickel-rich residual coke—roughly 1% of the heavy feedstock—instead of the typical 25% residuum. More than 95% of the vanadium and nickel contaminants in the original feedstock would be concentrated in this coke. The Rotterdam refinery was shut down on June 15, 1985, to permit unimpeded construction and revamping and was supposed to resume operations in mid-1986. The Rotterdam FLEXICOKING facility and a similar unit being installed at Baytown, TX, were expected to become significant sources of low-cost feed material for United States and European vanadium producers.[15]

Netherlands Antilles.—Venezuela and the nearby Netherlands Antilles have been a significant source of vanadium-bearing petroleum residues for the United States since World War II. On March 31, Lago Oil & Transport Co. Ltd., an affiliate of Exxon, closed its oil refinery and transshipment storage facilities on the island of Aruba after more than 60 years of operation. The 420,000-barrel-per-day refinery had been receiving the bulk of its vanadiferous heavy crude from Lagoven S.A., a subsidiary of the Venezuelan Government and PDVSA. The refinery has been operating at two-thirds capacity because of weak international oil prices and showed a $50 million loss for 1984. Lago Oil and Exxon tentatively agreed to sell the refinery to the new Government of Aruba for $1.00. On January 1, 1986, Aruba became an autonomous country within the Kingdom of the Netherlands and was no longer part of the Netherlands Antilles.

Shell Petroleum NV also took steps to close its more modern 320,000-barrel-per-day refinery on Curaçao. In August, Shell sold its refinery and the transshipment facility at Bullenbaai to the Government of Curaçao for a token sum of money. In November, the Venezuelan Cabinet approved a proposal that would allow PDVSA's new subsidiary, Isla Refineria, to lease the Curaçao refinery for 5 years at a cost of $11 million per year. PDVSA would supply the refinery with a total of 150,000 barrels per day of light and medium crudes. At yearend, Shell, Curaçao, and the Venezuelan Government were still involved in negotiations aimed at keeping the refinery in operation.[16]

South Africa, Republic of.—Highveld produced 63,207 tons gross weight of slag containing about 25% V_2O_5 in calendar year 1985.[17] The vanadium slag was a byproduct of iron smelting operations at the company's Witbank integrated steelworks in the Transvaal. Highveld brought its new No. 2 iron plant into operation on July 15 and exceeded the design capacity of the plant's 63-megavolt-ampere submerged arc smelting furnace within 3 months. Fused flake and NH_4VO_3 were produced at the company's Vantra facility, which has four rotary kilns and four multiple-hearth roasters. All four of the roasters were in full operation during the second quarter of 1985 because of increased orders. However, two roasters were taken off-line at the end of June when pentoxide sales slackened. Production by the Vantra Div. was estimated to be 4,900 tons of pentoxide. The vanadium-bearing titaniferous magnetite feed for both facilities came from the Mapochs Mine in the Bushveld Complex north of Roossenekal. During the year, the mine shipped 1.67 million tons of lumpy magnetite ore to the steelworks and 0.40 million tons of fines to the Vantra facility. Combined ore shipments were 19% higher than the 1.73-million-ton (revised) total for 1984.[18]

On August 21, Phibro-Salomon Inc., the international investment and commodities trading group, announced that it was withdrawing from all of its remaining businesses in the Republic of South Africa. Some analysts suggested that the withdrawal was prompted by management's concerns about the current sociopolitical situation in the Republic of South Africa, growing pressures in the United States to divest South African stocks, and diminishing returns from bulk ferroalloy sales.[19] The move was significant because of Phibro-Salomon's close financial ties to Anglo American Corp. of South Africa Ltd. The Philipp Brothers Inc. subsidiary of Phibro-Salomon was planning to close its ferroalloys and precious metals trading office in Johannesburg as soon as existing South African contracts expired. Philipp Brothers had been acting in Europe as a marketing agent for a variety of South African materials, including the V_2O_5 produced by Highveld. Highveld, the largest vanadium producer within the market economy countries, is a subsidiary of the Anglo American Industrial Corp. A new trading company, Newco, formed by Anglo American Industrial, Barlow Rand Ltd., and three former Philipp Brothers' employees, was given responsibility for marketing Highveld's V_2O_5 after January 1986. Newco will be headquartered in Switzerland.

East Rand Consolidated PLC (ERC), a

British finance company with South African mining interests, was in the process of raising $13.5 million to develop a major vanadium mine and processing plant in the eastern portion of the Transvaal.[20] The proposed open pit operation would be on the Kennedy's Vale Farm in the Lydenburg District of the Bushveld Complex and would be managed by Vansa Vanadium S.A. Ltd., a newly formed subsidiary of ERC. The vanadium-bearing titaniferous magnetite ore occurs in plug-like masses that average 1.8% V_2O_5, 13.1% TiO_2, and 56.7% Fe. These plug-like masses are situated within the mafic layered complex at a position stratigraphically above the platinum-rich Merensky Reef and the underlying chromite horizons.

The principal plug was mined previously by Highveld between 1960 and 1972. During that 12-year period, Highveld removed 2.58 million tons of ore grading 1.98% V_2O_5. Subsequent drilling by Vansa has delineated an ore body 340 meters long, 24 meters wide, and at least 100 meters deep within a pyroxenite envelope. The ore body contains an estimated 3.22 million tons of magnetite ore averaging 1.95% V_2O_5. An additional 1.5 million tons of ore averaging 0.4% V_2O_5 exists in a mineralized zone that extends 13 meters into the hanging wall and 11 meters into the footwall.

The new operation was projected to produce 3,300 tons of 99% V_2O_5 fused flake annually from 220,000 tons of ore. At that rate, the mine would have 15 to 20 years of reserves. This production could help offset the drop in world supply created by the permanent closure of Rautaruukki's two mines in Finland and the indefinite shutdown of numerous, but smaller uranium-vanadium mines on the Colorado Plateau. It would cost an estimated $14.4 million to bring the proposed mine into full production by 1988. ERC was also considering mining platinum-group metals from the Merensky Reef and the stratigraphically lower UG_2 Reef. The company has already drilled a total of five exploratory holes into the two platiniferous horizons.

Table 10.—Vanadium: World production, by country[1]

(Short tons of contained vanadium)

Country	1981	1982	1983	1984[p]	1985[e]
Production from ores, concentrates, slags:[2]					
Australia (in vanadium pentoxide product)[3]	77	[r]25	--	--	--
Chile[e] [4]	140	--	--	--	--
China (in vanadiferous slag product)[e]	5,000	5,000	5,000	5,000	5,000
Finland (in vanadium pentoxide product)	3,431	3,470	3,516	3,376	[5]2,716
Norway[e]	380	120	--	--	--
South Africa, Republic of:[6]					
Content of pentoxide and vanadate products[e]	4,648	3,981	4,117	[r]6,633	6,520
Content of vanadiferous slag product[e] [7]	9,260	8,930	5,620	[r]7,165	8,929
Total	13,908	12,911	9,737	13,798	[5]15,449
U.S.S.R.[e]	10,500	10,500	10,500	10,500	10,500
United States (recoverable vanadium)	5,126	4,098	2,171	1,617	W
Total	38,562	[r]36,124	30,924	34,291	33,665
Production from petroleum residues, ashes, spent catalysts: [8]					
Japan (in vanadium pentoxide product)	687	754	778	[e]770	840
United States (in vanadium pentoxide and ferrovanadium products)	1,900	1,513	893	1,701	2,695
Total	2,587	2,267	1,671	2,471	3,535
Grand total	41,149	[r]38,391	32,595	36,762	37,200

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1]In addition to the countries listed, vanadium is also recovered from petroleum residues in the Federal Republic of Germany, the U.S.S.R., and several other European countries, but available information is insufficient to make reliable estimates. Table includes data available through July 8, 1986.

[2]Production in this section is credited to the country that was the origin of the vanadiferous raw material.

[3]Reported output for export.

[4]Based on U.S. imports of vanadium-bearing slag.

[5]Reported figure.

[6]Includes production for Bophuthatswana.

[7]Data on vanadium content of vanadium slag are estimated on the basis of a reported tonnage of vanadium-bearing slag (gross weight) multiplied by an assumed grade of 14.1% vanadium.

[8]Production in this section is credited to the country where the vanadiferous product is extracted; available information is inadequate to permit crediting this output back to the country of origin of the vanadiferous raw material.

TECHNOLOGY

An evaluation of the iron-vanadium binary phase diagram was published in June by a scientist at Iowa State University.[21] The iron-vanadium binary is a relatively simple system with continuous solid solution at elevated temperatures and an intermediate phase that forms congruently from the high-temperature solid solution near equiatomic stoichiometry. The evaluation work was carried out at the Ames Laboratory as part of an international effort coordinated by the ASM and the National Bureau of Standards that provides industry with assessed phase diagrams of potential interest.

The petroleum industry has been studying the occurrence of vanadium, nickel, and other transition metals in crude oil for several decades. However, downward pressure on oil prices and the increasing amounts of heavy oil being refined have caused research on the subject to be stepped up. Even small amounts (i.e., 5 to 75 parts per million) of vanadium in refinery feedstocks can seriously degrade the activity of the cracking catalysts, resulting in increased gas and coke formation and reduced yields of gasoline. The burning of vanadium-bearing fuel oil at power stations produces corrosive vanadium ash that, if allowed to build up, can damage turbine rotors and refractory furnace linings.

As much as 40% of the vanadium and nickel may be present in the petroleum as metalloporphyrins (nitrogen-metal organocomplexes formed from four pyrrole rings). A significant part of the research on the nature of the metalloporphyrins and other metal complexes in petroleum was to be presented at a symposium sponsored by the American Chemical Society.[22] Because vanadium in the tetravalent state is paramagnetic and frequently occurs as the vanadyl complex cation (VO^{+2}) in crude oil and bitumen, electron paramagnetic resonance (EPR) is an effective tool for studying the distribution of vanadium between the metalloporphyrins, nonporphyrin complexes, and associated mineral clays such as montmorillonite and illite. EPR studies at Texas Christian University have confirmed that much of the vanadium in the asphaltene fractions from the Boscan heavy crude of Venezuela and the Circle Cliffs tar sands of Wyoming are in the form of vanadyl etioporphyrin. A joint team of researchers at the University of California at Berkeley and the Chevron Research Co. in neighboring Richmond, CA, have been using electron spin resonance spectroscopy (ESR) to analyze some of the vanadyl nonporphyrin compounds found in heavy crude. Similar ESR studies of vanadyl complexes in asphaltenes and maltenes were being carried out at the Chiyoda Chemical Engineering and Construction Co. Ltd., in Yokohama, Japan.

During the refining of heavy crude, the vanadium fouls the hydrodesulfurization (HDS) catalysts by depositing at the mouths of the particle pores. The nickel, in contrast, is able to penetrate deeper into the particle. Researchers at the Georgia Institute of Technology have been working with the American Cyanamid Co. to develop a process for removing the vanadium and nickel contaminants from the HDS catalysts without removing the active cobalt and molybdenum constituents. One promising rejuvenation method involves pretreating the catalyst with a 5% hydrogen sulfide-helium mixture at 540° C followed by the extraction of the vanadium and nickel with an acidic solution of ferric ion at 100° C.[23]

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Vermiculite

By A. C. Meisinger[1]

U.S. production of vermiculite concentrate in 1985 decreased slightly to 314,000 short tons sold and used and increased slightly in value to $32.4 million, compared with 315,000 tons and $31.5 million in 1984. Sales of exfoliated vermiculite from 41 plants in 27 States decreased slightly in quantity to 258,000 tons valued at $47.9 million.

Carolina Vermiculite Inc., Woodruff, SC, began mining and milling vermiculite during the year from deposits in Spartanburg and Laurens Counties, SC.

The United States and the Republic of South Africa continued to be the leading vermiculite producing countries with 93% of the estimated world production of 556,000 tons.

Domestic Data Coverage.—Domestic production data for vermiculite are developed by the Bureau of Mines from two separate voluntary surveys, one for domestic mine operations and the other for exfoliation plant operations. Of the four mining operations to which a request was sent, three responded. The one nonrespondent's data were estimated using previous years' production levels adjusted by trends in employment and other guidelines. Of the 43 exfoliating plants to which a request was sent, 41 were active, and 38, or 93%, responded, representing 85% of the total exfoliated vermiculite sold and used shown in table 1. Plant data for the three nonrespondents were estimated using reported previous years' production levels adjusted by trends in employment and other guidelines.

Table 1.—Salient vermiculite statistics

(Thousand short tons and thousand dollars unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Sold and used by producers:					
Concentrate	320	316	282	315	314
Value	$26,200	$28,500	$27,200	$31,500	$32,400
Average value[1] dollars per ton	$81.88	$90.19	$96.45	$100.00	$103.18
Exfoliated	274	235	224	264	258
Value	$58,600	$55,500	$52,200	$56,500	$47,900
Average value[1] dollars per ton	$213.87	$236.17	$233.04	$214.02	$185.66
Exports to Canada	31	22	19	22	[e]23
Imports for consumption	[e]27	[e]21	[e]24	32	[e]38
World: Production[2]	577	560	490	[p]545	[e]556

[e]Estimated. [p]Preliminary.
[1]Based on rounded data.
[2]Excludes production by centrally planned economy countries.

DOMESTIC PRODUCTION

U.S. production of vermiculite concentrate decreased slightly in tonnage to 314,000 tons valued at $32.4 million.

W. R. Grace & Co. continued as the leading domestic producer with operations at Libby, MT, and Enoree, SC. Vermiculite was also mined and processed by Patterson Vermiculite Co. near Enoree, SC, by Carolina Vermiculite, Woodruff, SC, and by Virginia Vermiculite Ltd. in Louisa County, VA. Carolina Vermiculite went on-stream in mid-1985 with processing operations near Woodruff and mines in Spartanburg and Laurens Counties, SC.

Domestic sales of exfoliated vermiculite by 12 producers declined slightly in quantity to 258,000 tons, and 15% in value to $47.9 million. Output came from 41 plants in 27 States, of which 29 plants in 24 States were operated by W. R. Grace.

In descending order of exfoliated vermiculite output sold and used, the principal producing States were California, Ohio, Florida, South Carolina, Texas, New Jersey, and Illinois.

CONSUMPTION AND USES

Apparent domestic consumption of vermiculite concentrate was 329,000 tons, a sight increase from 325,000 tons (revised) in 1984.

The quantity of exfoliated vermiculite sold and used for both construction aggregate material and agriculture increased slightly; however, insulation uses declined 14% from those of 1984. Other uses in 1985 increased 48% to 4,600 tons.

Table 2.—Exfoliated vermiculite sold and used in the United States, by end use

(Short tons)

End use	1984	1985
Aggregates:		
Concrete	51,600	52,700
Plaster	2,700	2,500
Premixes[1]	80,300	80,200
Total[2]	[r]134,700	135,300
Insulation:		
Loose-fill	25,900	20,500
Block	38,500	35,700
Other[3]	3,300	1,700
Total	67,700	57,900
Agricultural:		
Horticultural	22,100	22,400
Soil conditioning	4,700	8,400
Fertilizer carrier	31,600	29,000
Total	58,400	59,800
Other[4]	3,100	4,600
Grand total[2]	264,000	258,000

[r]Revised.
[1]Includes acoustic, fireproofing, and texturizing uses.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes high-temperature and packing insulation and sealants.
[4]Includes various industrial uses not specified.

Table 3.—Active vermiculite exfoliating plants in the United States in 1985

Company	County	State
A-Tops Corp	Beaver	Pennsylvania.
Brouk Co	St. Louis	Missouri.
	Irondale	Alabama.
	Maricopa	Arizona.
	Pulaski	Arkansas.
	Alameda	California.
	Orange	Do.
	Denver	Colorado.
	Broward	Florida.
	Duval	Do.
	Hillsborough	Do.
	Du Page	Illinois.
	Campbell	Kentucky.
	Orleans	Louisiana.
	Prince Georges	Maryland.
W. R. Grace & Co., Construction Products Div	Hampshire	Massachusetts.
	Wayne	Michigan.
	Hennepin	Minnesota.
	St. Louis	Missouri.
	Douglas	Nebraska.
	Mercer	New Jersey.
	Cayuga	New York.
	Guilford	North Carolina.
	Oklahoma	Oklahoma.
	Multnomah	Oregon.
	Lawrence	Pennsylvania.
	Greenville[1]	South Carolina.
	Davidson	Tennessee.
	Bexar	Texas.
	Dallas	Do.
Intermountain Products Inc	Salt Lake	Utah.
Koos Inc	Kenosha	Wisconsin.
O. M. Scott & Sons	Union	Ohio.
Patterson Vermiculite Co	Laurens	South Carolina.
Robinson Insulation Co	Cascade	Montana.
The Schundler Co	Middlesex	New Jersey.
Strong-Lite Products Corp	Jefferson	Arkansas.
Strong-Lite Products Corp. of Illinois	De Kalb	Illinois.
Verlite Co	Hillsborough	Florida.
Vermiculite Products Inc	Harris	Texas.

[1]2 plants in the county.

PRICES

The average value of vermiculite concentrate sold and used by U.S. producers increased slightly to about $103 per ton, f.o.b. plant. The average value of exfoliated vermiculite, f.o.b. plant, declined for the third straight year from $214 per ton to $186 per ton, a 13% decrease.

Engineering and Mining Journal quoted yearend prices for unexfoliated vermiculite as follows, per short ton: Montana and South Carolina, f.o.b. mine, $96 to $143.50; and the Republic of South Africa, c.i.f. Atlantic ports, $90 to $150.

FOREIGN TRADE

Imports of vermiculite concentrate from the Republic of South Africa were estimated to be 38,000 tons, compared with 32,000 tons (revised) in 1984. Exports to Canada were estimated to be 23,000 tons and represented 7% of total sales.

WORLD REVIEW

World production was estimated to be 556,000 tons, a slight increase over 1984 production of about 545,000 tons. The United States and the Republic of South Africa, together, accounted for 93% of the total 1985 output. Vermiculite concentrate production in the Republic of South Africa increased 6% to about 203,000 tons, and exports accounted for 86% of production.

[1]Industry economist, Division of Industrial Minerals.

Table 4.—Vermiculite: World production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Argentina	3,557	3,697	4,355	4,906	4,400
Brazil	15,771	15,497	10,888	10,094	11,000
Egypt	800	309	331	[e]360	360
India	3,995	2,280	2,658	2,153	2,200
Japan[e]	19,000	19,000	19,000	19,000	19,000
Kenya	[e]2,900	1,715	[e]1,300	961	1,100
Mexico	657	575	440	557	550
South Africa, Republic of	210,101	201,327	168,691	191,536	[2]202,902
Tanzania	([3])	([3])	([3])	([3])	NA
United States (sold and used by producers)	320,000	316,000	282,000	315,000	[2]314,000
Total	[r]576,781	[r]560,400	489,663	544,567	555,512

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Excludes production by centrally planned economy countries. Table includes data available through July 15, 1986.
[2]Reported figure.
[3]Revised to "Not available." Output is not officially reported and available information is inadequate for formulating reliable estimates of output levels, if any.

Zinc

By James H. Jolly[1]

World mine and smelter production were at record-high levels, whereas the U.S. zinc producing industry continued to decline. As a result of strikes and mine closures, domestic mine production fell for the fifth straight year, and 1985 was the lowest zinc output year in 77 years. Smelter output also fell owing mainly to the indefinite closure of a primary smelter in Texas early in the year. A primary smelter in Idaho, which had been indefinitely closed since December 1981, was closed permanently in 1985. As a result, U.S. primary zinc smelting capacity was reduced 20% to 404,000 metric tons. The United States accounted for about 3.9% of the world zinc mine output and 4.8% of the world zinc metal production, compared with 5.8% and 6.1%, respectively, in 1980.

World zinc consumption was at an all-time high. The United States was the leading zinc consumer, although zinc consumption declined in 1985. Domestic demand for zinc was met mainly by imports, largely from Canada. Slab zinc imports accounted for about 65% of the apparent slab zinc consumption, and zinc oxide imports cap-

Table 1.—Salient zinc statistics

(Metric tons unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production:					
Domestic ores, recoverable content	312,418	303,160	275,294	252,768	226,545
Value thousands	$306,879	$257,116	$251,204	$270,833	$201,607
Slab zinc:					
From domestic ores	259,835	193,284	210,315	197,912	172,773
From foreign ores	86,728	34,892	25,379	55,220	63,204
From scrap	50,192	74,288	69,390	78,113	75,574
Total	396,755	302,464	305,084	331,245	311,551
Secondary zinc[1]	290,658	210,681	279,237	320,456	289,440
Exports:					
Ores and concentrates (zinc content)	54,232	77,289	60,168	30,579	23,264
Slab zinc	323	341	427	760	1,011
Imports for consumption:					
Ores and concentrates (zinc content)	245,710	66,809	63,156	86,172	90,186
Slab zinc	612,007	456,233	617,679	639,228	610,900
Stocks of slab zinc, Dec. 31:					
Producer and consumer	126,581	111,777	112,940	118,834	91,342
Merchant	68,773	47,397	35,199	18,792	27,163
Government stockpile	340,581	340,578	340,577	340,577	340,577
Consumption:					
Slab zinc:					
Reported	840,875	709,491	805,891	848,903	764,752
Apparent[2]	938,886	794,536	933,371	980,226	940,561
All classes	1,189,369	953,111	1,120,548	1,214,558	1,095,364
Price: High Grade, cents per pound (delivered)	44.56	38.47	41.39	48.60	40.37
World:					
Production:					
Mine thousand metric tons	r5,919	r6,126	6,351	p6,564	e6,656
Smelter do	r6,081	r5,866	6,201	p6,463	e6,567
Price: Prime Western, London, cents per pound	38.34	33.74	34.73	40.46	36.23

eEstimated. pPreliminary. rRevised.
[1]Excludes redistilled slab zinc.
[2]Domestic production plus net imports plus/minus stock changes.

tured a record high 22% of the apparent zinc oxide consumption. Zinc prices rose through May, then fell for the rest of the year as demand weakened. At yearend, zinc prices, in constant dollar terms, were among the lowest recorded since the early 1930's.

Domestic Data Coverage.—Domestic data for zinc are developed by the Bureau of Mines from seven separate, voluntary surveys of U.S. operations. Typical of these surveys is the annual zinc survey, which, in part, covers the primary and secondary slab zinc producers. Of the 15 slab zinc producers to which the survey request was sent, 12 responded, representing 76% of the total slab zinc production shown for 1985 in tables 1, 7, and 8. Production for the three nonrespondents was estimated using prior year production levels.

Legislation and Government Programs.—The National Defense Stockpile goal for zinc was 1,292,739 tons, unchanged since May 1980. The total zinc inventory held by the Government at yearend was 343,202 tons, including 2,625 tons of zinc in the form of brass.

On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. According to the NSC guidelines, zinc would be categorized in tier II, and the goal would be 77,110 tons of zinc metal. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Public Law 96-510), commonly known as the Superfund, expired on September 30, 1985. Various reauthorization bills, such as S. 51, passed by the Senate on September 26, and H.R. 2817, passed by the House of Representatives on December 10, were under consideration by the Congress.

In August, the Environmental Protection Agency (EPA) issued new provisions designed to ensure proper handling of waste generated by about 175,000 businesses, including plants that roll, cast, coat, and draw nonferrous metals. Businesses that produce between 220 and 2,200 pounds of hazardous waste per month were covered. In November, EPA established new regulations covering effluent limits for foundry and die-cast companies in four metal categories, including zinc. Principal pollutants likely to be found in the plant's untreated waste waters were suspended solids, oil and grease, toxic metals, and chemicals. Most of the secondary zinc industry was excluded because the zinc recovery methods did not require process water.

The Occupational Safety and Health Administration promulgated rules in November that required manufacturers and distributors, including recyclers and scrap processors, to collect and provide data sheets on hazardous materials in their products and to label containers they ship out. In May 1986, additional standards were to go into effect requiring training and education of employees in contact with hazardous materials.

DOMESTIC PRODUCTION

MINE PRODUCTION

U.S. zinc mine production continued its downtrend for the fifth straight year, resulting in the lowest production year since 1908. Strikes at zinc mines in Tennessee and New York contributed most to the production decline. Tennessee was the principal zinc producing State, followed by Missouri and New York. The leading zinc mine producers were ASARCO Incorporated; St. Joe Minerals Corp., a subsidiary of Fluor Corp.; and Jersey Minière Zinc Co., a subsidiary of the Belgium company Union Minière S.A.

The 25 leading U.S. zinc producing mines accounted for 99% of the zinc mined, with the 10 leading mines accounting for 81%.

In Tennessee, zinc was produced from zinc ore at eight underground mines and from sulfur-copper-zinc ores at underground and open pit operations at Copperhill. Jersey Minière operated the Elmwood and Gordonsville Mines in central Tennessee and was the leading producer in the State in 1985. Zinc output by Asarco, operator of four zinc mines in east Tennessee and usually the leading producer, fell sharply owing to extended strikes during the year. Asarco's Young, Coy, and Immel Mines were struck for 6 months beginning April 1, and the New Market Mine was struck for 4 months beginning May 1. According to Asarco's annual report, the company milled 1.4 million tons of ore from its four mines in 1985, producing 34,020 tons of zinc in concentrate. In 1984, Asarco milled 2.6 million tons of ore, producing 61,050 tons of zinc in concentrate. At yearend 1985, ore reserves at the four mines were estimated by the company to be 6.3 million tons averaging 3.22% zinc.

Inspiration Mines Inc. reopened its Beaver Creek Mine near Jefferson City, TN, in late February following settlement of a 2-month strike. In late November, Inspiration closed down the operation, idling about 120 employees, reportedly because of poor results and declining zinc prices.

Zinc produced in Missouri was a coproduct of lead at seven underground lead mines, all along the Viburnum Trend. Zinc production improved over that of 1984 mainly because the lead-zinc mines in the State were strike-free in 1985. Asarco brought its new West Fork lead-zinc mine on-stream in early September following completion of the underground crusher. Zinc production in concentrate was only 90 tons but was planned to increase to about 2,800 tons or 40% of capacity in 1986. At yearend, the West Fork Mine reportedly had 13.5 million tons of ore reserves averaging 5.5% lead and 1.2% zinc with some copper and silver.

According to company annual reports, AMAX Lead Co. of Missouri and Homestake Mining Co., joint owners of the Buick Mine, mined and milled 2.1 million tons of Buick ore, yielding about 21,870 tons of zinc in concentrate. Although this represented a 52% increase over ore milled in 1984, zinc output was only up about 20% because the average grade of zinc in the ore milled fell 0.4% to 1.4% in 1985. As a result of a revised mining plan, proven and probable ore reserves at the Buick Mine were significantly reduced; however, the average ore grades were up substantially. At yearend, ore reserves were estimated by the operators to be 18.1 million tons grading 8.0% lead and 2.2% zinc compared with 32.7 million tons grading 5.6% lead and 1.4% zinc 1 year earlier.

The Magmont Mine, owned jointly by Cominco American Incorporated, the U.S. subsidiary of Cominco Ltd., and Dresser Industries Inc., was the second leading zinc producing mine in Missouri. According to the Cominco annual report, the company milled 1.04 million tons averaging 7.5% lead and 1.9% zinc and produced 28,100 tons of zinc concentrate containing 16,400 tons of zinc. At yearend, ore reserves at the Magmont Mine reportedly were 6.3 million tons averaging 6.5% lead, 1.1% zinc, and 0.4 troy ounce of silver per ton.

St. Joe operated four of its five zinc producing lead mines in Missouri during the year; the Brushy Creek Mine, closed during a 9-month strike of St. Joe operations in 1984, was not reopened after the strike was settled. According to the company's annual 10K report, St. Joe mined a combined total of 3.2 million tons of ore averaging 5.1% lead and about 0.4% zinc during the fiscal year ending October 31. Zinc production in concentrate was 11,700 tons, compared with 12,250 tons and 19,800 tons, respectively, in fiscal years 1983 and 1984. The zinc concentrates produced in 1985 were sent to St. Joe's zinc refinery in Bartlesville, OK, for processing. Ore reserves at St. Joe's lead mines in Missouri were estimated by the company to be 56.8 million tons averaging 5% lead and 0.5% zinc at the end of the fiscal year.

In New York, St. Joe operated the Balmat and Pierrepont Mines. All ore was milled at the company's Balmat mill, which had an ore milling capacity of about 3,900 tons per day. Production was affected by a strike that began in July and was not settled by yearend. In the latter half of the year, supervisory and nonunion personnel continued both mine and mill production but at a reduced rate. According to the company's 10K report, for the fiscal year ended October 31, St. Joe mined and milled 531,000 tons of ore averaging about 10.7% zinc and produced 53,300 tons of zinc in concentrate. In fiscal year 1984, the company mined 670,000 tons of ore and produced 57,500 tons of zinc in concentrate. At the end of fiscal year 1985, St. Joe estimated that its zinc ore reserves in New York were 3.7 million tons with an average grade of about 13.6% zinc.

In Colorado, zinc production came largely from the Leadville Mine, managed by Asarco but jointly owned by Asarco and Resurrection Mining Co., a Newmont Mining Corp. subsidiary. The State's other significant zinc producer, the Sunnyside gold-silver operation near Silverton, was indefinitely closed in March owing, in part, to financial problems of the mine's owner, Standard Metals Corp. In October, Standard sold the mine to the Canadian firm Echo Bay Mines Ltd., which planned to reopen the mine in the second half of 1986. The Idarado Mining Co. wrote off the asset value of its Idarado lead-zinc-copper-silver-gold mine in Colorado and put aside $1.5 million to eventually permanently close the property. The mine, which is near the Sunnyside Mine, had been closed since 1978.

Asarco reported that it milled 197,000 tons of Leadville ore, slightly more than that of 1984, resulting in a production of 12,060 tons of zinc in concentrate plus 6,080 tons of lead, 344,000 troy ounces of silver, and 17,195 troy ounces of gold. Yearend ore reserves at the Leadville Mine were 748,000 tons averaging 9.14% zinc, 4.35% lead, 0.21% copper, 2.9 ounces of silver per ton, and 0.1 ounce of gold per ton.

In Idaho, Hecla Mining Co., operating the Lucky Friday silver-lead-zinc mine, and Star-Morning Mining Co., operating the Star-Morning Mine under a lease from Hecla, were the only major zinc producers in the State. Minor quantities of zinc were produced at several silver mines. Hecla milled a record high 251,000 tons of ore and produced 3,550 tons of zinc in concentrates at the Lucky Friday Mine in 1985. Ore reserves were up marginally from that of 1984, and at yearend totaled 608,000 tons averaging 1.9% zinc, 16.6% lead, and 18.3 ounces of silver per ton. Star-Morning Mining ceased mining at the Star-Morning Mine late in the year because of poor zinc prices.

Noranda Ltd. and its partners continued underground drilling at the Greens Creek silver-lead-zinc property on Admiralty Island near Juneau, AK. Under the Alaska National Interest Lands Act of 1980, Noranda was given through 1985 to explore the area around its core mining claims; however, a 1-year extension was granted by Congress to do additional exploration because unexplored mineralized areas remained. Ore reserves, based on updated forecasts and mining plans, were reduced in 1985 and at yearend were estimated to be 2.4 million tons averaging 9.05% zinc, 3.50% lead, 0.46% copper, 22.5 ounces of silver per ton, and 0.13 ounce of gold per ton. An operations plan, approved by the U.S. Forest Service, envisioned mine startup in 1988, with an initial zinc production of about 8,000 tons per year, gradually increasing to about 22,000 tons per year.

Two government actions enhanced the development prospects of the huge Red Dog zinc-lead-silver deposit in northwestern Alaska in 1985. The President approved a land swap between the U.S. Park Service and NANA Regional Corp. that provided for a 100-year right-of-way easement through the Cape Krusenstern National Monument to allow construction of a road from the Chukchi Sea to the deposit. In another arrangement, the State agreed to finance construction of the road and port facilities at an estimated cost of $150 million. Plans called for port construction to begin in the summer of 1986, followed by 2 years of road construction beginning in 1987. At yearend, the State and the developers of the Red Dog deposit, Cominco American and NANA, were in the final stages of negotiating a user fee schedule that will reimburse the State for its financing of the road and port facilities. Development of the minesite was expected to begin in 1988 with production expected in 1990. Ore reserves at Red Dog were estimated to be 77 million tons averaging 17.1% zinc, 5% lead, and 2.6 ounces of silver per ton.

The development potential of the Lik lead-zinc deposit, 12 miles north of the Red Dog deposit, was also enhanced by the road and port development plans for northwestern Alaska. Noranda signed a 20-year joint venture agreement in May with GCO Minerals Co., owner of the Lik deposit. Terms of the agreement called for Noranda to spend $25 million for exploration over the next two decades to earn one-half interest in the deposit. The Lik deposit was estimated to contain about 23 million tons of 12% combined lead and zinc.

Centennial Minerals Ltd. and U.S. Minerals Exploration Co. received final approval from the Montana Hard Rock Mining Board to develop an open pit mine at their Montana Tunnels gold-silver-zinc-lead deposit, 35 miles north of Butte. Ore reserves were estimated to be 48 million tons averaging about 0.67% zinc, 0.28% lead, 0.4 ounce of silver per ton, and 0.03 ounce of gold per ton. Initial site preparation was expected to start in March 1986 with production scheduled to begin in May 1987. When fully operational, annual production was projected to be 22,700 tons of zinc, 5,200 tons of lead, 1.7 million ounces of silver, and 106,000 ounces of gold. Late in the year, the Canadian firm Pegasus Gold Inc. acquired Centennial Minerals and its 50% interest in the project, and at yearend, Pegasus was negotiating with U.S. Minerals Exploration to acquire its one-half interest.

Exxon Minerals Co. revised its mining plans at the Crandon deposit in Wisconsin to emphasize zinc production as opposed to simultaneous zinc-copper production. Under the new plan, the massive sulfide ore, which contains most of the zinc, would be mined first, leaving the stringer ore, which is mainly copper, to be mined later. In addition, the company expected to lower its daily production rate to 6,400 tons, down from the 8,300 tons initially planned. State permitting continued to delay development of the property but was progressing. At yearend, the impact of ground water drawdown owing to underground mining and drawdown effects on nearby lakes and streams was the principal concern. If all permits were obtained in 1986, Exxon envisioned production to start in the early 1990's.

SMELTER AND REFINERY PRODUCTION

Slab zinc was produced at five primary smelters and eight secondary plants in 1985. Production was down slightly from that of 1984 owing mainly to the indefinite closure of Asarco's Corpus Christi, TX, zinc refinery on April 1. The leading producers of primary slab zinc were St. Joe, Jersey Minière, and AMAX, and the leading producers of metal from secondary materials were St. Joe, Huron Valley Steel Corp., and Inter-american Zinc Co.

Asarco closed its 104,000-ton-per-year zinc refinery in Texas owing to poor results caused mainly by low metal prices, high power costs, and to a lesser extent, lack of feed materials. The shutdown of the plant, which had only resumed production in May 1984 after an 18-month suspension of operations, resulted in the layoff of about 275 workers. Metal production for the year totaled 11,400 tons, compared with a production of 28,500 tons in 1984. The closure represented $120 million of the $216 million writeoff the company took against its fourth-quarter 1984 results. As a result of the closing and to maintain other domestic operations requiring zinc metal, Asarco arranged a partial toll contract with Jersey Minière to provide metal in return for zinc concentrates from its Tennessee zinc mines.

St. Joe, owner of zinc refineries at Bartlesville, OK, and Monaca, PA, was the largest domestic producer of slab zinc, accounting for about 40% of U.S. production. The Bartlesville refinery, which was acquired in August 1984, operated near capacity in 1985, utilizing mainly purchased concentrate but also concentrates from St. Joe's lead-zinc mines in Missouri and from Asarco under a tolling arrangement. In fiscal year 1985, St. Joe's zinc refineries produced 147,200 tons of zinc in the form of slab zinc, dust, and oxide.

Bunker Ltd. permanently closed its 103,000-ton-per-year zinc refinery at the Bunker Hill Mine and smelter complex at Kellogg, ID. The complex was closed indefinitely in December 1981. In October, Bunker auctioned off substantial amounts of the complex's machinery, equipment, and metals used for electrolytic processing. Large items, including the zinc plant with or without the buildings and compressor room and electrical equipment, were scheduled to be sold through private negotiations.

Federated Metals Corp., a wholly owned subsidiary of Asarco, closed its zinc dust plant at Sand Springs, OK, in October owing to poor financial results. Federated had previously closed zinc-dust producing plants at Trenton, NJ, and Whiting, IN, in January 1983 for similar reasons.

Zinc Oxide.—The raw material sources of domestic zinc oxide production were 35% from ores and concentrates, 36% from slab zinc, and 29% from secondary materials. French-process zinc oxide accounted for about 65% compared with about 64% in 1984. Zinc oxide was produced at 11 plants. The largest producers of zinc oxide were Asarco; The New Jersey Zinc Co. Inc. (NJZI), a subsidiary of Horsehead Industries Inc. (HII); Pacific Smelting Co.; and St. Joe.

Zinc oxide production at Asarco's two plants, at Columbus, OH, and Hillsboro, IL, was 23,360 tons compared with 31,860 tons in 1984. The Columbus plant, which has a capacity to produce 21,000 tons of American-process zinc oxide annually, was written down against fourth-quarter 1984 results and was scheduled to be permanently closed in the second quarter of 1986. With this closure, the NJZI plant at Palmerton, PA, would be the only domestic producer of American-process zinc oxide.

NJZI processed direct-shipping ore from its Sterling, NJ, mine, slab zinc, and waste and scrap materials to produce both American- and French-process zinc oxide at its plant at Palmerton, PA. An NJZI sister company, Horsehead Resource Development Co. (HRD), also a subsidiary of HII, used Waelz-kiln and sintering facilities at the Palmerton plant to produce crude zinc oxide from steelmaking electric arc furnace (EAF) dusts. The crude zinc oxide products, which typically contained about 55% zinc, 6% lead, and some cadmium, were further processed into marketable metal and zinc oxide at the plant or were shipped elsewhere. In 1985, HRD processed about 54,000 tons of EAF dust, which generally contained 20% or higher zinc content; HRD planned to double the tonnage processed in 1986. Standard treatment cost per ton of EAF dust was about $45; an additional cost of $3 to $4 per ton was charged per percent zinc under 20%.

Zinc Salts.—Zinc sulfate was produced by 11 companies from secondary materials and concentrate; most was used for agricultural purposes. Zinc chloride was produced entirely from secondary materials by seven companies.

Byproduct Sulfur.—Production of sulfur in byproduct sulfuric acid at five primary zinc plants and one zinc oxide plant from zinc sulfide concentrates was 140,700 tons compared with 144,700 tons in 1984. The decrease was due mainly to decreased output at Asarco's zinc refinery in Texas. The estimated value of the sulfuric acid produced at zinc plants was $17.6 million, up $3.1 million from that of 1984.

CONSUMPTION AND USES

Domestic zinc consumption for most end-use categories fell slightly. The construction industry accounted for about 45% of zinc consumption, followed by transportation, 20%; machinery, 10%; electrical, 10%; and chemical and other industries, 15%. Galvanizing, mainly for sheet and strip, continued to be the principal use of slab zinc, consuming about 47%, followed by zinc-base alloys, 29%; brass and bronze alloys, 10%; rolled zinc, 6%; and other uses, 8%. Of the metal grades consumed, Special High Grade (SHG) accounted for about 55% and was mainly used for the production of zinc-base alloys. The Bureau of the Mint purchased about 28,550 tons of SHG zinc and produced about 10.9 billion pennies, 2.8 billion less than that of 1984. Prime Western (PW) was second in slab zinc consumption and was mainly used for hot-dip galvanizing purposes.

According to the Bureau of the Census, domestic producers' shipments of zinc-base alloy castings were about 312,000 tons, up about 22% from that of 1984. The estimated percentage distribution of zinc die and foundry castings by market sector, based on 1984 data, was as follows: automotive, 32%; builders' hardware, 28%; machinery and household appliances, 18%; electrical components, 15%; and other equipment, 7%.[2]

The average weight of zinc diecastings in the typical 1985 U.S.-built automobile was an estimated 20.2 pounds according to a Zinc Institute Inc. (ZI) study.[3] This represented a 1.5-pound drop from the 1984-model-year average weight and an average decline of 1 pound per year since 1980. The decrease was attributed to continuing weight reduction and downsizing programs, substitution, and improved zinc diecasting methods. Zinc die-cast usage in trucks and vans was not included in the study; however, the typical new truck was estimated to have averaged 15 to 20 pounds of aftermarket or optional equipment zinc diecastings in 1985.

The automobile industry continued to increase the amount of zinc used for corrosion protection per unit vehicle. According to a ZI report,[4] the typical U.S.-built 1985 automobile contained 6.79 pounds of zinc as coating materials in the form of galvanized, electrogalvanized, galvannealed, and zincrometal coated steel. This represented a 0.56-pound gain over the 1984-model average of 6.23 pounds. If zinc-rich paints and a 35% offal factor from coated steel stampings were included, the zinc used for the corrosion protection of a typical domestic-built automobile averaged about 11.4 pounds in 1985 compared with 10.6 pounds in 1984 and 9.7 pounds in 1983. An estimated 42,000 tons of zinc was used for corrosion protection of the 8.2 million U.S.-built automobiles in 1985. The trend toward using less zincrometal and zinc-rich paint and more galvanized and electrogalvanized metal continued. Further increases in zinc and zinc alloy usage for corrosion protection, especially in the form of electrogalvanized steel sheet, were expected. The steel industry was adding about 2.2 million tons of electrogalvanizing capacity, most of which was expected to be on-stream by the end of 1986.

Zinc consumption in copper-base alloys by brass mills, ingot makers, and foundries fell about 19% from that of 1984. According to the Copper Development Association Inc., the brass and bronze industry consumed about 160,000 tons of zinc, the source of which was about equally divided between refined zinc metal and brass and bronze scrap metal.[5] Brass mills accounted for more than 73% of the zinc consumption.

The apparent consumption of zinc oxide was about 177,000 tons, down from 186,000 tons in 1984. Imports were at record-high levels, whereas domestic production and shipments decreased. The rubber industry, which uses zinc oxide as a chemical accelerated and vulcanization activator in rubber processing, continued to be the largest single user of zinc oxide.

STOCKS

Slab zinc stocks held by domestic producers, consumers, and merchants were less at yearend 1985 than at the start of the year. Weakening prices and demand in the second quarter led to declining stock levels, which recovered some in July and more or less stabilized at that level for the rest of the year. Stocks of slab zinc held in the market economy countries, according to the International Lead and Zinc Study Group (ILZSG), fell about 34,000 tons in 1985, ending the year at 592,000 tons.[6]

Stocks of slab zinc at the London Metal Exchange (LME) ended 1985 at 30,600 tons, up about 1,500 tons from those of 1984. The longstanding good ordinary brand (GOB) zinc contract was phased out in September in preference of the new High Grade (HG) zinc contract. HG zinc accounted for more than 55% of the ending stocks, up from 16% at the start of the year.

Inventories of zinc in ores and concentrates at domestic smelters continuously declined from 66,000 tons in January to 37,000 tons in September, ending the year at 43,500 tons, according to the American Bureau of Metal Statistics Inc. Part of the decline and reduced amount at yearend was attributable to the closing down of Asarco's zinc refinery earlier in the year.

PRICES

U.S. zinc prices were relatively stable in the first half of 1985 but declined sharply in the second half. U.S. Mint tenders for SHG zinc metal for coin manufacture were major influencing factors in setting zinc-price trends during the year. Low winning bids in the mid-January Mint tender resulted in an almost immediate 2-cent drop to 43 cents per pound in the benchmark U.S. producers' HG zinc price. Higher winning bids in the February tender, coupled with improving zinc market fundamentals, led to a gradual 4-cent-per-pound increase in the benchmark zinc price by the end of April. Market conditions weakened in May, leading to widespread discounting from the producers' price. Lower-than-expected bids in the mid-June Mint tender accelerated a price drop to 41 cents per pound for HG zinc by mid-July. Price weakness continued in the summer months, and in September, surprisingly low Mint tender bids in the 34- to 35-cent-per-pound range for SHG zinc, coupled with continuing deterioration in world zinc market conditions, led to a severe drop to 35 cents per pound in the U.S. producers' HG price. Although this price held to yearend, discounting was widespread. In the first half of 1985, the Metals Week U.S. HG zinc price averaged 43.8 cents per pound, and in the second half, only 37.0 cents per pound.

The 0.5-cent-per-pound premium on the price of PW zinc over the HG zinc price largely disappeared in the domestic market in the latter half of the year. The premium cancellation was attributed to competition mainly from St. Joe, which dropped the PW premium in August 1984.

World zinc prices, which were essentially based on the European producer price (EPP) and LME price, paralleled U.S. price trends in 1985. The EPP, as quoted in Metal Bulletin, increased from $900 per ton at the start of the year to $970 in April before spiraling downward to $670 at the end of the year. The LME prices closely matched the EPP in the early months of 1985, but from May, generally were 3 to 4 cents lower. The collapse of world prices in the latter half of the year was attributed mainly to weakening demand and perceived surpluses of concentrates and metal. Exacerbating the price decline was a widely held perception through most of 1985 that China was reducing its zinc imports below those of 1984; the fact that China purchased about 268,000 tons of slab zinc, 38,000 more than in 1984, was not generally known until late in the year. Despite the price decreases, most Western European and other world zinc producers continued smelter production at high operating rates, in part because concentrates were readily available at favorable treatment-charge rates and because of advantages accruing from currency differences with the U.S. dollar. At yearend, several Western European zinc producers were considering plans to switch from the volatile U.S. dollar-base pricing system to a multicurrency system to reduce unpredictable swings in zinc values generated by currency fluctuations.[7]

American- and French-process lead-free zinc oxide prices at the beginning of the year were quoted in Metals Week at 52 to 54.5 cents and 53.5 to 56.0 cents per pound, respectively. In September, the zinc oxide prices for each fell 3 cents, and in December, prices were adjusted downward, ending the year at 40 to 51 cents per pound for American-process zinc oxide and 41.5 to 53 cents for French-process zinc oxide. Photoconductive grades of zinc oxide were generally priced 2 to 3 cents higher than French-process zinc oxide throughout the year.

The price quoted in Chemical Marketing Reporter (CMR) for zinc sulfate, granular monohydrate industrial grade, 36% zinc in bags in carload lots, ranged from $26.50 to $29.00 per 100 pounds. Agricultural zinc sulfate in bulk was quoted at $20.00 per 100 pounds. Technical-grade zinc chloride, 50% solution, in tanks, was quoted by CMR at $18.40 per 100 pounds until September and $20.20 thereafter. Standard pigment-grade zinc dust, types 1 and 2 in drums, was quoted by CMR at 59 to 67 cents per pound during the year.

FOREIGN TRADE

U.S. slab zinc imports were about 28,000 tons less than the record-high quantity imported in 1984. Imports from Canada were at record-high levels in terms of tonnage and percentage of U.S. imports. Canada accounted for about 63% of imports compared with an average import level of 54% in the 1980-84 period. The record-high import levels from Canada were, in part, attributed to intercontinental trades to reduce transportation costs. The second leading import source for slab zinc was Mexico, accounting for slightly less than 9%. Zinc oxide imports exceeded 1984's record-high level and captured about 22% of the domestic consumption, up from 20% in 1984.

Despite the closing of Asarco's primary zinc refinery in Texas early in the year, imports of concentrates continued at relatively high levels because of substantial reductions in domestic output. Exports of concentrates fell to their lowest level since 1979 owing mainly to reduced production at exporting mines.

Waste and scrap exports reached record-high levels in 1985; Taiwan was the principal importer, accounting for about 45% of the waste and scrap exported.

Table 2.—U.S. import duties for zinc materials, January 1, 1985

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1985	Jan. 1, 1987	Jan. 1, 1985
Zinc oxide, dry	473.76	0.4% ad valorem	Free	5.5% ad valorem.
Ores and concentrates[1]	602.20	0.39 cent per pound on zinc content.	0.3 cent per pound on zinc content.	1.67 cents per pound on zinc content.
Fume	603.50	do	do	Do.
Unwrought, other than alloys	626.02	1.6% ad valorem	1.5% ad valorem	1.75 cents per pound.
Alloys	626.04	19.0% ad valorem	19.0% ad valorem	45.0% ad valorem.
Waste and scrap[1]	626.10	2.9% ad valorem	2.1% ad valorem	11.0% ad valorem.

[1]Duty on zinc ores, concentrates, and zinc-bearing materials was suspended until Dec. 31, 1989, as provided by Public Law 98-573.

WORLD REVIEW

World consumption of zinc metal was an estimated record-high 6.7 million tons in 1985, up slightly over the record consumption posted in 1984. In the market economy countries, zinc metal consumption was about 4.7 million tons, about the same as that of 1984. Consumption decreases in the United States and Western Europe were offset by increases in some of the newly industrialized countries, most notably Brazil. The Western European countries, the United States, and Japan accounted for slightly more than one-half of world consumption.

Both mine and smelter production were also at record-high levels in 1985. World mine output was about 6.7 million tons, up about 0.1 million tons over the 1984 record-high output. Australia, China, North Korea, Peru, and Thailand mined more zinc, whereas Canada, Mexico, and the United States, because of strikes and/or production cutbacks, mined less. Canada continued to be the principal world producer and, together with Australia, Peru, and the U.S.S.R., accounted for about one-half of world output. Smelter production was about 6.6 million tons, up about 0.1 million tons over the record-high production of 1984. Most countries produced at 1984 levels; India, Italy, North Korea, and Thailand increased production, readily offsetting slight production decreases in Japan, the United States, and some Western European countries. Canada, Japan, and the U.S.S.R. produced more than one-third of world smelter output of zinc.

World mine capacity increased to about 8.0 million tons, up about 0.13 million tons from that of 1984 (revised). New mine openings in Canada, Australia, Peru, and Colombia accounted for most of the increase. World primary smelter capacity also was up about 0.1 million tons to 7.9 million tons owing mainly to the opening of a new smelter in Italy.

The world supply-demand position was more balanced than generally anticipated. Metal stock levels in the market economy countries fell for the third straight year, and at yearend, represented the equivalent of about 1 month of world consumption. Despite an apparent balanced world supply-demand situation coupled with slight reductions in world metal stocks, prices declined sharply in the second half of 1985.

ILZSG, at its October meeting, forecast that zinc consumption in the market economy countries would be about 100,000 tons higher in 1986 than in 1985. Forecasts of zinc mine output and zinc metal production showed similar gains.

Argentina.—Cía. Minera Aguílar S.A. (CMASA), a St. Joe subsidiary, operated its Aguílar Mine and mill near capacity in the fiscal year ending October 31, and accounted for virtually all of Argentina's primary zinc output. The company produced 31,670 tons of zinc in concentrates in the fiscal year in milling 577,000 tons of ore containing 6.2% zinc, 5.3% lead, and 3.5 ounces of silver per ton. The zinc concentrates were utilized for the production of slab zinc at an electrolytic zinc refinery operated by Cía. Sulfacid S.A.C.I.Y.F. in which CMASA owns a 50% interest. At the end of the fiscal year, the ore reserves at the Aguílar Mine were estimated to be 4.8 million tons with an average grade of 7.1% zinc, 5.7% lead, and 4.0 ounces of silver per ton.

Australia.—Australia was the world's third largest mine producer of zinc. Production was up substantially from that of 1984 owing to the return of normal production levels at major mines at Broken Hill, New South Wales, and Tasmania, together with increases at the Elura Mine. One new zinc mine came on-stream in the latter part of the year and the Beltana zinc-lead mine in South Australia, which closed in 1976, was reopened. Production at the Teutonic Bore Mine in Western Australia ceased at yearend because of depletion of ore reserves. Expansions at a number of mines were scheduled for completion in 1986, adding about 20,000 tons to the country's zinc production capacity. Intensive exploration and evaluation of various prospects continued.

The Woodcutters open pit mine near Darwin in the Northern Territory came on-stream late in the year. At capacity, the mine, which is owned by Nicron Resources Ltd. (75%), Lachlan Resources NL (16%), and Petrocarb Exploration NL (10%), was expected to have an annual output of 23,000 tons of zinc, 11,000 tons of lead, and 600,000 ounces of silver in concentrates. Ore reserves were estimated to be 1.1 million tons averaging 14% zinc, 7.7% lead, and 5.7 ounces of silver per ton.

In the fiscal year ending June 30, MIM Holdings Ltd. produced at its Mount Isa Mine in Queensland a record high 202,000 tons of zinc in concentrate in treating about 4.3 million tons of ore grading 6.6% zinc, 5.4% lead, and 5.6 ounces of silver per ton. Zinc-lead-silver ore reserves at yearend 1985 at the Mount Isa Mine were about 49 million tons averaging 6.8% zinc, 5.83% lead, and 7.5 ounces of silver per ton. MIM was developing the Hilton silver-zinc-lead deposit, about 12 miles north of Mount Isa, as a second source of feed for the Mount Isa concentrator because production tonnages from the Mount Isa Mine were expected to start declining after 1990. Plans at Hilton initially called for ore production of about 35,000 tons in fiscal year 1986, increasing gradually to 2.5 million tons by the middle 1990's.[8] The Hilton deposit, which consists of seven stratabound silver-lead-zinc ore bodies in the same geological formations as the Mount Isa deposits, contained an estimated in situ ore reserve of about 72 million tons that averages 10.35% zinc, 6.52% lead, and 3.7 ounces of silver per ton.

The Woodlawn open pit mine in New South Wales became a wholly owned subsidiary of Australian Mining & Smelting Ltd. when they acquired St. Joe International Corp.'s one-third interest. Ore reserves in the pit were expected to be depleted by early 1987; however, an evaluation of mining lower extensions of the ore body by underground methods was under way.

Aberfoyle Ltd. was converting a tin treatment facility in northwest Tasmania to a pilot-scale plant for trial milling of bulk underground ore samples from its Hellyer zinc-lead-silver deposit, just north of the Que River Mine. The estimated in situ ore reserves at Hellyer totaled about 15 million tons averaging 13% zinc, 7% lead, 0.4% copper, 5.0 ounces of silver per ton, and 0.7 ounce of gold per ton. A further 4 million tons of inferred ore reserves was added by exploration activities in 1985. A decision on whether or not to develop the deposit was expected in 1987.

In August, Pancontinental Mining Ltd. acquired MIM's interest in the Lady Loretta zinc-lead-silver deposit in northern Queensland, and later the remaining one-half of the joint venture from Elf Aquitaine Triako Mines Ltd. Late in the year, Pancontinental sold a 49% interest to the Finnish company Outokumpu Oy. Underground exploration was expected to be completed in 1986. Reserves were estimated at 9 million tons grading 14.8% zinc, 6.5% lead, and 3.0 ounces of silver per ton.

Canada.—Canada continued to be the world leader in zinc mine production, accounting for more than 18% of world output. Brunswick Mining and Smelting Corp. Ltd.'s (BMS) No. 12 Mine in New Brunswick had the largest zinc production, followed by Kidd Creek Mines Ltd.'s Kidd Creek Mine at Timmins, Ontario, and Cominco Ltd.'s Pine Point and Polaris Mines in the Northwest Territories and the Sullivan Mine in British Columbia. These five mines accounted for two-thirds of Canadian zinc production. About 17 other mine-mill operations accounted for the remaining output. Three new mines, the largest of which was Westmin Resources Ltd.'s H. W. Mine in British Columbia, opened, and two mines closed in 1985. As part of the Government privatization program, the Government-owned Canada Development Corp. sold most of its interest in Kidd Creek Mines to Falconbridge Ltd. in December. Kidd Creek Mines produced about 220,000 tons of zinc in concentrate in 1985.

Canada, the third leading world producer of refined zinc, produced a record high 692,000 tons, up marginally from the record production set in 1984. The four primary smelters operated about 99% of rated combined annual capacity. Owing to weak zinc markets in the second half of the year, several Canadian zinc mine and smelter producers reduced production late in the year or were planning production cutbacks in early 1986.

Curragh Resources Corp. bought most of the assets of the Cyprus Anvil Mining Corp. from Dome Petroleum Ltd. and Trans Canada Pipelines Ltd. in June. The assets purchased included the large Faro lead-zinc-silver open pit mine and several nearby zinc-lead deposits in the Yukon Territory and a 50% interest in the undeveloped Cirque zinc deposit in British Columbia. Curragh, aided by a complex financial plan involving loan credit lines guaranteed by the Yukon and Federal governments, government maintenance of an all-weather road to Skagway, AK, for shipments of concentrates, and incentives provided under the Yukon Mineral Recovery Program, planned to reopen the Faro Mine by the middle of 1986. The Faro Mine, which closed in 1982 for economic reasons, produced 107,000 tons of zinc in milling 2.75 million tons of ore in 1981, its last full year of operation. Curragh was planning to attain a full ore production rate of about 4 million tons by 1987. A mine life of about 7 years was expected. Boliden AB of Sweden contracted to be the general sales agent for Faro's production and also acquired a 10%

interest in the mine in 1985. At yearend, Boliden had reportedly located buyers for the 90,000 tons of zinc concentrates and 40,000 tons of lead concentrates expected to be produced in 1986. At the end of 1984, estimated ore reserves at the Faro open pit were 18.5 million tons grading 5.1% zinc and 3.5% lead with 1.3 ounces of silver per ton.

BMS, 64% owned by Noranda, milled 3.3 million tons of ore at its No. 12 Mine in New Brunswick, down from 3.6 million tons milled in 1984 mainly because of production cutbacks late in the year. Zinc production in zinc and bulk concentrates was down about 21,000 tons from that of 1984, but totaled 237,500 tons or about 20% of Canadian output in 1985. Diamond drilling proved up more ore than was mined out during the year, and at yearend, BMS ore reserves were up 3 million tons to 83 million tons grading 9.15% zinc, 3.73% lead, 0.31% copper, and 3.1 ounces of silver per ton. An additional 21.7 million tons of similar grade, probable ore was also indicated.

Pine Point Mines Ltd., 51% owned by Cominco Ltd., produced about 161,400 tons of zinc in 272,600 tons of concentrate at the Pine Point Mine. The company milled 2.14 million tons of ore, about the same as in 1984. Because of high operating costs, mainly due to increased strip ratios and mine dewatering costs, Pine Point Mines revised its production plans for 1986 and 1987 to maximize and increase production rates and lower costs. As a result of the revised plan, the life of the mine, shortened to about 6 years, was not expected to extend much beyond the opening of Cominco American's Red Dog Mine in Alaska. Also, ore reserves were revised downward about 6 million tons to 14.5 million tons averaging 6.0% zinc and 2.7% lead at yearend. Cominco Ltd. milled a record high 939,000 tons of ore grading 13.1% zinc and 3.5% lead at its Polaris Mine on Little Cornwallis Island, Northwest Territories, in 1985, yielding 117,900 tons of zinc in 190,700 tons of zinc concentrate, and 29,900 tons of lead in 39,300 tons of lead concentrate. Production of zinc and lead, respectively, were 10% and 7% higher than that of 1984. At yearend, ore reserves were 19 million tons averaging 14.3% zinc and 3.8% lead. Concentrate production from the Polaris Mine was shipped to Western European smelters during a 12-week period at the end of the Arctic summer when the sea was open for navigation.

The Sullivan Mine at Kimberley, British Columbia, continued to be the principal supplier of zinc and lead concentrates to Cominco Ltd.'s Trail smelter. The amount of ore milled and production of zinc and lead concentrates was below that of the record highs set in 1984 because of a decision at midyear to reduce output mainly because of weak metal prices. In 1985, 2.2 million tons of ore was milled yielding 76,000 tons of zinc in 154,800 tons of zinc concentrate and 94,400 tons of lead and 251,400 ounces of silver in 152,000 tons of lead concentrate. At yearend, ore reserves at the Sullivan Mine were 32.7 million tons averaging 6.3% zinc, 4.3% lead, and 1.1 ounces of silver per ton.

Falconbridge suspended development work in November on its Winston Lake zinc property in Ontario mainly because of deteriorating zinc prices and poor near-term outlook for zinc concentrate sales. The company had announced in September that it planned to bring the deposit into production by late 1986 at an annual production rate of 50,000 tons of zinc in concentrate. Ore reserves at the deposit were estimated at 2.2 million tons grading 18% zinc, 1.1% copper, 1.0 ounce of silver per ton, and 0.004 ounce of gold per ton.

China.—China National Nonferrous Metals Import-Export Corp. signed agreements with several Japanese companies to have a new 60,000-ton-per-year vertical retort zinc smelter built at Huladao in Liaoning Province. The plant, which will replace an existing vertical and horizontal retort smelter of similar capacity, was expected to be onstream in 1987.

Greenland.—Greenex A/S, a wholly owned subsidiary of Vestgron Mines Ltd., produced 70,300 tons of zinc in concentrate at the Black Angel zinc-lead-silver mine at Maarmorilik, compared with 71,300 tons in 1984. Although the amount of ore milled was up 53,000 tons to 728,000 tons in 1985, the grade of ore milled dropped to 9.6% zinc from 11.0% zinc in 1984. The ore reserves at the Black Angel Mine totaled only 1.4 million tons grading 9.7% zinc, 3.0% lead, and 0.9 ounce of silver per ton at yearend. Because of extremely depressed prices for zinc and lead in the second half of 1985 and its diminished ore reserve position, Greenex was considering whether or not to permanently close the mine. Late in the year, Greenex reached an agreement with its bankers and the Governments of Greenland and Denmark that would permit operations to continue at least until June 1, 1986. Because of the mine's uncertain future, Cominco Ltd., which owns 62.5% of Vestgron, wrote off its $14 million investment in that company in 1985.

Honduras.—Rosario Resources Corp., a wholly owned subsidiary of AMAX, continued its program to increase ore production levels at the El Mochito zinc-lead-silver mine to 2,300 tons per day by 1987. As part of an effort to lower production costs, the work force was reduced from 1,500 to 1,200 by the end of the year. Zinc output in concentrates was 44,000 tons in 1985, compared with 41,500 tons in 1984 and 38,000 tons in 1983. A 20% increase in zinc production was expected in 1986. Concentrates were sold to smelters in Japan, Western Europe, and the United States. At yearend, estimated ore reserves at the El Mochito Mine were 4.8 million tons grading 9.0% zinc, 4.6% lead, 0.54% copper, 4.0 ounces of silver per ton, and 0.002 ounce of gold per ton.

Korea, Republic of.—Planned expansions at the country's two zinc refineries continued. The Korea Zinc Co. Ltd. was doubling the annual capacity of its Onsan zinc refinery to 150,000 tons. Construction was expected to be completed by the end of 1986. Most of the feed for the Onsan refinery was expected to be imported mainly from Australia. In October 1985, Young Poong Corp. completed a 15,000-ton-per-year expansion of its Seakpho electrolytic zinc refinery, raising the annual capacity to 50,000 tons. Young Poong planned to provide all of the refinery's zinc concentrate feed from the company's nearby mines at Yeonhwa No. 1 and No. 2. In 1985, the company's mines at Yeonhwa produced about 72,000 tons of zinc or about 78% of the domestic production. The ore deposits at Yeonhwa No. 1 consisted of 7 lead-zinc bodies of chimney type and 10 smaller ones of vein type, all occurring in limestone. Reserves were estimated at over 1.5 million tons averaging 0.93% lead and 3.12% zinc. At Yeonhwa No. 2, 10 kilometers northeast of No. 1, the ore bodies occurred typically in moderately dipping limestone and slate beds, associated with intrusive sills and dykes of quartz monzonite porphyry. The estimated ore reserves at Yeonhwa No. 2 were 1.4 million tons grading 0.34% lead, 3.76% zinc, and 0.06% copper. An additional 10 million tons of ore containing 9.3% combined lead and zinc and about 3 ounces of silver per ton was indicated in several newly discovered nearby deposits. Young Poong planned to invest about $6.8 million for development by 1988.

Mexico.—Mine production fell in 1985 owing mainly to significant decreases in mine output at mines operated by México Desarrollo Industrial Minero S.A. (MEDIMSA) and Industrias Penoles S.A. de C.V. MEDIMSA's zinc output was about 59,000 tons in 1985, down about 11,000 tons from that of 1984, despite increased zinc production at the San Martin Mine, whose capacity was tripled in 1984. MEDIMSA completed the expansion program at its Charcas zinc-lead-silver mine in San Luis Potosí State in December. Mine and mill capacity was increased from 1,250 tons per day to 3,450 tons and was expected to result in a zinc production increase of 18,000 tons to 33,000 tons in 1986. MEDIMSA's Rosario lead-zinc-copper-silver mine in Sinaloa State was almost completed in 1985. Production at a rate of 550 tons per day was scheduled to start in March 1986. An annual output of about 6,000 tons of lead and 3,000 tons of zinc was planned.

South Africa, Republic of.—Shell South Africa (Pty.) Ltd. began open pit development at its lead-zinc deposit at Pering in northern Cape Province late in the year. Shell planned to have the mine in production by September 1986, producing at an annual rate of 33,000 tons of zinc contained in 60,000 tons of concentrate. Also to be produced annually was about 9,000 tons of lead concentrate containing 4,000 tons of lead. The zinc concentrates were scheduled to be processed at the Springs, Transvaal, zinc refinery owned by the Zinc Corp. of South Africa Ltd. Established geological reserves totaled 18.4 million tons averaging 3.61% zinc and 0.64% lead. A mine life of about 17 years was expected.

Prieska Copper Mines (Pty.) Ltd., which had intended to permanently close its Prieska copper-zinc mine by the end of 1985, planned to continue operations for an additional year as sufficient exploitable ore was found to enable mining to continue.

TECHNOLOGY

The Bureau of Mines devised a technique to recover a zinc-lead concentrate from geothermal brines produced in the Imperial Valley of California.[9] It was estimated that up to 90,000 tons of zinc per year could be extracted from these brines if the geothermal resources were developed to produce 1,600 megawatts of power. More than 99% of the zinc and lead were precipitated by treating the brine with hydrogen sulfide and controlling the pH with lime. A flowsheet for metal recovery was proposed.

The Bureau carried out studies to determine the feasibility of chlorine-oxygen leaching for treating complex low-grade zinc sulfide concentrates that are generally unacceptable as feed for conventional roast-leach-electrowin plants because of the low zinc and high iron contents.[10] A process using the Bureau's chlorine-oxygen leaching technique was expected to result in extraction of about 95% of the zinc in the form of purified crystalline zinc chloride, which could be fed into a molten-salt bath and electrolized to produce zinc metal and chlorine for recycle.

The Bureau conducted research to separate fluorine from byproduct zinc concentrates obtained from fluorspar production in an effort to make the concentrate acceptable to zinc producers,[11] devised a method to recover zinc and other metals from copper converter flue dust,[12] developed technology to use flue dust containing zinc as a source of zinc for electrogalvanizing,[13] and evaluated waste-derived electrogalvanized zinc coatings on wire.[14]

EAF steelmaking dusts, listed as hazardous waste by the EPA mainly because of leachable lead, cadmium, and chromium, continued to be a major problem for the steel industry as disposal costs ranged up to $200 per ton. In 1985, an estimated 450,000 tons of EAF dusts, all of which contained zinc, was generated in the United States. About 10% was utilized as a constituent in fertilizers, 15% was processed to recover zinc, and 75% was disposed of in hazardous landfills. By August 1988, an EPA ban on land disposal of hazardous EAF dust was scheduled, providing suitable treatment technology was available. Studies completed in 1985 by the Center for Metals Production[15] and the Bureau of Mines[16] discussed options available for EAF dust treatment and disposal. The studies considered four basic options: chemically stabilize the dust so it could be landfilled as nonhazardous waste; incorporate or mix with another material so the resultant product could be listed as nonhazardous; recycle directly back into the electric arc furnace to upgrade the zinc content of the dust to produce a salable or processable smelter-feed product; and establish regional processing plants near EAF steelmaking centers to recover zinc, lead, and cadmium and render the residue nonhazardous. Depending on the situation, each of the options were considered likely to be employed in the future. The studies indicated that most zinc recovery methods will require the zinc content in the EAF dust to be higher than 20%.

An upgraded dust product containing more than 50% zinc was considered a salable feed material for most nonelectrolytic zinc smelters. In 1985, a number of plants around the world recovered zinc from steelmaking dusts. In Sweden, a plasma arc reactor capable of processing 70,000 tons of dust per year came on-stream. Zinc metal and nontoxic residue were produced. Plants to process steelmaking dusts were under construction in both France and Spain. The French plant, expected on-stream in early 1986, was designed to process 12,000 tons of dust per month. Lead would be recovered by precipitation and zinc by electrolysis. The Spanish plant, which will employ a Waelz-kiln process, was expected to produce metal oxide briquets suitable as feed for plants using the Imperial Smelting Process. An annual production of about 14,000 tons of lead and zinc contained in briquets from the processing of 70,000 tons of dust was expected to begin in 1987.

A new technique, the Zincquench process, for producing Galfan-coated, dual-phase and related high-strength, deep-drawing steels at lower costs and with improved properties mainly for automotive uses was described.[17] The process consisted of continuous annealing followed by a drastic quench in a 95% zinc-5% aluminum plus some mischmetal alloy bath, followed by an overaging treatment. The new process reportedly avoided some of the complexities of hot-dip galvanizing and provided greater ductibility and corrosion performance than can be attained with electrolytic coating.

A comprehensive coverage of zinc-related investigations and an extensive review of current world literature on zinc extraction, alloys, uses, products, and research was published in quarterly issues of Zinc Abstracts issued by the Zinc Development Association, London, England.[18] The International Lead Zinc Research Organization, a research organization sponsored by private companies, carried out technical research and market development activities mainly related to galvanizing and diecasting alloys and technology.[19]

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[17]Radtke, S. F. Promising New Zn-Al Alloy Quench Coating Process for Steel Undergoing Production Trials. Ind. Heat., No. 9, Sept. 1985, pp. 21-24.
[18]Zinc Development Association. Zinc Abstracts. V. 43, Nos. 1-4, 1985, 466 pp.
[19]International Lead Zinc Research Organization. ILZRO Annual Review 1985. 13 pp.

Table 3.—Mine production of recoverable zinc in the United States, by month

(Metric tons)

Month	1984	1985
January	23,031	20,500
February	24,804	22,722
March	26,627	24,527
April	21,607	18,552
May	23,294	19,694
June	19,749	19,366
July	20,528	14,459
August	16,751	14,781
September	14,927	15,458
October	21,260	19,926
November	21,169	16,958
December	19,021	19,602
Total	252,768	226,545

Table 4.—Mine production of recoverable zinc in the United States, by State

(Metric tons)

State	1981	1982	1983	1984	1985
Arizona	138	--	--	--	--
California	W	--	--	--	--
Colorado	W	W	W	W	W
Idaho	W	W	W	W	W
Illinois	W	W	W	W	W
Kentucky	W	W	W	W	W
Missouri	52,904	63,680	57,044	45,458	49,340
Montana	25	W	--	--	--
Nevada	W	--	--	--	--
New Jersey	16,198	16,800	16,475	W	W
New Mexico	W	--	--	--	--
New York	36,889	52,237	56,748	W	W
Pennsylvania	24,732	24,762	16,792	--	--
Tennessee	117,684	121,306	109,958	116,526	104,471
Utah	1,576	--	--	W	--
Virginia	9,731	--	--	--	--
Total	312,418	303,160	275,294	252,768	226,545

W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 5.—Production of zinc and lead in the United States in 1985, by State and class of ore, from old tailings, etc., in terms of recoverable metals

(Metric tons)

State	Zinc ore: Gross weight (dry basis)	Zinc ore: Zinc	Zinc ore: Lead	Lead ore: Gross weight (dry basis)	Lead ore: Zinc	Lead ore: Lead	Zinc-lead ore: Gross weight (dry basis)	Zinc-lead ore: Zinc	Zinc-lead ore: Lead
Arizona	--	--	--	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	W	W	W
Idaho	--	--	--	--	--	--	W	W	W
Illinois	--	--	--	--	--	--	--	--	--
Kentucky	W	W	--	--	--	--	--	--	--
Missouri	--	--	--	6,433,706	49,340	371,008	--	--	--
Montana	--	--	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--
New Jersey	W	W	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	--	--	--
New York	W	W	W	--	--	--	--	--	--
Tennessee	W	W	W	--	--	--	--	--	--
Total	4,261,858	161,530	(1)	6,433,706	49,340	371,008	(1)	(1)	(1)
Percent of total zinc or lead	XX	71	(1)	XX	22	90	XX	(1)	(1)

State	Copper-zinc, copper-lead, copper-zinc-lead ores: Gross weight (dry basis)	Copper-zinc, copper-lead, copper-zinc-lead ores: Zinc	Copper-zinc, copper-lead, copper-zinc-lead ores: Lead	All other sources[2] [3]: Gross weight (dry basis)	All other sources[2] [3]: Zinc	All other sources[2] [3]: Lead	Total: Gross weight (dry basis)	Total: Zinc	Total: Lead
Arizona	--	--	--	51,010,198	--	581	51,010,198	--	581
Colorado	--	--	--	37,508	W	643	W	W	W
Idaho	--	--	--	W	W	W	[3]901,337	W	33,707
Illinois	--	--	--	--	W	W	(3)	W	W
Kentucky	--	--	--	--	--	--	W	W	--
Missouri	--	--	--	--	--	--	6,433,706	49,340	371,008
Montana	--	--	--	2,616,424	--	846	2,616,424	--	846
Nevada	--	--	--	73	--	(4)	73	--	(4)
New Jersey	--	--	--	--	--	--	W	W	--
New Mexico	--	--	--	W	--	W	W	--	W
New York	--	--	--	--	--	--	W	W	W
Tennessee	--	--	--	W	W	--	5,373,817	104,471	W
Total	--	--	--	56,435,942	15,675	42,947	67,131,506	226,545	413,955
Percent of total zinc or lead	XX	--	--	XX	7	10	XX	100	100

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.

[1]Included with "All other sources" to avoid disclosing company proprietary data.

[2]Includes zinc and lead recovered from zinc-lead ores in Colorado and Idaho and lead from zinc ores in New York and Tennessee in order to avoid disclosing company proprietary data. Also includes zinc and lead recovered from copper, gold, gold-silver, and molybdenum ores; from fluorspar; and from mill tailings.

[3]Excludes tonnages of fluorspar in Illinois from which zinc and lead were recovered as byproducts, and molybdenum ore in Idaho from which lead was recovered as a byproduct.

[4]Less than 1/2 unit.

Table 6.—Twenty-five leading zinc-producing mines in the United States in 1985, in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Elwood-Gordonsville	Smith, TN	Jersey Minière Zinc Co	Zinc ore.
2	Buick	Iron, MO	AMAX Lead Co. of Missouri	Lead ore.
3	Balmat	St. Lawrence, NY	St. Joe Minerals Corp	Zinc ore.
4	Pierrepont	do	do	Do.
5	Magmont	Iron, MO	Cominco American Incorporated.	Lead ore.
6	Zinc Mine Works	Jefferson, TN	United States Steel Corp	Zinc ore.
7	Sterling	Sussex, NJ	The New Jersey Zinc Co. Inc	Do.
8	Young	Jefferson, TN	ASARCO Incorporated	Do.
9	Leadville unit	Lake, CO	do	Lead-zinc ore.
10	Beaver Creek	Jefferson, TN	Inspiration Mines Inc	Zinc ore.
11	New Market	do	ASARCO Incorporated	Do.
12	Immel	Knox, TN	do	Do.
13	Viburnum No. 29	Washington, MO	St. Joe Minerals Corp	Lead ore.
14	Lucky Friday	Shoshone, ID	Hecla Mining Co	Silver ore.
15	Coy	Jefferson, TN	ASARCO Incorporated	Zinc ore.
16	Fletcher	Reynolds, MO	St. Joe Minerals Corp	Lead ore.
17	Star-Morning	Shoshone, ID	Star-Morning Mining Co	Silver ore.
18	Casteel	Iron, MO	St. Joe Minerals Corp	Lead ore.
19	Rosiclare	Hardin and Pope, IL.	Ozark-Mahoning Co	Fluorspar.
20	Viburnum No. 28	Iron, MO	St. Joe Minerals Corp	Lead ore.
21	Copperhill	Polk, TN	Tennessee Chemical Co	Copper-zinc ore.
22	Sunnyside	San Juan, CO	Standard Metals Corp	Gold ore.
23	Black Pine	Granite, MT	Black Pine Mining Co	Silver ore.
24	West Fork	Reynolds, MO	ASARCO Incorporated	Lead ore.
25	Clayton	Custer, ID	Clayton Silver Mines Inc	Silver ore.

Table 7.—Primary and redistilled secondary slab zinc produced in the United States

(Metric tons)

	1981	1982	1983	1984	1985
Primary:					
From domestic ores	259,835	193,284	210,315	197,912	172,773
From foreign ores	86,728	34,892	25,379	55,220	63,204
Total	346,563	228,176	235,694	253,132	235,977
Redistilled secondary:					
At primary smelters	14,438	42,418	40,545	44,930	42,730
At secondary smelters	35,754	31,870	28,845	33,183	32,844
Total	50,192	74,288	69,390	78,113	75,574
Grand total (excludes zinc recovered by remelting)	396,755	302,464	305,084	331,245	311,551

Table 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grade

(Metric tons)

Grade	1981	1982	1983	1984	1985
Special High	137,210	112,648	95,395	123,325	98,282
High	51,990	31,076	78,511	71,892	95,465
Continuous Galvanizing	55,008	57,739	50,661	48,200	26,139
Controlled Lead	38,660	7,612	10,231	9,384	20,952
Prime Western	113,887	93,389	70,286	78,444	70,713
Total	396,755	302,464	305,084	331,245	311,551

Table 9.—Annual slab zinc capacity of primary zinc plants in the United States, by type of plant and company

Type of plant and company	Plant location	Slab zinc capacity (metric tons) 1984	1985
Electrolytic:			
AMAX Inc	Sauget, IL	76,000	76,000
ASARCO Incorporated[1]	Corpus Christi, TX	104,000	104,000
Bunker Ltd.[2]	Kellogg, ID	103,000	--
Jersey Minière Zinc Co	Clarksville, TN	82,000	82,000
St. Joe Resources Corp	Bartlesville, OK	51,000	51,000
Electrothermic:			
St. Joe Resources Corp	Monaca, PA	91,000	91,000

[1]Zinc plant reopened in May 1984 closed indefinitely in Apr. 1985.
[2]Zinc plant closed in Dec. 1981, permanently closed in 1985.

Table 10.—Secondary slab zinc plant capacity in the United States, by company

Company	Plant location	Capacity (metric tons) 1984	1985
ARCO Alloys Corp	Detroit, MI	95,000	95,000
W. J. Bullock Inc	Fairfield, AL		
T. L. Diamond & Co. Inc	Spelter, WV		
Gulf Reduction Corp	Houston, TX		
Hugo Neu-Proler Co	Terminal Island, CA		
Huron Valley Steel Corp	Belleville, MI		
Interamerican Zinc Co	Adrian, MI		
The New Jersey Zinc Co. Inc	Palmerton, PA		
Pacific Smelting Co	Torrance, CA		
Do	Memphis, TN		
Prolerized Schiabo Neu Co	Jersey City, NJ		

Table 11.—Stocks and consumption of new and old zinc scrap in the United States in 1985, by class of consumer and type of scrap

(Metric tons, zinc content)

Class of consumer and type of scrap	Stocks, Jan. 1	Receipts	Consumption: New scrap	Old scrap	Total	Stocks, Dec. 31
Smelters and distillers:						
New clippings	27	779	650	--	650	156
Old zinc	400	1,128	--	1,400	1,400	128
Remelt zinc	135	6,630	6,635	--	6,635	130
Engraver's plates	W	583	--	585	585	W
Rod and die scrap	992	2,256	--	2,305	2,305	943
Diecastings	1,586	11,090	--	11,513	11,513	1,163
Fragmentized diecastings	W	27,668	--	27,711	27,711	W
Remelt die-cast slab	642	8,662	--	8,800	8,800	504
Skimmings and ashes	32,904	72,370	79,626	--	79,626	25,648
Sal skimmings	W	2,651	2,670	--	2,670	W
Die-cast skimmings	2,011	5,968	7,134	--	7,134	845
Galvanizer's dross	8,016	44,061	42,151	--	42,151	9,926
Flue dust	3,235	4,792	4,915	--	4,915	3,112
Chemical residues	W	W	W	--	W	W
Other	W	589	652	--	652	W
Total	53,581	190,522	145,777	52,314	198,091	46,012
Chemical plants, foundries, other manufacturers:						
Old zinc	W	W	W	W	W	W
Diecastings	W	W	W	W	W	W
Skimmings and ashes	W	4,631	4,474	--	4,474	W
Sal skimmings	W	2,863	2,359	--	2,359	W
Galvanizer's dross	W	W	W	W	W	W
Flue dust	W	11,832	11,503	--	11,503	W
Chemical residues	W	W	W	W	W	W
Other	W	W	W	W	W	W
Total	2,835	21,354	20,005	359	20,364	3,825
Grand Total	56,416	211,876	165,782	52,673	218,455	49,837

W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 12.—Production of zinc products from zinc-base scrap in the United States

(Metric tons)

Product	1981	1982	1983	1984	1985
Redistilled slab zinc	50,192	74,288	69,390	78,113	75,574
Zinc dust	39,626	25,296	34,773	40,697	36,899
Remelt zinc	195	69	66	71	--
Remelt die-cast slab	6,722	3,905	3,109	3,380	3,059
Zinc die and diecasting alloys	6,902	5,366	6,535	6,112	5,667
Galvanizing stocks	2,612	2,507	2,801	2,368	W
Secondary zinc in chemical products	62,557	61,827	59,085	r66,221	55,808

rRevised. W Withheld to avoid disclosing company proprietary data.

Table 13.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1984	1985
KIND OF SCRAP		
New scrap:		
Zinc-base	182,976	165,461
Copper-base	134,699	125,173
Magnesium-base	130	68
Total	317,805	290,702
Old scrap:		
Zinc-base	55,447	51,788
Copper-base	24,763	22,016
Aluminum-base	334	294
Magnesium-base	220	214
Total	80,764	74,312
Grand total	398,569	365,014
FORM OF RECOVERY		
As metal:		
By distillation:		
Slab zinc[1]	78,113	75,574
Zinc dust	40,697	36,899
By remelting	2,438	1,112
Total	121,248	113,585
In zinc-base alloys	9,492	8,726
In brass and bronze	r200,792	186,281
In aluminum-base alloys	466	332
In magnesium-base alloys	350	282
In chemical products:		
Zinc oxide (lead free)	40,072	32,036
Zinc sulfate	13,687	15,506
Zinc chloride	12,398	7,841
Miscellaneous	r64	425
Total	277,321	251,429
Grand total	398,569	365,014

rRevised.
[1]Includes zinc content of redistilled slab made from remelt die-cast slab.

Table 14.—U.S. production of zinc dust[1]

Year	Quantity (metric tons)	Value	
		Total (thousands)	Average per pound
1981	43,734	$53,801	$0.558
1982	37,516	49,327	.596
1983	40,508	45,849	.513
1984	46,487	67,846	.662
1985	29,542	37,123	.570

[1]Does not include zinc dust produced for internal plant use.

Table 15.—U.S. consumption of zinc

(Metric tons)

	1981	1982	1983	1984	1985
Slab zinc reported	840,875	709,491	805,891	848,903	764,752
Ores and concentrates (zinc content)[1]	60,643	35,515	38,287	47,637	42,284
Secondary (zinc content)[2]	287,851	208,105	276,370	318,018	288,328
Total	1,189,369	953,111	1,120,548	1,214,558	1,095,364

[1]Includes ore used directly in galvanizing.
[2]Excludes redistilled slab and remelt zinc.

Table 16.—U.S. reported consumption of slab zinc in 1985, by industry and grade

(Metric tons)

Industry	Special High Grade	High Grade	Continuous Galvanizing Grade	Controlled Lead Grade	Prime Western	Remelt	Total
Galvanizing	69,807	65,884	37,109	25,036	161,776	1,741	361,353
Zinc-base alloys	216,864	1,428	--	--	21	--	218,313
Brass and bronze	43,897	17,679	22	129	12,409	3,784	77,920
Rolled zinc	33,889	--	--	14,131	--	--	48,020
Zinc oxide	39,183	479	--	--	--	--	39,662
Other	16,912	1,939	--	--	633	--	19,484
Total	420,552	87,409	37,131	39,296	174,839	5,525	764,752

Table 17.—U.S. consumption of slab zinc, by industry and product

(Metric tons)

Industry and product	1981	1982	1983	1984	1985
Galvanizing:					
Sheet and strip	248,006	204,519	230,541	222,872	226,489
Wire and wire rope	22,119	17,180	18,328	18,430	14,437
Tubes and pipe	39,418	34,322	34,907	39,463	27,580
Fittings (for tubes and pipe)	6,369	5,707	5,990	4,446	3,830
Tanks and containers	5,781	6,507	4,195	4,044	5,442
Structural shapes	33,667	28,816	29,822	35,494	31,444
Fasteners	3,693	2,898	2,614	2,518	6,411
Pole-line hardware	3,788	2,955	3,013	3,326	3,755
Fencing, wire cloth, netting	17,722	17,330	15,916	12,644	13,319
Other and unspecified uses	30,484	21,810	27,853	32,386	28,646
Total	411,047	342,044	373,179	375,623	361,353
Brass and bronze products:					
Sheet, strip, plate	42,006	31,718	43,083	55,583	30,487
Rod and wire	36,639	26,551	32,387	34,231	17,814
Tubes	6,440	3,465	4,058	4,750	2,705
Castings and billets	2,880	2,211	7,499	9,726	12,183
Copper-base ingots	20,167	13,278	16,405	19,446	13,986
Other copper-base products	4,854	3,915	4,503	1,858	745
Total	112,986	81,138	107,935	125,594	77,920
Zinc-base alloys:					
Diecasting alloys	234,957	191,607	204,820	216,306	205,388
Dies and rod alloys	--	--	--	1,666	2,552
Slush and sand-casting alloys	8,408	6,147	8,071	14,660	10,373
Total	243,365	197,754	212,891	232,632	218,313
Rolled zinc[1]	23,156	37,168	56,291	56,886	48,020
Zinc oxide	25,657	32,374	36,201	37,038	39,662
Other:					
Light-metal alloys	8,183	8,326	12,538	14,922	15,204
Miscellaneous[2]	16,481	10,687	6,856	6,208	4,280
Total	24,664	19,013	19,394	21,130	19,484
Grand total	840,875	709,491	805,891	848,903	764,752

[1]Includes zinc used in penny production.
[2]Includes zinc used in making zinc dust, wet batteries, desilverizing lead, powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

Table 18.—U.S. consumption of slab zinc in 1985, by State

(Metric tons)

State	Galvanizers	Brass mills[1]	Die-casters[2]	Other[3]	Total
Alabama	W	W	--	--	19,336
Arkansas	W	--	--	W	W
California	27,771	1,060	--	3,841	32,672
Colorado	W	--	W	W	W
Connecticut	2,853	5,030	W	W	13,428
Delaware	W	--	--	--	W
Florida	W	--	--	--	W
Georgia	W	--	W	--	7,110
Hawaii	W	--	--	--	W
Illinois	53,425	13,301	24,111	11,926	102,763
Indiana	68,522	W	W	W	84,719
Iowa	--	--	W	W	W
Kansas	--	--	W	--	W
Kentucky	16,550	--	--	--	16,550
Louisiana	W	--	W	--	2,545
Maine	W	--	--	--	W
Maryland	11,359	--	--	--	11,359
Massachusetts	2,481	W	--	W	3,148
Michigan	602	W	50,985	W	55,744
Minnesota	654	--	--	--	654
Mississippi	W	--	--	--	W
Missouri	W	--	--	W	3,552
Nebraska	W	--	--	W	6,056
New Jersey	1,518	W	W	W	9,320
New York	4,409	W	88,565	W	113,749
North Carolina	W	--	W	--	W
Ohio	34,257	W	32,574	W	76,754
Oklahoma	W	--	--	W	3,118
Oregon	W	--	W	W	1,353
Pennsylvania	47,466	6,263	W	W	80,102
South Carolina	W	--	--	--	W
Tennessee	838	--	W	W	48,234
Texas	10,556	--	W	W	10,715
Utah	W	--	--	--	W
Virginia	W	W	W	--	4,611
Washington	W	--	--	W	1,906
West Virginia	W	--	--	W	22,310
Wisconsin	725	757	W	W	7,917
Undistributed	75,625	47,723	22,080	91,400	19,502
Total[4]	359,611	74,134	218,315	107,167	759,227

W Withheld to avoid disclosing company proprietary data; included with "Total" and "Undistributed."
[1]Includes brass mills, brass ingot makers, and brass foundries.
[2]Includes producers of zinc-base alloys for diecastings, stamping dies, and rods.
[3]Includes slab zinc used in rolled zinc products and in zinc oxide.
[4]Excludes remelt zinc.

Table 19.—Rolled zinc produced and quantity available for consumption in the United States

(Metric tons)

	1984	1985
Production[1]	55,633	46,641
Exports	975	776
Imports	850	943
Available for consumption	52,343	48,119

[1]Figures represent net production. In addition, 40,855 tons in 1984 and 37,755 tons in 1985 were rerolled from scrap originating in fabricating plants operating in connection with zinc-rolling mills. Includes other plate over 0.375 inch thick, sheet zinc less than 0.375 inch thick, and rod and wire. The Bureau of Mines is not at liberty to publish separately.

Table 20.—Production and shipments of zinc pigments and compounds[1] in the United States

(Metric tons)

	1984		1985	
	Production	Shipments	Production	Shipments
Zinc oxide	150,623	146,918	137,382	136,129
Zinc sulfate	37,408	37,112	42,316	42,509
Zinc chloride[2]	25,664	26,705	20,546	20,041

[1]Excludes leaded zinc oxide and lithopone.
[2]Includes zinc content of zinc ammonium chloride.

Table 21.—Zinc content of zinc pigments[1] and compounds produced by domestic manufacturers, by source

(Metric tons)

	1984				1985			
	Zinc in pigments and compounds produced from—			Total	Zinc in pigments and compounds produced from—			Total
	Ore	Slab zinc	Secondary material		Ore	Slab zinc	Secondary material	
Zinc oxide	43,450	37,038	40,072	120,560	38,168	39,662	32,036	109,866
Zinc sulfate	W	--	15,150	15,150	W	--	17,138	17,138
Zinc chloride[2]	--	--	r12,453	r12,453	--	--	9,782	9,782

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Secondary material."
[1]Excludes leaded zinc oxide, zinc sulfide, and lithopone.
[2]Includes zinc content of zinc ammonium chloride.

Table 22.—Distribution of zinc oxide shipments, by industry

(Metric tons)

Industry	1981	1982	1983	1984	1985
Agriculture	7,328	3,929	2,569	2,380	2,575
Ceramics	7,822	5,215	5,987	7,472	7,283
Chemicals	20,561	19,432	19,217	23,611	22,466
Paints	12,346	9,283	9,716	8,117	8,215
Photocopying	10,308	9,516	10,239	9,246	8,323
Rubber	69,364	62,923	67,971	79,390	71,552
Other	21,222	17,136	19,355	16,702	15,715
Total	148,951	127,434	135,054	146,918	136,129

Table 23.—Distribution of zinc sulfate shipments

(Metric tons)

Year	Agriculture	Other	Total
1982	29,882	9,040	38,922
1983	29,373	5,613	34,986
1984	28,162	8,950	37,112
1985	33,786	8,723	42,509

Table 24.—Stocks of slab zinc in the United States, December 31

(Metric tons)

	1981	1982	1983	1984	1985
Primary producers	41,124	30,381	20,750	42,025	29,030
Secondary producers	3,540	3,831	3,149	4,303	3,389
Consumers	81,917	77,565	89,041	72,506	58,923
Merchants	68,773	47,397	35,199	18,792	27,163
Total	195,354	159,174	148,139	137,626	118,505

Table 25.—Consumer stocks of slab zinc at plants in the United States, December 31, by grade

(Metric tons)

Year	Special High Grade	High Grade	Continuous Galvanizing Grade	Controlled Lead Grade	Prime Western	Remelt	Total
1984	40,296	6,310	3,963	2,284	19,437	216	72,506
1985	32,485	5,757	941	2,187	17,416	137	58,923

Table 26.—Average monthly U.S., LME,[1] and European producer prices for Prime Western zinc and equivalent

(Metallic zinc, cents per pound)

Month	1984			1985		
	United States[2]	LME cash	European producer	United States[2]	LME cash	European producer
January	49.22	43.41	44.45	42.94	39.20	40.82
February	50.61	45.26	47.63	42.65	40.14	40.82
March	51.07	47.16	47.63	43.20	41.70	41.90
April	51.90	45.52	49.44	44.88	42.14	43.54
May	52.77	45.38	49.44	45.12	39.87	42.99
June	52.45	42.67	48.90	43.73	36.56	40.48
July	49.52	38.70	45.34	41.44	34.70	38.06
August	47.85	37.81	44.91	39.84	33.29	37.14
September	46.42	39.31	43.12	37.86	31.24	35.38
October	44.19	38.09	40.64	35.76	28.62	33.53
November	43.60	38.67	40.82	33.36	27.06	30.10
December	43.62	38.87	40.82	33.61	31.05	30.56
Average	48.60	40.46	45.30	40.37	36.23	37.94

[1]London Metal Exchange.
[2]Based on High Grade zinc delivered.

Source: Metals Week.

Table 27.—U.S. exports of zinc and zinc alloys, by country

Country	1983		1984		1985	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Unwrought zinc and zinc alloys:						
Australia	12	$46	(1)	$2	--	--
Belgium-Luxembourg	(1)	2	(1)	1	20	$22
Canada	416	762	88	222	432	925
Chile	3	57	398	419	501	451
Costa Rica	12	21	5	12	7	9
Egypt	--	--	1	4	255	250
Germany, Federal Republic of	1	2	16	35	21	18
Ghana	--	--	--	--	26	26
India	--	--	--	--	48	62
Israel	--	--	1	3	25	56
Japan	28	76	166	220	37	73
Korea, Republic of	15	56	108	96	87	98
Mexico	4	17	73	137	79	207
Netherlands	--	--	(1)	1	27	67
Panama	10	17	40	63	5	9
Saudi Arabia	108	277	6	14	1	2
Singapore	40	131	2	4	18	30
Spain	--	--	22	24		
Switzerland	72	377	2	6	1	1
Taiwan	288	260	361	332	618	463
United Kingdom	41	181	8	34	12	40
Venezuela	4	14	2	4	20	63
Other[2]	r35	r99	r49	r165	11	54
Total	1,089	2,395	1,348	1,798	2,251	2,926
Wrought zinc and zinc alloys:						
Argentina	17	38	19	53	17	47
Australia	8	26	6	13	1	2

See footnotes at end of table.

Table 27.—U.S. exports of zinc and zinc alloys, by country —Continued

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Wrought zinc and zinc alloys — Continued						
Bahamas	8	$12	46	$53	41	$52
Belgium-Luxembourg	2	14	1	6	--	--
Brazil	--	--	37	71	--	--
Canada	1,221	1,762	769	1,571	1,379	2,085
Chile	3	4	--	--	11	80
Colombia	14	42	24	56	13	56
Dominican Republic	9	10	8	29	11	45
Ecuador	9	30	12	35	20	41
Egypt	11	25	1	4	6	17
El Salvador	12	36	3	14	6	18
France	5	9	4	6	23	69
Guyana	5	11	5	9	4	11
India	9	22	19	21	--	--
Italy	--	--	1	3	--	--
Japan	39	55	15	25	9	24
Korea, Republic of	(1)	1	(1)	2	14	34
Leeward and Windward Islands	25	22	43	33	1	1
Libya	119	340	1	1	3	7
Mexico	147	395	387	932	397	821
Netherlands Antilles	2	16	19	23	6	4
Nicaragua	25	42	4	14	--	--
Pakistan	3	8	1	4	--	--
Panama	1	3	4	10	20	41
Philippines	34	108	12	33	3	9
Saudi Arabia	28	72	9	16	2	24
Singapore	4	20	3	15	1	1
South Africa, Republic of	13	42	95	203	11	26
Suriname	--	--	--	--	8	21
Switzerland	--	--	46	130	17	63
Taiwan	72	123	92	177	34	83
Trinidad and Tobago	--	--	15	42	27	35
United Kingdom	90	218	33	142	48	41
Venezuela	5	12	4	21	33	182
Zimbabwe	--	--	36	79	--	--
Other[3]	r63	r287	r41	r101	44	131
Total	2,003	3,805	1,815	3,947	2,210	4,071

rRevised.
[1]Less than 1/2 unit.
[2]Includes Argentina, Barbados, Dominican Republic, Ecuador, El Salvador, France, Guatemala, Honduras, Hong Kong, Italy, Leeward and Windward Islands, Libya, Netherlands Antilles, New Zealand, Peru, Philippines, the Republic of South Africa, and the United Arab Emirates.
[3]Includes Austria, Belize, Bermuda, China, Costa Rica, Denmark, Finland, French Guiana, the Federal Republic of Germany, Ghana, Guatemala, Hong Kong, Iran, Israel, Jamaica, Kuwait, Morocco, the Netherlands, New Zealand, Norway, Peru, Portugal, Qatar, Somalia, Sri Lanka, Turkey, the United Arab Emirates, and Uruguay.

Source: Bureau of the Census.

Table 28.—U.S. exports of zinc

Year	Ores and concentrates		Blocks, pigs, anodes, etc.			
			Unwrought		Unwrought alloys	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1983	60,168	$22,868	427	$801	662	$1,594
1984	30,579	13,353	760	975	588	823
1985	23,264	8,216	1,011	1,525	1,240	1,402

Year	Wrought zinc and zinc alloys				Waste and scrap (zinc content)		Dust (blue powder)	
	Sheets, plates, strips		Angles, bars, pipes, rods, etc.					
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1983	957	$2,142	1,046	$1,663	28,255	$15,389	1,914	$3,000
1984	975	2,421	840	1,526	39,146	20,360	2,933	3,511
1985	776	1,973	1,434	2,098	43,947	19,600	2,037	2,480

Source: Bureau of the Census.

Table 29.—U.S. exports of zinc ores and concentrates, by country

(Zinc content)

Country	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Bulgaria	3,028	$1,801	--	--
Canada	19,102	8,360	6,141	$3,226
France	--	--	3,793	426
Germany, Federal Republic of	--	--	1,948	683
India	20	13	--	--
Israel	--	--	2	4
Italy	--	--	5,275	2,338
Jamaica	38	56	--	--
Japan	--	--	6,043	1,519
Korea, Republic of	33	19	--	--
Mexico	2,574	866	--	--
Sweden	1	3	--	--
Taiwan	--	--	62	20
U.S.S.R	5,783	2,235	--	--
Total	30,579	13,353	23,264	8,216

Source: Bureau of the Census.

Table 30.—U.S. general imports of zinc, by country

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Australia	2,261	$1,113	2,577	$1,264	2,934	$819
Canada	13,715	3,370	34,717	14,631	47,200	18,351
Chile	27	15	--	--	--	--
Germany, Federal Republic of	6,552	1,067	--	--	--	--
Honduras	12,632	3,920	10,352	4,365	14,302	4,175
Mexico	17,887	4,518	20,125	6,650	12,988	4,232
Peru	9,136	3,208	17,610	7,100	13,402	4,970
South Africa, Republic of	--	--	10,186	2,633	473	1,963
United Kingdom	--	--	--	--	92	64
Total	62,210	17,211	95,567	36,643	91,391	34,574
BLOCKS, PIGS, OR SLABS[1]						
Algeria	2,051	1,846	403	374	--	--
Argentina	--	--	--	--	2,500	1,741
Australia	30,537	23,331	23,188	23,292	29,610	26,482
Austria	102	87	--	--	--	--
Belgium-Luxembourg	5,820	3,787	3,366	2,750	1,000	802
Brazil	--	--	3,280	4,260	--	--
Canada	307,156	263,145	340,380	351,715	383,618	326,388
Congo	--	--	1,311	1,032	--	--
Finland	25,402	20,614	15,953	16,197	19,601	16,832
France	8,932	6,858	12,923	12,807	5,410	4,027
Germany, Federal Republic of	29,675	23,645	27,930	27,543	11,991	11,937
India	--	--	99	84	--	--
Italy	11,913	9,483	13,719	12,270	--	--
Japan	--	--	3,000	3,050	2,700	2,386
Mexico	56,029	44,433	56,221	55,352	53,846	38,355
Netherlands	21,544	16,546	17,296	16,284	13,053	10,293
Netherlands Antilles	100	85	--	--	--	--
Nigeria	2,553	2,073	--	--	--	--
Norway	9,197	7,277	13,348	12,790	10,822	8,975
Panama	--	--	--	--	13	13
Peru	45,318	34,729	34,025	32,117	36,326	29,104
Poland	917	1,082	600	607	652	491
Saudi Arabia	--	--	--	--	39	25
South Africa, Republic of	1,000	644	993	1,054	3,696	2,753
Spain	18,728	14,453	16,907	16,476	17,058	13,370
Sweden	143	115	4,000	3,937	--	--
Switzerland	--	--	100	78	--	--
Taiwan	--	--	--	--	6	7
Tanzania	370	261	173	173	--	--
United Kingdom	9,602	7,387	5,685	5,251	6,779	5,320
Yemen (Sanaa)	127	100	--	--	--	--

See footnotes at end of table.

Table 30.—U.S. general imports of zinc, by country —Continued

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
BLOCKS, PIGS, OR SLABS[1] —Continued						
Yugoslavia	1,558	$1,247	2,467	$2,251	--	--
Zaire	24,593	18,623	32,329	25,769	12,042	$8,597
Zambia	--	--	2,476	2,291	--	--
Total	613,367	501,851	632,172	629,804	610,762	507,898

[1]In addition, in 1985, 332 tons of zinc anodes was imported from Australia, Canada, Denmark, India, Italy, Mexico, Norway, Sweden, Switzerland, Taiwan, Thailand, and the United Kingdom.

Source: Bureau of the Census.

Table 31.—U.S. imports for consumption of zinc, by country

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Australia	858	$114	1,683	$307	1,936	$256
Canada	17,165	4,895	27,467	9,533	50,031	20,017
Chile	27	15	--	--	--	--
Germany, Federal Republic of	6,552	1,067	--	--	--	--
Honduras	11,709	2,965	10,118	4,102	14,302	4,175
Mexico	17,988	4,536	20,113	6,639	12,900	4,149
Peru	8,857	2,956	16,605	5,972	10,452	3,002
South Africa, Republic of	--	--	10,186	2,633	473	1,963
United Kingdom	--	--	--	--	92	64
Total	63,156	16,548	86,172	29,186	90,186	33,626
BLOCKS, PIGS, OR SLABS[1]						
Algeria	2,051	1,846	403	374	--	--
Argentina	--	--	--	--	2,500	1,741
Australia	30,537	23,331	23,188	23,292	29,610	26,483
Austria	102	87	--	--	--	--
Belgium-Luxembourg	5,820	3,787	3,366	2,750	1,000	802
Brazil	--	--	3,280	4,260	--	--
Canada	307,156	263,145	340,490	351,836	383,618	326,388
Congo	--	--	1,311	1,032	--	--
Finland	20,651	16,305	20,704	20,506	19,601	16,832
France	8,932	6,858	12,923	12,807	5,410	4,027
Germany, Federal Republic of	29,675	23,645	27,930	27,543	11,991	11,937
India	--	--	99	84	--	--
Italy	11,913	9,483	13,719	12,270	--	--
Japan	4,305	3,425	3,000	3,050	2,700	2,386
Mexico	59,568	46,706	58,416	57,058	53,984	38,460
Netherlands	21,544	16,546	17,296	16,284	13,053	10,293
Netherlands Antilles	100	85	--	--	--	--
Nigeria	2,553	2,073	--	--	--	--
Norway	9,966	7,847	13,348	12,790	10,822	8,975
Panama	--	--	--	--	13	12
Peru	45,318	34,729	34,025	32,117	36,326	29,104
Poland	917	1,082	600	607	652	491
Saudi Arabia	--	--	--	--	39	25
South Africa, Republic of	1,000	644	993	1,054	3,696	2,753
Spain	18,978	14,691	16,907	16,476	17,058	13,370
Sweden	143	115	4,000	3,937	--	--
Switzerland	--	--	100	78	--	--
Taiwan	--	--	--	--	6	7
Tanzania	370	261	173	173	--	--
United Kingdom	9,602	7,387	5,685	5,251	6,779	5,320
Yemen (Sanaa)	127	100	--	--	--	--
Yugoslavia	1,558	1,247	2,467	2,251	--	--
Zaire	24,793	18,463	32,329	25,769	12,042	8,597
Zambia	--	--	2,476	2,291	--	--
Total	617,679	503,888	639,228	635,940	610,900	508,003

[1]In addition, in 1985, 332 tons of zinc anodes was imported from Australia, Canada, Denmark, India, Italy, Mexico, Norway, Sweden, Switzerland, Taiwan, Thailand, and the United Kingdom.

Source: Bureau of the Census.

Table 32.—U.S. imports for consumption of zinc

	Ores and concentrates (zinc content)		Blocks, pigs, slabs[1]		Sheets, plates, strips, other forms		Waste and scrap	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1983	63,156	$16,548	617,679	$503,888	319	$426	3,900	$1,676
1984	86,172	29,186	639,228	635,940	850	1,308	6,259	3,940
1985	90,186	33,626	610,900	508,003	3,559	2,757	3,247	1,848

	Dross and skimmings (zinc content)		Zinc fume (zinc content)		Dust, powder, flakes		Total value[2] (thousands)
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	
1983	6,508	$3,314	631	$420	6,533	$7,126	$533,398
1984	5,027	3,161	314	171	7,572	9,505	683,211
1985	4,942	2,419	--	--	8,681	10,781	559,434

[1]Unwrought alloys of zinc were imported as follows, in metric tons: 1983—49 ($34,907); 1984—118 ($100,047); and 1985—1,096 ($841,413).
[2]In addition, the value of manufactures of zinc imported was as follows: 1983—$542,571; 1984—$926,981; and 1985—$713,112.

Source: Bureau of the Census.

Table 33.—U.S. imports for consumption of zinc pigments and compounds

	1984		1985	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Zinc oxide	35,741	$35,516	39,375	$35,122
Zinc sulfide	982	1,455	672	1,037
Lithopone	1,455	793	1,108	620
Zinc chloride	1,226	855	2,385	1,668
Zinc sulfate	2,855	1,574	3,615	2,049
Zinc cyanide	150	304	160	254
Zinc hydrosulfite	288	477	142	227
Zinc compounds, n.s.p.f.	9,735	7,204	4,853	7,267

Source: Bureau of the Census.

Table 34.—Zinc: World mine production (content of concentrate and direct shipping ore unless noted), by country[1]

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Algeria	[r]10.7	[r]11.1	12.1	14.6	12.0
Argentina	[r]35.2	36.4	36.6	35.9	36.0
Australia	518.3	664.8	699.0	659.1	[2]734.0
Austria	18.2	19.1	19.4	20.9	21.5
Bolivia	47.0	45.7	47.1	37.8	41.0
Brazil	[r]95.2	[r]110.6	118.6	103.2	110.0
Bulgaria[e]	65.0	66.0	68.0	68.0	68.0
Burma	3.6	5.4	4.5	5.3	[2]4.4
Canada	1,096.0	1,036.1	1,069.7	1,207.1	1,175.0
Chile	1.5	5.7	6.0	19.2	18.0
China[e]	160.0	160.0	160.0	160.0	190.0
Colombia	.3	--	--	--	1.0
Congo (Brazzaville)[e]	3.0	3.0	3.0	[r]2.8	3.0
Czechoslovakia	[r]9.2	[r]9.3	9.8	7.2	7.3
Ecuador	.7	[r]([3])	([3])	[e].1	.1
Finland	53.5	54.6	55.9	60.2	61.0
France	37.4	37.0	34.3	36.2	[2]39.9
Germany, Federal Republic of	110.7	105.8	113.5	113.0	117.8
Greece	27.0	20.4	21.3	[e]21.5	22.0
Greenland	79.7	80.0	73.1	71.3	[2]70.4
Guatemala	3.0	1.0	--	--	--
Honduras	16.2	24.6	38.0	41.5	[2]44.0
Hungary[e]	1.3	1.5	2.4	2.3	2.2

See footnotes at end of table.

Table 34.—Zinc: World mine production (content of concentrate and direct shipping ore unless noted), by country[1] —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
India	29.1	29.1	40.4	44.3	[2]44.3
Iran	[e]35.0	[e]40.0	30.0	30.0	36.0
Ireland	120.3	167.2	186.0	206.1	192.0
Italy	43.9	39.6	42.9	42.3	[2]45.4
Japan	242.0	251.4	255.7	252.7	[2]252.0
Korea, North[e]	140.0	140.0	140.0	140.0	160.0
Korea, Republic of	56.2	58.2	56.0	49.2	44.8
Mexico	206.6	242.3	266.3	303.6	280.0
Morocco[e]	[r]7.2	11.2	[r]7.5	[r]10.9	13.6
Namibia	29.6	[e]32.2	33.5	32.2	[2]29.7
Nigeria[e]	.1	.1	.1	.1	.1
Norway	28.5	31.8	32.3	28.7	[2]27.8
Peru	498.9	507.1	576.4	558.5	[2]588.6
Philippines	5.3	3.0	2.3	2.2	[2]1.9
Poland	[r]201.5	[r]183.5	189.0	190.7	187.0
Romania[e]	50.0	45.0	45.0	44.0	43.0
South Africa, Republic of	87.2	91.5	110.0	106.1	[2]96.9
Spain	182.0	167.0	167.7	230.4	[2]227.8
Sweden	180.9	185.0	202.9	205.9	[2]206.8
Thailand	--	--	--	41.4	77.5
Tunisia	[r]8.2	[r]8.4	7.5	6.7	5.5
Turkey	[r]30.8	[r]33.5	31.1	50.7	50.4
U.S.S.R.[e]	790.0	800.0	805.0	810.0	810.0
United Kingdom	10.9	10.2	8.9	7.5	[2]5.4
United States	343.0	326.5	296.7	277.5	[2]251.9
Vietnam[e]	[r]6.5	6.0	7.0	7.0	5.0
Yugoslavia[4]	88.6	83.8	86.8	82.0	84.0
Zaire	63.3	82.1	76.2	74.8	74.0
Zambia	[r]40.6	[r]52.0	55.2	41.1	36.0
Total	[r]5,918.9	[r]6,125.8	6,350.7	6,563.8	6,656.0

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 15, 1986.
[2]Reported figure.
[3]Less than 1/2 unit.
[4]Content in ore hoisted.

Table 35.—Zinc: World smelter production, by country[1]

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Algeria, primary	[r]27.0	[r]28.5	31.2	35.0	31.2
Argentina, primary	26.8	28.9	32.0	31.0	31.0
Australia:					
Primary[2]	295.9	291.4	298.5	301.9	288.4
Secondary[e]	4.5	4.5	4.5	4.5	4.5
Total[e]	300.4	295.9	303.0	[r]306.4	292.9
Austria, primary and secondary	22.7	23.0	23.0	24.0	25.0
Belgium, primary and secondary	234.7	228.3	262.6	270.7	277.0
Brazil:					
Primary	91.9	95.5	99.9	106.9	110.0
Secondary	19.0	14.4	11.0	7.5	10.0
Total	110.9	109.9	110.9	114.4	120.0
Bulgaria, primary and secondary[e]	90.0	90.0	90.0	90.0	90.0
Canada, primary	[r]618.6	[r]511.9	617.0	683.2	[3]692.4
China, primary and secondary[e]	160.0	160.0	175.0	185.0	190.0
Czechoslovakia, undifferentiated	9.0	9.2	[r][e]9.1	[r][e]9.1	9.2
Finland, primary	139.8	[r]155.0	155.3	158.8	[3]160.4
France:					
Primary[e]	232.1	223.8	[r]231.5	238.8	230.0
Secondary[e]	25.0	20.0	18.0	20.0	17.0
Total	257.1	243.8	249.5	258.8	[3]247.0
German Democratic Republic, primary and secondary[e]	16.0	17.0	16.5	17.0	16.0

See footnotes at end of table.

Table 35.—Zinc: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1981	1982	1983	1984[p]	1985[e]
Germany, Federal Republic of:					
Primary	331.5	303.4	328.7	325.6	[3]339.9
Secondary	35.1	31.6	27.8	30.8	[3]27.9
Total	366.6	335.0	356.5	356.4	[3]367.8
Greece, secondary	.4	NA	NA	NA	NA
Hungary, secondary[e]	.6	.6	.6	.6	.6
India:					
Primary	57.4	52.6	53.3	55.8	[3]70.9
Secondary[e]	.2	.2	.2	.2	.2
Total	57.6	52.8	53.5	56.0	71.1
Italy, primary and secondary	180.9	[r]158.6	155.9	169.7	[3]215.6
Japan:					
Primary	575.6	549.0	579.0	644.4	[3]630.0
Secondary	94.6	113.4	122.3	110.1	[3]110.0
Total	670.2	662.4	701.3	754.5	[3]740.0
Korea, North, primary[e]	120.0	120.0	120.0	120.0	140.0
Korea, Republic of, primary	83.9	99.2	108.0	108.5	111.7
Mexico, primary	126.5	127.0	175.7	167.0	170.0
Netherlands, primary and secondary	177.4	186.0	187.5	209.7	202.8
Norway, primary	80.3	79.0	90.7	94.2	[3]92.7
Peru, primary	126.2	160.7	154.0	149.0	[3]162.8
Poland, primary and secondary	167.1	165.4	170.3	176.0	[3]180.0
Portugal, primary	4.6	[r]4.2	3.8	6.4	6.0
Romania, primary and secondary[e]	[3]45.2	[r]39.8	42.0	41.0	40.0
South Africa, Republic of, primary	87.2	79.7	84.4	88.4	[3]89.8
Spain, primary	179.5	181.8	189.9	207.4	[3]205.3
Thailand, primary	--	--	--	([4])	62.1
Turkey, primary	18.1	14.9	14.3	19.5	12.0
U.S.S.R.:[e]					
Primary	820.0	830.0	835.0	850.0	850.0
Secondary	85.0	90.0	95.0	95.0	100.0
Total	905.0	920.0	930.0	945.0	950.0
United Kingdom, primary and secondary	[r]81.6	79.3	87.7	85.6	[3]74.3
United States:					
Primary	346.6	228.2	235.7	253.1	[3]236.0
Secondary	50.2	74.3	69.4	78.1	[3]75.6
Total	396.8	302.5	305.1	331.2	[3]311.6
Vietnam, primary[e]	[r]5.0	5.0	6.0	6.0	4.2
Yugoslavia:					
Primary[e]	86.4	76.8	[r]77.0	81.6	71.4
Secondary[e]	10.0	10.0	11.0	11.0	12.0
Total	96.4	86.8	88.0	92.6	[3]83.4
Zaire, primary	57.6	64.4	62.5	66.1	67.9
Zambia, primary	33.3	39.2	37.9	29.2	23.0
Grand total	[r]6,081.0	[r]5,865.7	6,200.7	6,463.4	6,566.8
Of which:					
Primary	[r]4,571.8	[r]4,350.1	4,621.3	4,827.8	4,889.1
Secondary	[r]324.6	359.0	359.8	357.8	357.8
Undifferentiated	[r]1,184.6	[r]1,156.6	1,219.6	1,277.8	1,319.9

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Wherever possible, detailed information on raw material source of output (primary—directly from ores, and secondary—from scrap) has been provided. In cases where raw material source is unreported and insufficient data are available to estimate the distribution of the total, that total has been left undifferentiated (primary and secondary). To the extent possible, this table reflects metal production at the first measurable stage of metal output. Table includes data available through July 15, 1986.

[2]Excludes zinc dust.

[3]Reported figure.

[4]Revised to zero.

Zirconium and Hafnium[1]

By W. Timothy Adams[2]

Zircon, the principal ore mineral of zirconium, was mined as a coproduct of ilmenite and rutile from sand deposits in Florida. Most zircon was used in the Eastern United States, with approximately 35% being used in foundry sands and the remainder in refractories, ceramics, abrasives, and in miscellaneous uses including the manufacture of chemicals and the production of zirconium metal and alloys. The value of zircon consumed was about $16 million. Hafnium was used in nuclear reactors, refractory alloys, and cutting-tool alloys.

Table 1.—Salient U.S. zirconium statistics

(Short tons)

	1981	1982	1983	1984	1985
Zircon:					
Production	W	W	W	W	W
Exports	11,630	11,011	13,222	9,528	16,855
Imports	91,108	68,465	44,487	66,436	43,787
Consumption[e] [1]	150,000	93,000	100,000	130,000	130,000
Stocks, yearend: Dealers and consumers[2]	33,385	[e]48,595	[e]36,498	[e]32,861	[e]29,288
Zirconium oxide:					
Production[3]	8,251	5,059	[e]4,118	[e]7,373	[e]9,173
Exports	782	1,017	698	422	1,048
Imports	235	332	451	793	1,468
Consumption[e]	8,600	5,600	3,400	5,800	7,500
Stocks, yearend: Producers[3]	1,483	1,357	[e]895	[e]1,183	[e]1,524

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Includes insignificant amounts of baddeleyite.
[2]Excludes foundries.
[3]Excludes oxide produced by zirconium metal producers.

Domestic Data Coverage.—Domestic mine production data for zircon are developed by the Bureau of Mines from one voluntary survey of U.S. operations entitled "Production of Zircon." Of the two operations to which a survey request was sent, both responded, representing 100% of production. Data are withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—As part of a longstanding program to supply contractors with nuclear reactor construction material manufactured to U.S. Navy specifications, the U.S. Department of Energy had an inventory, as of December 31, 1985, of about 39 short tons of zirconium sponge, 1,000 tons of zirconium ingots and shapes, 2 tons of zirconium scrap, 31 tons of hafnium ingots and shapes, 3 tons of hafnium crystal bar, 5 tons of hafnium oxide, and 1 ton of hafnium scrap.

DOMESTIC PRODUCTION

Zircon was recovered, along with titanium minerals, by E. I. du Pont de Nemours & Co. Inc. at Starke and Trail Ridge, FL, and by Associated Minerals (USA) Ltd. Inc. at Green Cove Springs, FL. The combined zircon capacity of these plants was estimated to be 125,000 tons per year. Production data were withheld from publication to avoid disclosing company proprietary data.

Five firms produced 47,117 tons of milled (ground) zircon from domestic and imported zircon, and six companies, excluding those that produce the oxide as an intermediate product in making zirconium sponge metal, produced 9,173 tons of zirconium dioxide. Two companies produced zirconium sponge, ingot, and alloys, as well as hafnium sponge and crystal bar.

Table 2.—Producers of zirconium and hafnium materials in 1985

Company	Location	Materials
ZIRCONIUM MATERIALS		
American Minerals	Camden, NJ	Milled zircon.
Associated Minerals (USA) Ltd. Inc	Green Cove Springs, FL	Zircon.
Carborundum Co	Falconer, NY	Refractories.
Ciba-Geigy Corp., Drakenfeld Colors	Washington, PA	Ceramic colors and milled.
Continental Mineral Processing Corp	Sharonville, OH	Milled zircon.
Corhart Refractories Corp	Louisville, KY	Refractories.
Do	Corning, NY	Do.
Do	Buckhannon, WV	Do.
Didier-Taylor Refractories Corp	South Shore, KY	Do.
Do	Cincinnati, OH	Do.
E. I. du Pont de Nemours & Co. Inc	Starke and Trail Ridge, FL	Zircon and foundry mixes.
Elkem Metals Co	Alloy, WV	Alloys.
Foote Mineral Co	Cambridge, OH	Do.
A. P. Green Refractories Co., Remmey Div	Philadelphia, PA	Refractories.
Harbison-Walker Refractories	Mount Union, PA	Do.
Harshaw Chemical Co	Elyria, OH	Oxide and other compounds.
Leco Corp., Ceramics Div	St. Joseph, MI	Refractories and milled zircon.
Lincoln Electric Co. Inc	Cleveland, OH	Welding rods.
M & T Chemicals Inc	Andrews, SC	Ultrox and milled zircon.
Magnesium Elektron Inc	Flemington, NJ	Compounds.
Norton Co	Huntsville, AL	Oxide.
Reading Alloys	Robesonia, PA	Alloys.
Shieldalloy Corp	Newfield, NJ	Welding rods and alloys.
Sola Basic Industries, Engineered Ceramics Div	Gilberts, IL	Ceramics.
TAM Ceramics	Niagara Falls, NY	Milled zircon, oxide, compounds.
Teledyne Wah Chang Albany	Albany, OR	Oxide, sponge, ingot, mill products.
Thiokol Corp., Ventron Chemicals Div	Beverly, MA	Oxide.
Transelco, a division of Ferro Corp	Bow, NH	Do.
Western Zirconium Inc	Ogden, UT	Oxide, sponge, ingot, mill products.
Zedmark Inc	Butler, PA	Refractories.
Zircar Products Inc	Florida, NY	Fibrous ceramics.
ZIRCOA Products, Ceramic Products	Solon, OH	Oxide and ceramics.
HAFNIUM MATERIALS		
Teledyne Wah Chang Albany	Albany, OR	Oxide, sponge, ingot, crystal bar.
Western Zirconium Inc	Ogden, UT	Do.

CONSUMPTION AND USES

About 35% of the domestic zircon produced in 1985 was used in proprietary mixtures as foundry sand, and the remainder was used in refractory sand blends with kyanite, sillimanite, and staurolite; in chemicals; in weighting agents; in glazes and enamels; in refractories; in ceramics; in zircon-titanium dioxide blends for welding-rod coatings; for sandblasting applications; and for the production of zirconium and hafnium metals. Baddeleyite, another zirconium mineral, was used mainly in the manufacture of alumina-zirconia abrasives, and also for ceramic colors, refractories, and other uses.

Table 3.—Estimated[1] consumption of zircon[2] in the United States, by end use

(Short tons)

End use	1984	1985
Zircon refractories[3]	24,500	28,200
AZS refractories[4]	8,200	4,300
Zirconia[5] and AZ abrasives[6]	15,300	20,600
Alloys[7]	4,400	4,700
Foundry applications	49,500	45,500
Other[8]	28,100	26,700
Total	130,000	130,000

[1]Based on incomplete reported data.
[2]Includes insignificant amounts of baddeleyite.
[3]Dense and pressed zircon brick and shapes.
[4]Fused cast and bonded alumina-zirconia-silica-based refractories.
[5]Excludes oxide produced by zirconium metal producers.
[6]Alumina-zirconia-based abrasives.
[7]Excludes alloys above 90% zirconium.
[8]Includes chemicals, metallurgical-grade zirconium tetrachloride, sandblasting, welding rods, and miscellaneous uses.

Research on calcia, magnesia, and yttria transformation-toughened zirconias continued. These materials were considered to have considerable potential for use in ceramic coatings in jet aircraft engines and in other applications where strength and high-temperature oxidation resistance is important. Zirconia ceramics were also used in the automobile industry in sensors for the microprocessor controls on engines.

All of the hafnium metal and most of the zirconium metal consumed were used by the nuclear power industry. For the seventh consecutive year, there were no new orders for commercial nuclear powerplants. However, for the first time in 10 years, no commercial nuclear powerplant was canceled. Most of the remainder of the zirconium metal was used in superalloys and in the chemical and electronics industries.

Table 4.—Estimated[1] consumption of zirconium oxide[2] in the United States, by end use

(Short tons)

End use	1984	1985
AZ abrasives	W	W
AZS refractories[3]	900	300
Other refractories	2,900	4,300
Chemicals	700	1,300
Glazes, opacifiers, colors	1,300	1,600
Total	5,800	7,500

W Withheld to avoid disclosing company proprietary data.
[1]Based on incomplete data.
[2]Excludes oxide produced by zirconium metal producers. Includes baddeleyite.
[3]Fused cast and bonded.

Table 5.—Estimated[1] yearend stocks of zirconium and hafnium materials in the United States

(Short tons)

Item	1984	1985
Zircon concentrate held by dealers and consumers excluding foundries	25,653	20,240
Milled zircon held by dealers and consumers excluding foundries	7,208	9,048
Zirconium:[2]		
Oxide	1,183	1,524
Sponge, ingot, scrap, alloys	785	924
Refractories	17,281	6,673
Hafnium: Sponge and crystal bar	30	30

[1]Based on incomplete data.
[2]Excludes material held by zirconium sponge metal producers.

Table 6.—Published prices of Australian zircon

(U.S. dollars per ton)

Date of publication	Standard grade	Intermediate grade	Premium grade
December 1984	83-90	86- 94	98-101
December 1985	77-83	99-108	102-108

Source: Industrial Minerals (London). No. 207, Dec. 1984, p. 78; and No. 219, Dec. 1985, p. 101.

Table 7.—Published yearend prices of zirconium and hafnium materials

Specification of material	1984	1985
Zircon:		
Domestic, standard grade, f.o.b. Starke, FL, bulk, per short ton[1]	$165.00	$175.00
Domestic, 75% minimum quantity zircon and aluminum silicates, Starke, FL, bulk, per short ton[1]	99.00	99.00
Imported sand, containing 65% ZrO_2, f.o.b., bulk, per metric ton[2]	$91.00- 99.00	$86.00- 92.00
Domestic, granular, bags, bulk rail, from works, per short ton[3]	165.00- 177.00	165.00- 177.00
Domestic, milled, 200- and 325-mesh, rail, from works, bags, per short ton[3]	225.00	225.00
Baddeleyite, imported concentrate:[4]		
96% to 98% ZrO_2, minus 100-mesh, c.i.f. Atlantic ports, per pound	.50	.50
99+% ZrO_2, minus 325-mesh, c.i.f. Atlantic ports, per pound	.97	.97
Zirconium oxide:[3]		
Powder, commercial grade, drums, 2,000-pound minimum, per pound	4.25	4.25
Electronic, same basis, per pound	7.25	7.25
Insulating, stabilized, 325° F, same basis, per pound	3.31- 3.82	3.31- 3.82
Insulating, unstabilized, 325° F, same basis, per pound	3.55- 3.75	3.55- 3.75
Dense, stabilized, 30° F, same basis, per pound	2.82	2.82
Zirconium oxychloride: Crystal, cartons, 5-ton lots, from works, per pound[3]	.91- 1.04	.91- 1.04
Zirconium acetate solution:[3]		
25% ZrO_2, drums, carlots, 15-ton minimum, from works, per pound	.97	.97
22% ZrO_2, same basis, per pound	.78	.78
Zirconium hydride: Electronic grade, powder, drums, 100-pound lots, from works, per pound[3]	31.75	31.75
Zirconium:[5]		
Powder, per pound	75.00- 150.00	75.00- 150.00
Sponge, per pound	12.00- 17.00	12.00- 17.00
Sheets, strip, bars, per pound	20.00- 40.00	20.00- 40.00
Hafnium: Sponge, per pound[5]	80.00- 130.00	80.00- 130.00

[1]E. I. du Pont de Nemours & Co. Inc. price list Dec. 1984 (effective Jan. 1, 1985); and Dec. 1985 (effective Jan. 1, 1986).
[2]Industrial Minerals (London). No. 207, Dec. 1984, p. 78; and No. 219, Dec. 1985, p. 101.
[3]Chemical Marketing Reporter. V. 226, No. 27, Dec. 31, 1984 (effective Dec. 28, 1984), p. 28; and v. 228, No. 27, Dec. 30, 1985 (effective Dec. 27, 1985), p. 32.
[4]Ronson Metals Corp. Baddeleyite price lists. Jan. 1, 1985, and Jan. 1, 1986.
[5]American Metal Market. V. 92, No. 250, Dec. 28, 1984, p. 7; and v. 93, No. 249, Dec. 27, 1985, p. 5.

Table 8.—U.S. exports of zirconium ore and concentrate, by country

Country	1984		1985	
	Short tons	Value	Short tons	Value
Algeria	56	$28,050	56	$28,050
Argentina	523	184,361	370	102,218
Belgium-Luxembourg	--	--	80	51,736
Brazil	--	--	3,601	557,658
Canada	391	128,552	249	72,678
Colombia	487	247,990	291	115,725
Ecuador	147	79,922	104	65,006
Germany, Federal Republic of	2,197	827,562	2,194	752,900
India	15	10,883	10	5,850
Japan	3,643	389,940	3,578	493,252
Mexico	1,105	302,334	5,391	1,242,628
United Kingdom	38	5,239	38	9,752
Venezuela	762	352,029	662	344,829
Other	164	89,717	231	123,179
Total	9,528	2,646,579	16,855	3,965,461

Source: Bureau of the Census.

Table 9.—U.S. exports of zirconium, by class and country

Class and country	1984		1985	
	Short tons	Value	Short tons	Value
Zirconium and zirconium alloys, wrought:				
Belgium-Luxembourg	47	$3,854,895	12	$918,662
Canada	181	10,566,721	184	9,658,049
France	12	291,188	1	45,012
Germany, Federal Republic of	88	5,240,786	107	5,782,189
Italy	2	48,188	31	2,644,304
Japan	259	12,418,815	473	20,938,200
Korea, Republic of	9	411,756	1	55,851
Spain	(1)	12,644	7	52,948
Sweden	13	400,851	37	1,434,725
Switzerland	1	76,488	4	385,578
Taiwan	(1)	39,657	17	1,405,102
United Kingdom	33	1,299,754	53	2,232,026
Other	3	150,928	3	120,091
Total	648	34,812,671	930	45,672,737
Zirconium and zirconium alloys, unwrought and waste and scrap:				
Chile	20	693,440	12	380,000
France	(1)	5,667	48	491,293
Germany, Federal Republic of	9	74,364	18	375,887
Japan	108	6,704,625	122	4,086,304
Netherlands	3	13,038	1	9,110
Peru	--	--	16	328,000
United Kingdom	17	116,019	1	80,776
Other	3	102,928	5	133,751
Total	160	7,710,081	223	5,885,121

[1]Less than 1/2 unit.

Source: Bureau of the Census.

Table 10.—U.S. exports of zirconium oxide, by country

Country	1984		1985	
	Short tons	Value	Short tons	Value
Argentina	18	$56,261	--	--
Belgium-Luxembourg	16	22,222	18	$25,106
Brazil	19	66,491	20	777,387
Canada	52	182,928	157	516,629
France	13	46,313	31	109,597
Germany, Federal Republic of	19	82,222	9	58,966
Greece	--	--	5	6,400
Hong Kong	5	10,491	5	10,886
Italy	37	115,801	38	114,279
Japan	62	192,127	45	162,614
Korea, Republic of	--	--	315	125,819
Mexico	47	113,212	93	287,644
Netherlands	11	31,923	2	10,506
Sweden	16	65,241	2	38,276
Taiwan	17	54,974	19	66,965
United Kingdom	70	131,532	281	942,148
Other	20	91,025	8	78,693
Total	422	1,262,763	1,048	3,331,915

Source: Bureau of the Census.

Table 11.—U.S. imports for consumption of zirconium ores, by country

Country	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)	1985 Quantity (short tons)	1985 Value (thousands)
Argentina	--	--	--	--	5,799	$520
Australia	36,140	$3,385	44,214	$5,289	24,348	2,272
Austria[1]	118	13	--	--	--	--
Belgium-Luxembourg	--	--	461	87	--	--
Canada[1]	1,176	122	1,451	151	2,307	225
Hong Kong	--	--	--	--	333	28
Italy	--	--	--	--	64	25
Philippines	--	--	--	--	87	407
South Africa, Republic of[2]	7,053	897	20,309	2,016	10,849	1,120
Other	(3)	3	1	5	(3)	2
Total	44,487	4,420	66,436	7,548	43,787	4,599

[1]Believed to be country of shipment rather than country of origin.
[2]In addition, very small quantities of baddeleyite were imported.
[3]Less than 1/2 unit.

Source: Bureau of the Census.

Table 12.—U.S. imports for consumption of zirconium and hafnium in 1985, by class and country

Class and country	Short tons	Value
Zirconium, wrought:		
Canada	2	$64,709
France	340	17,504,003
Japan	3	43,410
Other	(1)	12,271
Total	[2]346	17,624,393
Zirconium, unwrought and waste and scrap:		
Belgium-Luxembourg	9	79,570
Canada	28	61,630
France	6	98,121
Japan	9	60,095
Netherlands	9	80,898
United Kingdom	33	199,399
Total	94	579,713
Zirconium alloys, unwrought:		
Belgium-Luxembourg	1	7,364
Germany, Federal Republic of	5	141,610
United Kingdom	5	37,808
Total	[2]10	186,782
Zirconium oxide:		
France	145	287,870
Germany, Federal Republic of	1	39,352
Japan	110	304,304
Netherlands	2	3,520
South Africa, Republic of	750	431,562
United Kingdom	460	2,518,725
Total	1,468	3,585,333
Zirconium compounds:		
Australia	19	3,072
Belgium-Luxembourg	17	50,401
France	30	95,197
Germany, Federal Republic of	6	274,378
Greece	40	71,101
Japan	177	125,632
South Africa, Republic of	1,370	1,226,312
United Kingdom	624	1,133,646
Other	1	6,109
Total	2,284	2,985,848

See footnotes at end of table.

Table 12.—U.S. imports for consumption of zirconium and hafnium in 1985, by class and country —Continued

Class and country	Short tons	Value
Hafnium, unwrought and waste and scrap:		
France	1	$179,613
United Kingdom	(1)	5,654
Total	1	185,267

[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

WORLD REVIEW

Australia led the world in the production of zircon in 1985. Zircon was also produced in the Republic of South Africa, the U.S.S.R., and the United States, and in lesser amounts in six other countries. Baddeleyite was produced in Brazil and in the Republic of South Africa.

Australia.—The Commonwealth Scientific and Industrial Research Organization (CSIRO) and ICI Australia collaborative research effort developed a suitable manufacturing process for the production of zirconia in Australia. Process trials conducted in the second half of 1985 showed the feasibility of producing a wide range of high-value zirconia ceramic powders and zirconium chemicals for domestic use and export to world markets. CSIRO and ICI Australia formed Z-Tech, a joint venture company, on October 29, 1985, to manufacture these materials from Australian zircon. A plant, with a capacity of 2,000 tons per year, was scheduled to be constructed at Kwinana, Western Australia, and completed in 1987.[3]

Renison Goldfields Pty. Ltd., owned by Consolidated Goldfields Pty. Ltd., acquired Du Pont's 50% interest in Allied Eneabba Pty. Ltd., which has holdings in Western Australia. Consolidated Goldfields, a holding company, thus assumed a leading role in the mineral sands industry through this acquisition and through its Associated Minerals Consolidated Pty. Ltd. operation in Australia, as well as through Associated Minerals Consolidated (USA) Ltd. Inc. operations in Florida.[4]

Brazil.—A Brazilian mining company, Minegral-Cia. Brasileira de Mineração Industria e Comercio S.A., completed plans for the construction of a 1,100-ton-per-year zirconium dioxide plant. The oxide was to be produced from coldasite, a mineral that contains 60% zirconium dioxide. The mineral was to be concentrated to a 99% grade and the oxide produced from the concentrate. The concentration and oxide plants were scheduled to be built next to the mine at Poco de Caldas, in Minas Gerais State.[5]

Gambia, The.—The apparent firming of zircon prices induced the Government to reexamine heavy mineral reserves in the coastal areas of the country. Known heavy mineral reserves total 910,000 tons at 1% cutoff, of which 149,000 tons is zircon. It was proposed by the consultant that a small plant be erected to extract zircon from zircon-bearing waste material that had accumulated from earlier mining and recovery of titanium materials. The cash flow from sales of zircon was to be used to erect a larger heavy mineral extraction plant.[6]

Germany, Federal Republic of.—The State Authority for Geosciences of Niedersachsen (Lower Saxony State) concluded an extensive exploratory drilling program. An 11-million-ton deposit of heavy mineral sands was discovered near the Weser River close to the towns of Midlum and Hoisel. The deposit reportedly contains 1.1 million tons of zircon. Additional reserves west of the Weser River were indicated.[7]

South Africa, Republic of.—Richards Bay Minerals announced plans for the expansion in mining capacity for mineral sands in Natal. Production of zircon, estimated at 115,000 tons in 1985, was expected to increase to 160,000 tons in 1987.[8]

Table 13.—Zirconium concentrate: World production, by country[1]

(Short tons)

Country	1981	1982	1983	1984[p]	1985[e]
Australia	478,673	509,792	421,419	501,037	485,000
Brazil	6,614	5,507	15,201	7,027	7,700
China[e]	16,500	16,500	16,500	16,500	16,500
India[2]	13,669	11,556	12,561	[e]13,000	15,000
Malaysia[3]	1,441	2,367	2,809	8,393	9,900
South Africa, Republic of	[e]110,000	[e]140,000	178,884	168,789	220,500
Sri Lanka	3,600	6,381	6,306	4,087	4,080
Thailand	115	216	219	320	330
U.S.S.R.[e]	80,000	90,000	90,000	90,000	95,000
United States	W	W	W	W	W
Total	710,612	[r]782,319	743,899	809,153	854,010

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."
[1]Includes data available through May 20, 1986.
[2]Data are for fiscal year beginning Apr. 1 of that stated.
[3]The 1981-83 figures are exports, and the 1984-85 figures are production.

TECHNOLOGY

A review of the market for two distinct raw materials—natural zirconia in the form of baddeleyite, and the higher purity manufactured zirconia, produced from zircon or in some cases from baddeleyite—was published. The reasons for the growth to date of markets for both materials were examined. The article gave a brief overview of zirconia markets and examined the possibility for growth, which is partly contingent on work still in the research stage.[9]

Work done at Sandia National Laboratories showed that failure of the yttria-stabilized thermal barrier coating on gas turbine blades can be caused by as little as 5 parts per million of sodium or 2 parts per million of vanadium, reducing the life of the blades by a factor of 100. The contaminants cause loss of yttria from the zirconia at operating temperature, leading to failure of the coating.[10]

Efforts to reduce signal attenuation in chemical-vapor-deposited zirconium fluoride glass fiber below 4 decibels per kilometer were unsuccessful. However, another manufacturing process, the double-crucible solid-state melting process, was used to produce a single-mode zirconium fluoride fiber of only 0.02 decibel per kilometer, significantly superior to the standard 0.16 decibel per kilometer silicon dioxide fiber presently used in the telecommunications industry.[11]

RMI Co., Niles, OH, announced acceptance of its zirconium-containing Bets-C titanium alloy for inclusion in the National Association of Corrosion Engineers Materials Requirement Standard for resistance to sulfide cracking in "sour" environments. The alloy contains 3.5% to 4.5% zirconium and is a heat-treatable, deep-hardenable alloy capable of ultimate strengths in excess of 200,000 pounds per square inch.[12]

Zirconia-based materials were used for precision casting molds to give highly accurate dimensions and smooth nonporous surfaces to cast titanium dental crowns. The titanium alloy, melted in a small electric arc furnace designed for use in a dental clinic, is cast in the precision zirconia mold in a vacuum, which prevents oxygen embrittlement and contamination.[13]

It was shown that hafnium hydroxide, precipitated by the addition of ammonium hydroxide to hafnium oxychloride solution, and calcined at 500° C, gives a catalyst capable of yielding isobutylene from synthesis gas with 98% yield at 400° C. Isobutylene is used to improve the octane rating of gasoline.[14]

Zirconium or hafnium additions to nickel aluminide were shown to extend potential commercial applications into diverse areas other than aerospace components. The new alloys were shown to have good ductility and extraordinary strength and oxidation resistance at high-temperature uses.[15]

[1]Zirconium and hafnium are nearly identical in chemical properties and atomic volume and are associated in the principal ore mineral, zircon, in a ratio of about 50 to 1. The two elements are separated for nuclear power applications but not for other uses.
[2]Physical scientist, Division of Nonferrous Metals.
[3]Industrial Minerals (London). World of Minerals. Australia. Z-Tech Zirconia Plans. No. 219, Dec. 1985, p. 9.
[4]———. Comment. No. 219, Dec. 1985, p. 7.

[5]Engineering and Mining Journal. This Month in Mining: Brazil. V. 196, No. 11, Nov. 1985, p. 105.

[6]Industrial Minerals (London). A Proposal To Rejuvenate the Heavy Mineral Industry of The Gambia. No. 212, May 1985, p. 53.

[7]———. The Industrial Minerals of West Germany. No. 219, Dec. 1985, p. 47.

[8]American Metal Market. RBM Plans Expansion for South Africa-Based Ilmenite Smelting Unit. V. 93, No. 138, July 19, 1985, pp. 5, 7.

[9]Dickson, E. M. Zirconia—Growth of a Specialty. Ind. Miner. (London), No. 209, Feb. 1985, pp. 49-53.

[10]Industrial Minerals (London). Sandia Research on Zirconia Coatings. No. 209, Feb. 1985, p. 16.

[11]Lasers and Applications. Fluoride Fiber Losses Reduced Further. V. 5, No. 2, Feb. 1985, pp. 36-37.

[12]American Metal Market. Alloying and Precious Metals. RMI's Beta-C Titanium Alloy Listed in NACE's Standards. V. 93, No. 64, Apr. 3, 1985, p. 6.

[13]———. Dental Crowns of Titanium Under Study. V. 93, No. 154, Aug. 12, 1985, pp. 19-20.

[14]Chem Tech. Techgram Japan. Tokyo Institute of Technology. Research Laboratory of Resources Utilization, 4259, Nagatsuda-Machi, Midori-Ku, Yokahama 227 (0205 G2ON). V. 15, No. 9, Sept. 1985, p. 587.

[15]American Metal Market. Alloys and New Materials. New Applications Open Up for Nickel Aluminide. V. 95, No. 203, Oct. 21, 1985, pp. 17, 28.

Other Industrial Minerals

By Staff, Division of Industrial Minerals

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ASPHALT (NATIVE)[1]

Native asphalt was produced by four companies in two States, Texas and Utah. Bituminous limestone, used primarily as a paving material for street and road repair, was produced by one firm, R. L. White Co., Dabney Quarry, Uvalde County, TX.

Gilsonite, a solidified hydrocarbon found only in Utah and Colorado, was mined by three firms: American Gilsonite Co., a division of Chevron Resources Co. (a subsidiary of Standard Oil Co. of California); Ziegler Chemical and Mineral Corp.; and Hydrocarbon Mining Co. (a subsidiary of Oberon Oil Inc., a Utah corporation), from properties in Uintah County, UT.

Gilsonite is used for a variety of purposes including automobile bodysealer, lightweight aggregate for cement used in oil well drilling, asphaltic building board, protective coverings, anticorrosive paints, and roofing compounds. Gilsonite production in 1985 declined 57% owing primarily to reduced oil well drilling activity. The value per ton was essentially unchanged.

Specific information on bituminous limestone and gilsonite production and value is withheld to avoid disclosing company proprietary data.

GREENSAND[2]

Greensand, also known as glauconite, a natural silicate of potassium, aluminum, iron, and magnesium, was produced by Inversand Co., a subsidiary of Hungerford and Terry Inc., near Clayton, NJ, and by a new producer, Contractors Sand & Gravel Co., near Middletown, DE, who started production in the middle of May 1984. Production and sales information is withheld to avoid disclosing company proprietary data. Processed greensand continued to be sold as a filter media for the removal of manganese and iron from drinking water supply systems. Classified raw greensand was resold by Zook and Ranck Inc. as a soil conditioner and as a source of slowly released potash to organic farmers in North America.

MEERSCHAUM[3]

Crude or block meerschaum was not imported during the year. Imports of crude or block meerschaum were last reported in 1983, all from the United Kingdom, totaling

1,543 pounds, with a customs declared value of $19,290. The high unit value of the 1983 imported material, $12.51 per pound, indicates that the shipments consisted of shaped or formed meerschaum blocks. The major suppliers in the past were the Federal Republic of Germany and Somalia.

Crude or block meerschaum continued to be mined in Turkey and recovered by artisans in Somalia and Tanzania. The block material was used by companies in New York and Ohio for manufacturing smokers' pipes and cigarette holders. Smokers' specialty houses complemented their finished meerschaum items with mail-order kits with detailed instructions for do-it-yourself carving of meerschaum smoking articles. Turkish production in 1985 was estimated to be over 300 unit boxes, 44 pounds each, of block meerschaum. Turkey, the largest producer of crude or block meerschaum, had prohibited exports of uncarved material since 1975.

QUARTZ CRYSTAL[4]

Both U.S. mine production of lascas and consumption as feedstock for cultured quartz crystal output declined in 1985, owing to reduced domestic demand. Domestic cultured quartz crystal producers operated at less than 50% capacity. Imports of Brazilian lascas declined sharply, and exports of cultured quartz crystal were significantly lower than those of 1984.

Domestic Data Coverage.—Domestic production and consumption data for quartz crystal are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the seven operations canvassed for production of cultured quartz, all responded, and the six active operations represented 100% of total production shown in table 1. Of the 28 operations that consumed quartz crystal, all responded, and the 27 active operations represented 100% of total consumption also shown in table 1.

Table 1.—Salient U.S. electronic- and optical-grade quartz crystal statistics

(Thousand pounds and thousand dollars)

	1981	1982	1983	1984	1985
Production:					
Mine[e] [1]	175	200	600	2,500	1,000
Cultured	660	478	426	1,027	568
Exports:					
Natural:[2]					
Quantity	127	69	28	42	60
Value	$490	$380	$156	$234	$290
Cultured:[2]					
Quantity	125	115	80	277	185
Value	$4,600	$3,500	$3,258	$11,021	$3,723
Lascas:[3]					
Quantity	NA	NA	[3]339	[e]1,600	[e]800
Imports of Brazilian lascas:[2]					
Quantity	389	417	153	569	173
Value	$233	$245	$121	$373	$99
Consumption:					
Natural (electronic- and optical-grade)	14	16	13	7	7
Cultured (lumbered)	282	99	112	77	44
Cultured (as grown)	327	383	312	[r]391	224
Total	623	498	437	[r]475	275

[e]Estimated. [r]Revised. NA Not available.
[1]Excludes lascas produced for specimen and jewelry material uses.
[2]Bureau of the Census.
[3]The Journal of Commerce Port Import/Export Reporting Service.

Legislation and Government Programs.—On July 8, the President approved National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict, which would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of material already possessed by the Government. Under this system, 265,000 pounds of natural quartz crystal would be placed in tier I, and 1.8 million pounds would be placed in tier II. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any reduction in a stockpile goal in effect on October 1, 1984.

At yearend 1985, the National Defense Stockpile total inventory was 1.8 million pounds of natural quartz crystal, with a goal of 600,000 pounds. Total sales of natural quartz crystal by the General Services Administration were 83,813 pounds.

DOMESTIC PRODUCTION

Domestic mine production of lascas in 1985 was approximately 1 million pounds, all from Arkansas. The two producers were Geomex Mine Services Inc. and Coleman Crystal Inc. Coleman Crystal was the major supplier of lascas to the U.S. cultured quartz crystal industry. Primary output of Geomex was exported to the Federal Republic of Germany and Japan.

Domestic cultured quartz producers operated at reduced capacity, owing to increased lower-unit-cost production from Japan in the world market. Six companies produced cultured quartz crystal in the United States and output declined 45% from that of 1984. The two largest, Sawyer Research Products Inc., Eastlake, OH, and Thermo Dynamics Corp., Shawnee-Mission, KS, were independent growers that produced crystal bars for domestic and foreign consumers in the crystal device fabrication industry. Motorola Inc., Chicago, IL, produced for both internal consumption and the domestic fabrication industry. P. R. Hoffman Material Processing Co., Carlisle, PA, also reported outside sales during the year. AT&T Technologies Inc., North Andover, MA, was inactive. Bliley Electric Co., Erie, PA, and Electro Dynamics Corp., Shawnee-Mission, KS, produced only for internal consumption.

CONSUMPTION AND USES

U.S. consumption of lascas by the six growers declined 60%, from 1.3 million pounds in 1984 to 522,000 pounds in 1985. Quartz crystal consumption by 27 companies in 10 States declined 42%, from 475,000 pounds (revised) in 1984 to 275,000 pounds in 1985. Of these companies, 22 consumed only cultured quartz crystal, 2 consumed only natural quartz crystal, and 3 consumed both natural and cultured material.

Imported natural quartz crystal continued to be required as seed material for growing cultured quartz. Cultured quartz crystal is the primary material used as resonators in electronic applications. Such applications include timing signals for watches and clocks; microprocessors in industrial, automotive, and consumer products; and military-aerospace and commercial band-pass filters and oscillators that require very high selectivity and stability.

STOCKS

Reported industry stocks of cultured quartz crystal totaled approximately 138,000 pounds at the beginning of the year and increased to approximately 204,000 pounds by yearend.

PRICES

The average reported value of lascas consumed for production of cultured quartz crystal was $0.57 per pound, the same as that reported in 1984. The average value of "as-grown" cultured quartz, based on reported sales of nearly 212,000 pounds, was $15.92 per pound, a decrease of 34% from that of 1984. The average value of lumbered quartz, as-grown quartz that has been processed by sawing and grinding, was $62.23 per pound, an increase of 13% from that of 1984, based upon 1985 sales of about 88,000 pounds.

FOREIGN TRADE

Cultured quartz crystal exports, as reported by the Bureau of the Census, declined 33% to 185,000 pounds. Average value was $20.12 per pound. Japan received 114,000 pounds, and the Republic of Korea, 45,000 pounds. Most of the natural quartz crystal exports were bought from the National Defense Stockpile, primarily for nonpiezoelectric uses.

Imports of Brazilian lascas, designated "Crude Brazilian Pebble," declined 70% to 173,000 pounds.

STAUROLITE[5]

Staurolite is a naturally occurring, complex, hydrated aluminosilicate of iron having a variable composition. The mineral most commonly occurs as opaque reddish-brown to black crystals with a specific gravity ranging from 3.74 to 3.83 and Mohs' hardness between 7 and 8.

A limited rock-shop trade in cruciform twinned staurolite crystals ("fairy crosses") exists, notably from deposits in Georgia, North Carolina, and Virginia. Staurolite in the United States was produced commercially in 1985 by E. I. duPont de Nemours & Co. Inc. and by Associated Minerals (U.S.A.) Ltd. Inc.

Staurolite is a byproduct of heavy mineral concentrates recovered from a glacial-age beach sand in Clay County, north-central Florida. The staurolite is removed by means of electrical and magnetic separation after the concentrates have been scrubbed and chemically washed with caustic, rinsed, and dried. The resulting fraction produced is comprised of about 77% clean, rounded, and uniformly sized grains of staurolite, with minor proportions of tourmaline, ilmenite and other titanium minerals, kyanite, zircon, and quartz. A nominal composition of this staurolite sand is 45% aluminum oxide (minimum), 18% ferric oxide (maximum), 5% titanium dioxide (maximum), and 5% silica.

Although originally marketed only as an ingredient in some portland cement formulations, staurolite is now marketed as a specialty sand under the trade name Biasill for use as a molding material in nonferrous foundries, owing to its low thermal expansion, high thermal conductivity, and high melting point. Its low softening point tends to restrict it to nonferrous casting. Its major use is as an abrasive for impact finishing of metals and sandblasting of buildings under the trade names Starblast (80 mesh) and Biasill (90 mesh), as well as a coarse grade (55 mesh) abrasive.

Quantitative production data are not released for publication, but the 1985 production of staurolite decreased 42% from that of 1984; shipments decreased 8% in tonnage and increased 12% in price per ton. Domestic productive capacity remained at about 135,000 short tons per year.

Staurolite has continued to be produced in India in small quantities and sometimes by other nations as well.

STRONTIUM[6]

Imports of major strontium compounds for use in several downstream products increased, whereas imports of celestite, a strontium sulfate mineral, decreased because of consumer preference for the refined compounds. Strontium demand increased in several end uses requiring increased imports of strontium chromate, strontium nitrate, and precipitated and nonprecipitated strontium carbonate. The United States had been the leading producer of strontium compounds as late as 1982; however, only one U.S. producer, Chemical Products Corp. (CPC), remained in operation in 1985. Because celestite was not mined in the United States, CPC produced strontium carbonate from imported celestite.

Domestic Data Coverage.—Domestic production data for strontium are developed by the Bureau of Mines from a voluntary survey of U.S. operations. The one operation to which a survey request was sent responded, representing 100% of total production. However, to avoid disclosing company proprietary data, production and stock data were withheld from publication.

The strontium survey is also used to calculate the distribution of major strontium compounds by end use. Of the 12 operations to which a survey request was sent, 8 responded, representing an estimated 67% of the end-use data shown in table 3. Consumption for the nonrespondents was estimated using reported prior year consumption levels adjusted by trends in employment and industrial market patterns.

Table 2.—Major producers of strontium compounds in 1985

Company	Location	Compounds
Chemical Products Corp	Cartersville, GA	Carbonate and nitrate.
Mallinckrodt Inc	St. Louis, MO	Chloride.
Mineral Pigments Corp	Beltsville, MD	Chromate.

DOMESTIC PRODUCTION

With the closure of FMC Corp.'s Modesto, CA, plant in 1984, CPC became the sole domestic producer of strontium carbonate from imported celestite. Several other firms manufactured various strontium compounds from strontium carbonate in 1985.

Church & Dwight Co. Inc. purchased a 49% share in a Mexican producer of barium and strontium carbonates. Church & Dwight intended to market the strontium carbonate in the United States through its marketing and sales network.

CONSUMPTION AND USES

Strontium carbonate used in the manufacture of faceplate glass for color television picture tubes accounted for more than one-half of domestic consumption of strontium compounds. Strontium carbonate was also used to make ferrite ceramic magnets and in the electrolytic production of zinc.

Strontium nitrate was used in pyrotechnics and signals. That sector remained the second largest consumer of strontium compounds. Other strontium compounds for domestic consumption included strontium chromate used as a corrosion inhibitor in pigments, strontium chloride used in the manufacture of toothpaste for sensitive teeth, and strontium phosphate used in fluorescent lights.

Table 3.—U.S. estimated distribution of primary strontium compounds, by end use

(Percent)

End use	1983	1984	1985
Electrolytic production of zinc	3	6	6
Ferrite ceramic magnets	9	11	12
Pigments and fillers	4	8	8
Pyrotechnics and signals	14	14	15
Television picture tubes	64	53	52
Other	(1)	1	1
Unidentified	6	7	6
Total	100	100	100

[1]Less than 1/2 unit.

PRICES

The average value of imported celestite from Mexico, which was the sole supplier of the mineral in 1985, was $88.43 per short ton. Average values for imported strontium compounds varied according to the type of compound.

FOREIGN TRADE

Mexico supplied all of the celestite imported by the United States. Canada, China, Japan, Mexico, and several countries in Western Europe were the sources of imports of various strontium compounds.

Because of the closure of FMC's facility in 1984, foreign competition for domestic strontium markets was strong. Imports of strontium materials in 1985 were more than those of the preceding year in all categories. Unwrought strontium metal imports increased more than six times the 1984 level. The leading suppliers of strontium carbonate, in descending order, were the Federal Republic of Germany, Mexico, and Canada. Strontium nitrate imports nearly doubled in response to the decrease in domestic supply.

According to the Port Import/Export Reporting Service of the Journal of Commerce, exports of various strontium compounds were about 38 tons. These compounds included the carbonate, chloride, chromate, peroxide, silicate, and zirconate of strontium.

Table 4.—U.S. imports for consumption of strontium minerals[1] by country

Country	1984		1985	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Madagascar	(2)	$1	--	--
Mexico	46,873	3,940	37,552	$3,321
Spain	1,978	352	--	--
Total	[3]48,852	4,293	37,552	3,321

[1]Celestite (strontium sulfate).
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

Source: Bureau of the Census.

Table 5.—U.S. imports for consumption of strontium compounds and metal, by country

Country	1984		1985	
	Pounds	Value[1]	Pounds	Value[1]
Strontium carbonate, not precipitated:				
Canada	436	$345	--	--
Germany, Federal Republic of	39,683	11,233	--	--
Mexico	84,000	23,880	186,384	$51,256
Spain	39,683	9,423	--	--
Total	163,802	44,881	186,384	51,256
Strontium carbonate, precipitated:				
Canada	158,733	66,935	119,049	35,169
China	829,547	253,331	37,478	11,003
Germany, Federal Republic of	5,586,138	1,577,834	9,676,889	2,955,649
Mexico	354,200	130,219	244,100	64,800
Total	6,928,618	2,028,319	10,077,516	3,066,621
Strontium chromate:[2]				
Belgium	5,291	5,941	154,102	149,580
France	222,665	224,149	207,154	231,333
Germany, Federal Republic of	13,228	19,340	260,541	244,541
Italy	--	--	17,637	19,456
Spain	147,647	161,879	187,714	212,206
United Kingdom	4,698	13,574	--	--
Total	393,529	424,883	827,148	857,116
Strontium nitrate:				
Germany, Federal Republic of	--	--	882	3,014
Italy	970,517	417,918	935,633	371,571
Spain	865,619	325,233	2,427,631	966,496
Total	1,836,136	743,151	3,364,146	1,341,081
Strontium compounds, other:				
Belgium	441	390	7,716	9,450
Germany, Federal Republic of	22,391	22,913	58,863	55,379
Japan	157,364	109,954	261,795	175,069
Netherlands	7,726	11,598	--	--
United Kingdom	--	--	22,157	29,695
Total	187,922	144,855	350,531	269,593
Strontium metal, unwrought: Canada	1,424	17,980	9,052	86,160

[1]Customs value.
[2]Imported as strontium chromate pigment (TSUS 473.19).

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Timminco Ltd. won the bid for the mineral rights to a celestite-bearing deposit that had been mined from 1970 to 1976 by Kaiser Celestite Mining Ltd. Because the two beds of celestite have strontium sulfate grades from 45% to 55% and 60% to 70%, the ore would require beneficiation to achieve the commercially acceptable minimum of 90% strontium sulfate content.

Mexico.—Cía. Mineral la Valenciana S.A. completed construction of a 12,000-ton-per-year strontium carbonate plant at Torreón, Coahuila. The company, which was the largest celestite producer in the world, was the sole supplier to CPC in the United States.

Church & Dwight purchased a 49% interest in Sales y Oxidos, which produced barium and strontium carbonates at Monterrey. Plant capacity was expected to be increased to 8,800 tons per year of strontium carbonate by 1986.

Table 6.—Strontium minerals: World production, by country[1]

(Short tons)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Algeria[e]	6,000	6,000	6,000	6,000	6,000
Argentina	342	855	742	440	550
Iran[e 3]	5,500	5,000	5,100	5,100	5,100
Italy	7,382	3,607	[e]3,600	[r e]3,700	3,700
Mexico	45,574	34,917	41,343	35,264	35,300
Pakistan	[r]317	[r]513	149	622	750
Spain	39,683	[r]38,470	38,000	29,760	30,000
Turkey[e]	16,500	16,500	[4]42,808	38,600	38,600
United Kingdom	16,000	19,800	13,340	17,750	18,700
Total	[r]137,298	[r]125,662	151,082	137,236	138,700

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 10, 1986.
[2]In addition to the countries listed, China, Poland, and the U.S.S.R. produce strontium minerals, but output is not reported quantitatively, and available information is inadequate for formulation of reliable estimates of output levels.
[3]Year beginning Mar. 21 of that stated.
[4]Reported figure.

WOLLASTONITE[7]

Wollastonite is a natural calcium silicate and has a theoretical composition of $CaO \cdot SiO_2$.

The tonnage of wollastonite sold or used by U.S. producers in 1985 was approximately the same as that of 1984. Specific data are withheld to avoid disclosing company proprietary data. The two producers, in descending order of output, were NYCO, a division of Processed Minerals Inc., Essex County, NY, and R. T. Vanderbilt Co. Inc., Lewis County, NY.

NYCO announced the opening of a pilot plant to perform a variety of reduced-scale functions for the development and application of specialty and surface modified minerals. The plant offers customers full replication of commercial processes in the use of NYCO products, providing information on the effect of process variables and enabling production conditions to be optimized in advance of commercial operation.[8]

Some of the major uses of wollastonite are as a filler in ceramic tile, marine wallboard, paint, plastics, and refractory liners in steel mills; and as a partial replacement for short-fibered asbestos in certain applications such as brake linings.

For use in paints, finer grades of wollastonite are employed, especially in the 325-mesh range. The mineral is fairly alkaline and is used in polyvinyl acetate paints to prevent undesirable acidity and to reduce corrosion of steel substrates. Wollastonite is also used in exterior architectural coating, especially in water-based paints, giving improved weatherability. It has also found use in traffic paints, and as an asbestos replacement in asphalt-based coatings.[9]

A comprehensive report published by Charles H. Kline & Co. Inc., Fairfield, NJ, deals with chemically modified minerals and forecasts a growth in consumption for these minerals from $110 million in 1984 to $150 million by the end of the century. This represents an average annual growth rate of approximately 6%. Several mineral fillers are discussed in the report, including wollastonite. These minerals are chemically treated with organic chemicals to improve bonding, processing, and moisture resistance within the matrix media. Chemical compounds such as stearates and silanes are used to produce the chemically modified minerals, which, in turn, are employed in plastics and rubbers. Chemically treated minerals were originally seen as a cost-effective way of reducing the volume of raw polymer material being used. However, during the past several years, developments have increased mineral compatability with the matrix polymer so that chemically treated fillers and extenders actually contribute to the products' eventual physical characteristics and performance.[10]

In Finland, Oy Partek AB planned to bring on-stream a new beneficiation plant that would increase capacity from 22,000 tons per year to 44,000 tons per year of wollastonite in 1986. The plant was to include an improved flotation process, increased automation, and wet high-intensity magnetic separation. Partek's mine at Lappeenranta had proven reserves of 4 million tons of ore. A newly discovered deposit 18 miles northwest of Lappeenranta had calculated reserves of approximately 22 million tons of ore. This deposit will undergo further investigation during the next few years. The increase in production capacity will enable the company to introduce new micronized grades of wollastonite, primarily for filler applications where high reinforcing performance is desired.[11]

Chemical Marketing Reporter, December 30, 1985, quoted prices for wollastonite, truckloads, f.o.b. plant, as $200 per ton for general grade, $140 per ton for 325 mesh, $160 per ton for 400 mesh, and $500 per ton for 1,250 mesh.

ZEOLITES[12]

Domestic production of natural zeolites was approximately 13,000 short tons. Five companies mined clinoptilolite and chabazite in five States.

The Double Eagle Petroleum & Mining Co. leased its Castle Creek zeolite mine in Idaho to International Minerals & Chemical Corp. The deposit is composed of more than 90% clinoptilolite and has proven reserves in excess of 20 million tons.[13] Zeolite International Inc. developed and operated a zeolite deposit at Ash Meadows, CO. The deposit was leased from Anaconda Minerals Co., a subsidiary of Atlantic Richfield Co. The Ash Meadows deposit is a high-purity clinoptilolite deposit. The clinoptilolite was marketed for aquaculture, desiccation, solar energy, and gas separation.[14]

The Georgia Institute of Technology in Atlanta established a program to study the synthesis, characterization, catalytic, and absorption properties of molecular sieves and zeolites.[15] The program will be funded by industrial sponsors, who will receive royalty-free, nonexclusive licenses to the products of the center.

The use of zeolites as molecular sieves for absorbents and desiccant applications increased in 1985, replacing silica gel and activated alumina. Zeolites were estimated to account for 50% of the market, up from 33% in 1976.[16]

Zeolites are used in water treatment as ion exchangers.[17] Synthetic zeolites, in particular, are widely employed where water purity is critical to prevent scale buildup, such as in electric power station and other industrial boiler operations. Synthetic zeolite resins exchange sodium for calcium and magnesium to reduce the hardness of the water without affecting the total dissolved solids content. Natural zeolites are used less extensively. They do not possess the same cation exchange capacities of synthetic zeolites, but they are lower in cost, more resistant to attrition, and have greater affinities for some heavy cations. Several uses, both experimental and commercial, include ammonium-ion removal in wastewater treatment, odor control for fish farming, chicken farming, and in cat litter, and removal of heavy metal ions from nuclear, mine, and industrial wastewaters.

PQ Corp. began an expansion of its synthetic zeolite facility in Kansas City, KS, with construction of a new specialty zeolite catalyst plant in 1985.[18] The company planned to expand its zeolite product market from the current detergent-grade zeolite A. Sodium Y zeolite would be converted into an ultrastable zeolite Y and other Y derivatives for use as catalysts for petroleum refining and chemical synthesis. The plant would manufacture zeolites requiring either pressurized or atmospheric crystallization.

Union Carbide Corp. and its subsidiary, Katalistics International BV, ran commercial trials using newly developed zeolite catalysts based on ultrastable zeolites.[19] The new catalysts were reported to produce high-octane gasoline, rich in olefins, and to impede coke formation and aromatic condensation and offer a viable alternative to other methods of producing high octane levels, such as polymerization, isomerization, alkylation, or the addition of methanol.

The New Zealand Synthetic Fuels Co. began operation of the first commercial application of Mobil Oil Corp.'s methane-to-gasoline (MTG) process at their Motunui plant.[20] The key element of the MTG process is the ZSM-5 zeolite used in the process. With intersecting 6-angstrom-diameter channels, the zeolite allows hydrocarbons to boil in the gasoline range and limits products to short chain hydrocarbons. The MTG conversion is a new technology that may challenge traditional methods of producing synthetic fuels and organic feedstocks.

A private group called Inversiones BIMA, Buenos Aires, Argentina, applied for Government approval to build a $920 million MTG plant.[21] The planned plant capacity would be 1 million cubic meters of gasoline per year, with annual revenues from exports estimated at $300 million at 1985 world prices. This plant would be only the second commercial application of Mobil Oil's MTG process.

Several new zeolite deposits were discovered in the Angora, Yakut, and Buryat areas in Eastern Siberia.[22] The All-Union Institute of Geology, Geochemistry, and Minerals Raw Materials in Irkutsk set up a laboratory to study the mineralogical characteristics of zeolites from these deposits.

TECHNOLOGY

The cesium exchange properties of several zeolitic tuffs and several synthetic zeolites were tested using equilibrium exchange reactions.[23] The zeolitic tuffs were composed of phillipsite, mordenite, clinoptilolite, erionite, chabazite, and analcime. Zeolitic tuffs composed of phillipsite had the best ion exchange characteristics over a range of solution concentrations. The phillipsite tuffs also reacted more favorably to heat treatment, used to immobilize the cesium in the structure, than other zeolites types. The significance of the exchange capacities and phase transformations of the phillipsite-rich tuffs is the potential to decontaminate nuclear waste solutions and fix cesium in the crystal structure to prevent removal by leaching with ground water.

Single metal atoms can be directed and attached to the intracrystalline cavities of some zeolites by using a solvated metal atom that can pass through the crystal structure and enter the α-cages while maintaining the integrity of the zeolite structure.[24] Bis(toluene)iron(o) and bis(toluene)cobalt(o) were filtered through faujasite zeolite Y at 173 to 193 K. Upon reaching room temperature, the bis(toulene)metal(o) complex decomposed to toluene and a metal atom, leaving metal atoms in the crystal structure. Metal atom clusters then formed when single atoms diffused through the structure and agglomerated. The cluster sizes are controlled by the initial atom loading in the structure and the size of the α-cage. This technique was proven to be a nondestructive means of depositing zero-valent metal atoms in the zeolite structure. Zeolites containing site-specific metal clusters may be potentially useful as catalysts for oil, gas, and petroleum production.

Aluminosilicate zeolites were synthesized using a nonaqueous solvent technique.[25] Usually, zeolites are synthesized from alkaline aqueous solutions or by solid-state reactions between silica and alumina salts at high temperatures. Using a nonaqueous technique, pure silica zeolites, called silica-sodalite, were synthesized. This research suggested that other framework aluminosilicates could be synthesized in silica-rich or pure silica forms.

Union Carbide developed a molecular sieve with many properties similar to zeolites.[26] The sieves, called silicoaluminophosphates (SAPO), formed in a similar manner as zeolites, crystallizing at temperatures from 100° to 200° C from reactive mixtures containing template materials. The template materials, usually organic amines or quaternary ammonium compounds, were retained within the products. SAPO were expected to be useful as absorbents, ion exchange agents, catalysts, and catalyst supports.

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[2]Prepared by James P. Searls, physical scientist.
[3]Prepared by Sarkis G. Ampian, physical scientist.
[4]Prepared by A. C. Meisinger, industry economist.
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Other Metals

By Staff, Divisions of Nonferrous and Ferrous Metals

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ARSENIC[1]

In 1985, ASARCO Incorporated terminated copper smelting operations and associated byproduct arsenic trioxide recovery at Tacoma, WA, although shipments of arsenic trioxide from stocks and limited production from cleanup operations continued. Imports of arsenic trioxide increased markedly as a result of increased demand for arsenical wood preservatives and the decline in domestic shipments of trioxide. Expanded world capacity more than met the increased demand for arsenic and its compounds, and prices remained unchanged throughout the year.

Domestic Data Coverage.—Arsenic trioxide was produced by one U.S. company, which voluntarily reported its production to the Bureau of Mines.

Legislation and Government Programs.—On July 13, 1984, the Environmental Protection Agency (EPA) issued a "Notice of Intent To Cancel Registrations of Pesticide Products Containing Creosote, Pentachlorophenol, and the Inorganic Arsenicals" and announced that certain modifications to the terms and conditions of registration for wood preservative uses of the three chemicals were required to avoid cancellation. In addition, it established workplace regulations and air monitoring criteria at wood preserving plants and required wood pressure treaters to provide consumer information sheets on the safe handling and disposal of treated wood. As a result of challenges filed by the wood preservative industry, EPA, in several separate actions during 1984 and 1985, stayed the effective date of the modifications to the terms and conditions of registration.[2]

On September 30, Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), expired. Under Superfund, arsenic was taxed at a rate of $4.45 per ton, and arsenic trioxide was taxed at a rate of $3.41 per ton. At yearend, several bills to reauthorize Superfund taxing authority were under consideration by Congress.

DOMESTIC PRODUCTION

During 1985, production of arsenic trioxide and metal by Asarco, the only domestic producer, declined from that of 1984 by 68%. Asarco produced arsenic trioxide at its Tacoma, WA, copper smelter as a byproduct of the smelting of imported high-arsenic copper concentrates and ores, mainly from Chile and the Philippines, as well as from domestic arsenic-bearing residues and concentrates. Arsenic metal was produced from high-purity imported arsenic trioxide; the low grade and antimony contamination of the arsenic trioxide produced at Tacoma made it unsuitable for metal production.

In March, copper smelting operations at Tacoma, WA, were permanently terminated. The company cited low copper prices, a shortage of suitable concentrates, and the estimated $150 million cost of meeting Federal, State, and local sulfur dioxide emissions standards as the reasons for closure. Although copper smelting ceased in March, production of arsenic trioxide from stocks of residues continued throughout the year. By yearend, production of arsenic trioxide and metal had ended, though shipments of arsenic metal and trioxide from stocks were expected to continue through the first half of 1986. Asarco was reportedly investigating alternatives to its Tacoma roasting process for processing arsenic-bearing residues generated at other Asarco nonferrous smelters.

In addition to purchasing refined arsenic trioxide, Koppers Co. Inc., a major producer of arsenical wood preservatives, produced refined arsenic trioxide at its plant in Conley, GA, from low-grade material imported from Canada. Arsenic acid was produced from the trioxide and was marketed or consumed internally in the production of chromated copper arsenate (CCA) wood preservatives. A second company, Mineral Research Development Corp., Charlotte, NC, produced arsenic acid for use in wood preservatives directly from low-grade Canadian material. Mineral Research was purchased by Laporte Industries Ltd. of the United Kingdom, which also purchased Chemical Specialties Inc., a producer of CCA wood preservatives, in Valdosta, GA. Chemical Specialties expanded its CCA mixing capacity, making it one of the largest domestic producers of arsenical wood preservatives. W. R. Metals Inc., formerly Williams Strategic Metals Inc., Wheat Ridge, CO, produced arsenic acid for sale to the wood preservative industry from arsenic-bearing lead smelter flue dusts containing about 50% arsenic at its plant in Wyoming.

High-purity arsenic metal for use in electronic devices was refined from commercial-grade metal by at least two companies—Asarco at its Globe, CO, plant, and Canyonlands 21st Century Corp. at its Blanding, UT, facility. By yearend, Canyonlands had declared bankruptcy and was closed; its assets were to be sold at auction.

CONSUMPTION AND USES

Arsenic compounds, principally arsenic trioxide, accounted for 98% of the arsenic consumed in 1985. Demand for arsenic and its compounds was estimated to be equivalent to about 18,000 metric tons of contained arsenic, up slightly from that of 1984. Domestic production accounted for about 21% of demand. Three major producers of arsenical wood preservatives and four producers of agricultural chemicals accounted for most of the domestic consumption of arsenic trioxide. Arsenic acid, produced from arsenic trioxide, was used directly, or as an intermediate product. The estimated end-use distribution of arsenic was 67% in wood preservatives, 25% in agricultural products (principally herbicides and desiccants), 4% in glass, 2% in metallic form in nonferrous alloys and electronics, and 2% in other uses (animal feed additives, pharmaceuticals, etc.).

CCA, by far the most important of the arsenical wood preservatives, is a waterborne, leach-resistant wood preservative prepared by mixing arsenic acid with copper oxide or sulfate and chromic acid. It is used to pressure treat a variety of wood products that are subject to outdoor or inground exposure, and may serve to extend the service life of wood by a factor of at least 15.[3] According to data published by the American Wood Preservers Institute for 1983 and 1984, there were 547 wood treating plants operating in the United States in 1984, 342 of which treated with waterborne (96% CCA) preservatives. The plants treated 499.1 million cubic feet of wood products in 1984: 301.7 million with waterborne preservatives, 137.6 million with creosote solutions, 53.6 million with pentachlorophenol, and 6.2 million with fire retardant chemicals. Although total production of treated wood in 1984 was 12% above 1983 production levels, production of wood products treated with waterborne preservatives increased by 17%. Of the wood products treated with waterborne preservatives, 76% was lumber; 7%, timbers; 5%, fence posts; 4%, poles; and 8%, other products.[4]

The principal agricultural market for arsenicals was in cotton growing, where arsenic acid was used as a desiccant to aid in mechanical stripper harvesting of cotton, and other arsenical chemicals, such as monosodium methanearsonate (MSMA) and disodium methanearsonate (DSMA), were used as herbicides for control of grassy and broadleaf weeds. Cotton planting in 1985 declined slightly from 1984 levels. To a lesser extent, arsenical herbicides were used in noncrop areas such as railroad right-of-ways.

Arsenic trioxide and arsenic acid were

used in the glass industry primarily as a fining agent to remove tiny, dispersed air bubbles and also as a decolorizing agent. Use in recent years has been limited to the pressed and blown glass sector for products such as tableware, lead glass, optical glass, and glass ceramics.

The bulk of metallic arsenic was used in lead- and copper-based alloys as a minor additive (about 0.01% to 0.5%) to increase strength in the posts and grids of lead-acid storage batteries and to improve corrosion resistance and tensile strength in copper alloys. A relatively small amount, less than 10 tons, of high-purity arsenic metal was used in the electronics industry. Gallium arsenide and its alloys have been used in such products as light-emitting diodes and displays, room-temperature lasers, microwave devices, solar cells, and photoemissive surfaces. Development of gallium arsenide integrated circuits (IC) continued to gain momentum during 1985, the first commercially available gallium arsenide IC's having become available early in 1984. Because gallium arsenide devices, compared with silicon devices, have higher operating frequencies, lower power consumption, lower noise, and superior resistance to radiation, they were expected to have extensive military applications.

PRICES

The price of domestically produced crude arsenic trioxide, guaranteed minimum 95% purity, remained constant throughout the year at $0.33 per pound for carload quantities, as supplies of trioxide remained plentiful despite the closure of Asarco's Tacoma, WA, smelter. Prices for imported refined trioxide also remained constant throughout the year, Mexican trioxide having a published price of $0.42 per pound.

The price of domestically produced arsenic metal, marketed in 250-pound drums or 2,000-pound pallets, remained constant at $2.10 per pound. High-purity arsenic metal for electronics usage was sold in evacuated or argon-filled ampules to inhibit oxidation. While domestic material, guaranteed to be 99.999% pure, sold for $100 per kilogram, imported material of higher guaranteed purity cost as much as $100 per gram in small quantities.

Table 1.—Arsenic price quotations

(Cents per pound, yearend)

	1983	1984	1985
Trioxide, domestic, 95% As_2O_3, f.o.b. Tacoma, WA[1]	33	33	33
Trioxide, Mexican, 99.13% As_2O_3, f.o.b. Laredo, TX[2]	45	42	42
Metal, domestic, 99% As[1]	225	210	210

[1]Producers' quote.
[2]Metals Week.

FOREIGN TRADE

In response to increased demand and curtailed domestic shipments, imports of arsenic trioxide increased by 18% in 1985. Imports of arsenic trioxide from Canada were largely arsenic trioxide-bearing flue dusts, generated during the roasting of arsenical gold ores by Campbell Red Lake Mines Ltd. and Giant Yellowknife Mines Ltd. A small portion of Canadian imports of arsenic trioxide were from Cominco Ltd.'s new arsenic recovery plant associated with the Con Mine in the Northwest Territories.

Small quantities of low-grade, minimum 97%, arsenic trioxide were received from new arsenic refineries in Chile and the Philippines. Industry sources indicated that major wood preservers were testing this material as a substitute for domestic crude material.

Table 2.—U.S. imports for consumption of arsenicals, by class and country

Class and country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Arsenic trioxide:						
Australia	37	r$10	--	--	30	$3
Belgium-Luxembourg	946	848	843	$654	1,498	1,074
Bolivia	--	--	16	4	98	67
Canada	2,525	542	4,767	1,468	3,669	4,059
Chile	--	--	--	--	191	101
China	17	36	--	--	105	46
France	667	706	1,261	849	3,608	2,264
Germany, Federal Republic of	1	6	(1)	1	--	--
Japan	(1)	1	--	--	371	184
Korea, Republic of	--	--	68	51	--	--
Mexico	2,531	2,700	3,115	2,820	3,399	2,946
Namibia	16	11	--	--	--	--
Netherlands	--	--	--	--	236	149
Philippines	--	--	--	--	23	10
Portugal	--	--	--	--	18	12
South Africa, Republic of	17	18	--	--	113	72
Sweden	3,430	3,528	3,914	3,608	2,996	3,014
United Kingdom	--	--	--	--	116	58
Total[2]	10,186	8,406	13,985	9,454	16,472	14,059
Arsenic acid:						
Australia	74	54	21	15	--	--
Canada	--	--	(1)	1	--	--
France	34	34	--	--	--	--
Germany, Federal Republic of	(1)	2	(1)	(1)	--	--
Japan	--	--	(1)	1	--	--
Mexico	--	--	65	57	--	--
United Kingdom	2,277	2,304	2,420	1,973	1,993	1,360
Total	2,385	2,394	2,506	2,047	1,993	1,360
Arsenic sulfide:						
Canada	(1)	(1)	20	3	--	--
Japan	1,127	1,522	(1)	1	--	--
Philippines	--	--	--	--	2	2
Total	1,127	1,522	20	4	2	2
Arsenic metal:						
Belgium-Luxembourg	(1)	7	--	--	--	--
Canada	6	328	21	712	23	644
China	128	428	102	350	136	311
France	--	--	(1)	4	--	--
Germany, Federal Republic of	1	111	2	215	2	195
Hong Kong	--	--	--	--	47	158
Japan	(1)	30	1	127	22	171
Netherlands	--	--	5	19	--	--
Sweden	108	435	158	614	171	642
Taiwan	--	--	--	--	5	17
United Kingdom	(1)	62	15	87	(1)	12
Total[2]	243	1,401	304	2,127	407	2,150
Lead arsenate:						
Canada	--	--	3	3	29	13
Germany, Federal Republic of	(1)	2	3	9	--	--
Japan	--	--	--	--	(1)	1
Netherlands	--	--	12	26	66	128
Peru	17	35	54	105	68	144
United Kingdom	--	--	1	2	--	--
Total[2]	17	37	73	145	162	287
Sodium arsenate:						
France	--	--	--	--	20	7
Other	(1)	2	1	3	(1)	3
Total	(1)	2	1	3	20	10

See footnotes at end of table.

Table 2.—U.S. imports for consumption of arsenicals, by class and country —Continued

Class and country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)	1985 Quantity (metric tons)	1985 Value (thousands)
Arsenic compounds, n.e.c.:						
Canada	--	--	17	$588	--	--
Mexico	--	--	--	--	23	$52
Sweden	17	$22	17	20	--	--
United Kingdom	9	108	1	165	(1)	66
Other	(1)	28	(1)	29	(1)	13
Total[2]	26	158	35	801	23	131

[r]Revised.
[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 3.—U.S. import duties for arsenicals

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Arsenic metal	632.04	0.8 cent per pound	Free	6.0 cents per pound.
Trioxide and sulfide	417.62, 417.60	Free	do	Free.
Other compounds	417.64	4.0% ad valorem	3.7% ad valorem	25% ad valorem.

WORLD REVIEW

Arsenic trioxide was produced in at least 16 countries as a byproduct of processing nonferrous ores. The nine principal producing countries accounted for about 90% of world production. With the exception of Canada, which had at least two producers of crude trioxide and one producer of refined trioxide, the production in each of the nine countries was principally from one company.

The closing of Asarco's Tacoma, WA, smelter, which had been the largest market economy country producer of arsenic trioxide, did not result in a shortage of world supplies. New production facilities in Chile and the Philippines have resulted in a world oversupply of arsenic, with much of their 1985 production being stockpiled. Significant stocks of arsenic trioxide were also reported being held by Western European producers. In addition, during 1985, Société des Mines et Produits Chimiques de Salsigne S.A., in France, which produced arsenic from gold-silver-copper ores, installed a new roaster to treat high-arsenic concentrates and expanded its arsenic trioxide production capacity by about 50%.

In addition to the United States, which accounted for more than 60% of the world demand, the United Kingdom was a major consumer of arsenic trioxide and metal. There were at least three British companies, Rentokil PLC, Hickson Timber Products Ltd., and Laporte Industries, producing arsenical wood preservatives domestically and abroad. At least two British companies, Johnson Matthey Chemicals Ltd. and MCP Electronic Materials Ltd., produced high-purity arsenic metal.[5]

Table 4.—Arsenic trioxide:[1] World production, by country[2]

(Metric tons)

Country[3]	1981	1982	1983	1984[p]	1985[e]
Belgium[e]	3,000	3,000	3,000	3,000	3,000
Bolivia	127	261	107	144	400
Canada[e 4]	[r]2,000	[r]2,000	[r]2,000	[r]3,000	3,000
Chile[5]	--	--	--	[e]3,500	4,000
France	[e]5,200	[r e]6,000	4,727	3,828	4,000
Germany, Federal Republic of[e]	360	360	360	360	360
Japan[e]	[6]95	100	300	500	500
Korea, Republic of	170	306	560	NA	NA
Mexico	6,517	4,740	4,557	5,496	5,000
Namibia[7]	1,370	1,895	1,126	2,504	2,500
Peru[8]	2,164	1,663	1,110	887	800
Philippines[9]	--	--	--	--	5,000
Portugal[e]	[6]257	200	[r]180	180	170
Sweden[e 10]	6,900	7,200	5,300	5,900	6,000
U.S.S.R.[e]	7,750	7,800	7,900	8,000	8,100
United States	7,800	8,000	7,300	6,800	[6]2,200
Zimbabwe	21	--	--	--	--
Total	[r]43,731	[r]43,525	38,527	44,099	45,030

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.

[1]Including calculated arsenic trioxide equivalent of output of elemental arsenic and arsenic compounds other than arsenic trioxide where inclusion of such materials would not duplicate reported arsenic trioxide production.

[2]Table includes data available through June 10, 1986.

[3]Austria, China, Czechoslovakia, the German Democratic Republic, Hungary, Spain, the United Kingdom, and Yugoslavia have produced arsenic and/or arsenic compounds in previous years, but information is inadequate to make reliable estimates of output levels, if any.

[4]Figures include estimated production of low-grade dusts that were exported to the United States for further refining.

[5]Chile began producing arsenic trioxide during 1983 from the El Indio gold-copper ores; however, it was not of marketable quality and required further refining by foreign producers. It has not been listed separately to avoid double counting.

[6]Reported figure.

[7]Output of Tsumeb Corp. Ltd. only.

[8]Output of Empresa Minera del Centro del Perú (Centromín Perú).

[9]The Philippines may have had some arsenic output in 1984 from the Philippine Associated Smelting and Refining Corp. (PASAR) copper smelter, but available data are not adequate to make reliable estimates of output levels, if any.

[10]Based on arsenic trioxide exported plus the arsenic trioxide equivalent of the output of metallic arsenic exported.

TECHNOLOGY

CSS Management Inc., in Skykomish, WA, in cooperation with the Bureau of Mines, developed a process to leach its gold-bearing arsenical copper flotation concentrate. Its concentrates had previously been processed at Asarco's Tacoma, WA, smelter. The process is based on a patented calcium-chloride, compressed-air leaching technology developed at the Bureau's Reno Research Center to process arsenic-bearing complex sulfides.[6] The copper and precious metals are extracted by leach solution at elevated temperatures and then selectively precipitated. The arsenic remains with the residue in an insoluble form. CSS was exploring the application of the process to high-arsenic flue dusts accumulated at the closed Anaconda copper smelter in Montana.[7]

Researchers at the Montana College of Mineral Science and Technology, Butte, MT, investigated methods of stabilization for permanent disposal of arsenic and other heavy metals contained in the flue dusts generated during copper smelting. Analysis of flue dusts stockpiled at various smelters revealed arsenic contents of up to 29.4%. The researchers found that by low-temperature roasting of the flue dusts with lime, the arsenic was converted to calcium arsenate and calcium arsenite, which could be effectively dissolved in copper reverberatory slags. Leach tests on the solidified slags indicated low arsenic extractive rates, making them suitable for outdoor storage.[8] Other research at the Montana College of Mineral Science, with support from the Bureau of Mines Mineral Industry Waste Treatment and Recovery Generic Center at Butte, involved the removal of arsenic from lead smelter speiss. More than 98% of the arsenic was removed by volatilizing it in the presence of sulfur under a carbon dioxide atmosphere at 800° C. Arsenic removed from the speiss was deposited on the reactor wall as elemental arsenic.[9]

Rapid advances continued to be made in the commercial development of gallium arsenide IC technology, and major investments in new facilities continued. Ford Motor Co., in a major diversification move, began production of gallium arsenide IC's at a new $33 million facility in Colorado Springs, CO. Ford reportedly planned to produce gallium arsenide chips for use in electronic data processing, instrumentation and testing, telecommunications, and aerospace applications. The plant, when fully operational, was expected to produce about 25,000 wafers per year.[10]

Improvement in the techniques for epitaxial growth of gallium arsenide crystal layers on either silicon or gallium arsenide substrates was a major research focus. Bell Communications Research, Livingston, NJ, unveiled a new crystal growth process that involved the concept of floating wafers while growing crystal layers on them. Using its "vapor levitation epitaxy" (VLE) method, the company reportedly produced ultrathin layers of gallium arsenide and other semiconductor materials in the exceptionally pure state essential to fiber-optic communications systems.[11] Another process, developed at the University of Illinois, involved the use of molecular-beam epitaxy to deposit nearly perfect layers of gallium arsenide onto silicon wafer substrates. Use of silicon wafer substrates avoids some of the brittleness, size limitations, and poor thermal conductivity of gallium arsenide substrates.[12]

CESIUM AND RUBIDIUM[13]

Cesium, usually in the form of chemical compounds, was used mainly in research and development, including the development of magnetohydrodynamic (MHD) electric power generators, thermionic energy converters, and biological research. Commercially, cesium was used in electronic, photoelectric, and medical applications. Rubidium, usually in the form of chemical compounds, also was used mainly in research and development. It was also used commercially in electronic and medical applications.

Domestic Data Coverage.—Domestic data for cesium and rubidium are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the four operations to which a survey request was sent, all responded, but only one company reported production of cesium and rubidium products. Production data are withheld to avoid disclosing company proprietary data.

DOMESTIC PRODUCTION

Small quantities of cesium metal and compounds were produced from pollucite ore imported from Canada and Zimbabwe. Rubidium metal and compounds were produced from imported lepidolite ores.

The only producer of cesium and rubidium metals and compounds was the KBI Div. of Cabot Corp. at its plant at Revere, PA. The Callery Chemical Co., Callery, PA, a producer in past years, retained its production capacity and was considered a potential supplier.

CONSUMPTION AND USES

Data concerning specific end uses and consumption patterns for cesium and rubidium and their compounds were not available. Cesium and rubidium and their respective compounds were interchangeable in most applications, although cesium compounds were most widely accepted because of their availability and price advantages.

More than 75% of the cesium and rubidium consumed in the United States was used in research. The principal use in this application was developmental research on direct energy-conversion devices, such as MHD generators, solar photovoltaic cells, and thermionic and high-temperature Rankine-cycle turboelectric power generators. Commercial consumption included uses for high-voltage rectifying tubes and for infrared lighting. Cesium chloride was used in photoelectric cells because its color sensitivity is higher than that of other alkali salts.

PRICES

Prices of rubidium compounds increased 10% in 1985, while prices of cesium compounds remained unchanged. Metal prices did not change from the 1984 levels. At yearend, cesium metal was $275 per pound for technical-grade and $375 per pound for high-purity metal. Rubidium metal prices were $300 per pound for technical-grade and $375 for high-purity metal. All price data were obtained from the KBI Div. of Cabot.

Table 5.—Prices of selected cesium and rubidium compounds

(Base price per pound[1])

Compound	1983		1984[2]		1985	
	Technical grade	High-purity grade	Technical grade	High-purity grade	Technical grade	High-purity grade
Cesium bromide	$34.25	$69.50	$36.80	$74.70	$36.80	$74.70
Cesium carbonate	34.25	69.50	36.80	74.70	36.80	74.70
Cesium chloride	36.50	72.50	39.20	78.00	39.20	78.00
Cesium fluoride	43.50	80.00	46.80	86.00	46.80	86.00
Cesium hydroxide	41.25	78.00	44.40	83.90	44.40	83.90
Rubidium carbonate	83.50	125.00	89.80	134.40	98.80	147.80
Rubidium chloride	84.50	126.00	90.90	135.50	100.00	149.10
Rubidium fluoride	91.00	132.00	97.80	141.90	107.60	156.10
Rubidium hydroxide	91.00	132.00	97.80	141.90	107.60	156.10

[1]For quantities of less than 100 pounds, f.o.b. Revere, PA, excluding packaging costs.
[2]Effective Oct. 1, 1984.

Source: Cabot Corp. (KBI Div.).

FOREIGN TRADE

The quantity of cesium compounds imported in 1985 was approximately equal to that of 1984. Most cesium compounds were imported from the Federal Republic of Germany. Trade data on raw materials and metal were not available.

Table 6.—U.S. imports for consumption of cesium compounds, by class and country

Class and country	1983		1984		1985	
	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value
Cesium chloride:						
Germany, Federal Republic of	13,655	$507,876	25,050	$741,468	20,452	$630,635
Netherlands	220	10,949	110	6,465	33	1,887
Norway	--	--	--	--	362	11,335
Sweden	--	--	18	884	115	7,367
United Kingdom	--	--	--	--	192	5,464
Total	13,875	518,825	25,178	748,817	21,154	656,688
Cesium compounds, n.s.p.f.:						
Austria	13	685	--	--	--	--
Canada	2,406	2,093	520	4,100	--	--
German Democratic Republic	--	--	--	--	119	2,625
Germany, Federal Republic of	2,930	94,532	18,206	626,885	28,358	735,785
Greece	--	--	--	--	110	2,726
Israel	--	--	100	30,000	--	--
Japan	--	--	210	60,087	170	32,250
Netherlands	--	--	231	11,980	--	--
United Kingdom	3	397	9,207	69,925	626	164,468
Total	5,352	97,707	28,474	802,977	29,383	937,854

Source: Bureau of the Census.

Table 7.—U.S. import duties for cesium and rubidium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1985	Jan. 1, 1987	Jan. 1, 1985
Ore and concentrate	601.66	Free	Free	Free.
Cesium	415.10	6.1% ad valorem	5.3% ad valorem	25% ad valorem.
Cesium chloride	418.50	4.5% ad valorem	4.0% ad valorem	Do.
Other cesium compounds	418.52	4.3% ad valorem	do	Do.
Rubidium	415.40	4.0% ad valorem	3.7% ad valorem	Do.
Rubidium compounds	423.00	do	do	Do.

WORLD REVIEW

The Tantalum Mining Corp. of Canada Ltd.'s mine at Bernic Lake, Canada, the major world source of the cesium ore pollucite and the rubidium ore lepidolite, remained on standby throughout 1985. The mine suspended operations at the end of 1982 owing to weak markets and large inventories.

TECHNOLOGY

A new commercial use for radioactive cesium for the sterilization of medical instruments was reported. Large shipments of the material were reportedly made for the Hanford, WA, nuclear reservation to two firms in Colorado and Ohio.[14]

Cornell University reportedly purchased 20 tons of thallium-activated cesium iodide single crystals, used for detecting high-energy gamma rays, from Horiba Ltd., Kyoto, Japan. The cesium material reportedly is easier to fabricate and has a higher resistance to humidity than the sodium iodide used in conventional detectors.[15]

GERMANIUM[16]

The estimated domestic production and consumption of refined germanium increased compared with those in 1984. Infrared systems and fiber optics continued to be the major markets for germanium.

Domestic Data Coverage.—Domestic refinery production and consumption data for germanium are estimated by the Bureau of Mines based on discussions with domestic producers.

Legislation and Government Programs.—On September 20, the EPA issued final regulations under the Clean Water Act for nonferrous metals manufacturing operations that limit the discharge of pollutants into navigable waters and into publicly owned treatment works. The primary and secondary germanium and gallium subcategory, 1 of 25 subcategories covered by this regulation, set limits on effluent discharges from both new and existing plants. Daily and monthly average maximums on the arsenic, fluoride, lead, and zinc content of effluents emanating from these plants were specified. Since the germanium content of these effluents, previously proposed for regulation, was expected to be controlled by best practical technology methods, the EPA decided that any specific limitations on this metal would be made on a case-by-case basis.[17]

On May 23, the U.S. Department of Commerce, with the approval of the Federal Emergency Management Agency, published National Defense Stockpile Purchase Specifications for refined intrinsic germanium metal. As of December 31, 1985, the stockpile goal remained at 30,000 kilograms; however, no germanium metal had been acquired.

On July 8, the President approved the National Security Council (NSC) recommendations for modernizing the strategic and critical materials stockpile. Under the NSC proposal, the National Defense Stockpile would be structured into two tiers. Tier I would contain materials required by military, industrial, and essential civilian users during a military conflict that would not be available from domestic or reliable foreign sources. Tier II would contain a supplemental reserve of materials already possessed by the Government. Germanium was included in tier I of this proposal with a goal of 146,049.4 kilograms. At yearend, this proposal was under consideration by the Congress. The Department of Defense Authorization Act, 1986 (Public Law 99-145), signed by the President on November 8, 1985, stated that no action may be taken before October 1, 1986, to implement or administer any change in a stockpile goal in effect on October 1, 1984, that results in a reduction in the quality or quantity of any strategic and critical material to be acquired for the National Defense Stockpile.

DOMESTIC PRODUCTION

Domestic refinery production from both primary and secondary materials was estimated to be 22,000 kilograms. Based on the published U.S. producer price for refined germanium metal, the approximate value of production was $23 million.

Refined germanium products were produced by Eagle-Picher Industries Inc., Quapaw, OK; KBI Div. of Cabot, Revere, PA; and Atomergic Chemetals Corp., Plainview, NY.

In September, Rare Materials International Inc. reported the permanent closure and dismantling of its 1,200-kilogram-per-year germanium production facility in Irving, TX.

The Jersey Minière Zinc Co. in Clarksville, TN, continued to produce germanium-rich residues as a byproduct of processing zinc ores from its Gordonsville and Elmwood Mines. These residues reportedly were shipped to Métallurgie Hoboken-Overpelt SA (MHO) in Belgium for germanium recovery and refining.

Startup problems continued to delay the opening of Musto Explorations Ltd.'s primary gallium and germanium recovery plant near St. George, UT. The plant reportedly began limited production of 99.9%-pure gallium in October, but full-scale gallium production was postponed until 1986. The germanium production circuit was reportedly nearing completion by yearend 1985. Development continued on the Apex Mine ore zone, which reportedly contained recoverable quantities of copper, silver, and zinc, as well as germanium and gallium. The plant was the only operation in the world to recover germanium or gallium as principal products, and, when fully operational, the plant's annual production capacity was expected to be 17,900 kilograms of germanium and 10,000 kilograms of gallium.

According to a report published by the U.S. Geological Survey, the Apex Mine ore body was defined as a goethite-limonite-hematite zone that contained local concentrations of jarosite, azurite, malachite, and other supergene copper, iron, lead, and zinc minerals. Most of the copper-rich ore at the Apex Mine was removed during previous mining operations, leaving behind the iron oxide minerals in which most of the germanium was concentrated.[18]

CONSUMPTION AND USES

The consumption of germanium was estimated at 38,000 kilograms, a slight increase compared with that of 1984. The estimated consumption pattern by end use of germanium in 1985 was as follows: infrared systems, 65%; fiber optics, 15%; gamma-ray, X-ray, and infrared detectors, 5%; semiconductors, 5%; and other, 10%.

The largest end use for germanium continued to be in infrared optics, especially military use in guidance and weapon-sighting systems. Germanium-containing lenses and windows transmit thermal radiation in a manner similar to visible light transmission by optical glass. Other important uses for germanium glass included nonmilitary surveillance and monitoring systems in fields such as satellite systems and fire alarms.

Another important market for germanium was in fiber-optic cables used in telecommunications systems. Fiber-optic systems were used as replacements for conventional wire telecommunication systems and were finding increased use in existing underground conduits where space was often limited. Fiber-optic systems provided a compact, short-circuit-free transmission medium that was not susceptible to distortion by an electromagnetic field and could not be tapped by currently available technology. Although not used in all fiber-optic systems, germanium was an important constituent in many fiber-optic cables.

Pirelli Cable Corp. of Union, NJ, announced the construction of a new fiber-optic cable manufacturing facility near Lexington, SC. The plant was expected to begin operations in early 1986. This installation would be the third Pirelli plant producing fiber-optic cables in North America; the other two were in Wallingsford, CT, and in Surrey, British Columbia, Canada.[19] In April, International Telephone & Telegraph Corp.'s Electro-Optical Products Div. announced the opening of a high-volume, fiber-optic cable production plant in Worchester, MA.[20]

Santa Fe Southern Corp. and Norfolk Southern Corp. announced that construction of an 8,000-mile transcontinental fiber-optic network, known as Fibertrak and originally scheduled for completion by 1987, was deferred because of difficulty in obtaining the customer commitments necessary to begin construction.[21] Teleconnect Co. and Williams Pipe Line Co. announced the construction of a 1,200-mile fiber-optic network linking Chicago, IL, to cities in six States. Construction of 85% of the line reportedly would involve pulling the cable through pipeline once used to transport liquid petroleum products. The project was scheduled to be completed in 1986.[22] US Telecom reported plans to construct a 23,000-mile fiber-optic network linking major U.S. cities from coast to coast.[23] Representatives of 22 telecommunications companies and agencies in 10 countries announced the approval of a draft agreement to construct and maintain the first fiber-optic undersea cable to span the Pacific Ocean. The system covering 7,200 nautical miles and connecting California, Hawaii, Japan, Guam, and the Philippines was expected to be completed by the end of 1988.[24]

Germanium was used as a substrate upon which gallium arsenide phosphide was deposited to form an essential part of light-emitting diodes. Germanium was also used in the manufacture of other semiconductor electronic equipment; to improve the hardness of aluminum, copper, and magnesium alloys; and, in some foreign countries, as a catalyst in the production of polyester fibers and plastic bottles.

PRICES

The domestic producer prices, published in Metals Week, for germanium metal and germanium dioxide were unchanged throughout 1985 at $1,060 and $660 per kilogram, respectively. Competition from imported material reportedly resulted in some discounting by domestic producers..

FOREIGN TRADE

A comparison of the value per kilogram of imported germanium material with the published foreign producer price for germanium metal was used to estimate the germanium content of imported scrap. In 1985, the estimated germanium content of total imports was calculated to be approximately 11,000 kilograms.

Table 8.—U.S. imports for consumption of germanium, by class and country

Class and country	1984		1985	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Unwrought and waste and scrap:				
Belgium-Luxembourg	108,508	$4,258,829	3,772	$1,980,066
Canada	47	91,512	23	7,206
China	--	--	4,044	1,952,255
Costa Rica	--	--	1,000	597,643
France	3,600	1,493,087	1,227	722,304
German Democratic Republic	--	--	8	2,220
Germany, Federal Republic of	1,438	594,313	102	165,612
Netherlands	249	111,283	141	7,191
Nigeria	--	--	3	3,205
Switzerland	--	--	111	41,037
U.S.S.R	--	--	5	1,865
United Kingdom	1,432	230,977	611	242,226
Total	115,274	6,780,001	11,047	5,722,830
Wrought:				
Belgium-Luxembourg	1,023	509,373	2,540	2,385,340
Brazil	--	--	249	307,609
Canada	1	745	9	5,625
Germany, Federal Republic of	133	34,411	5	4,624
Norway	--	--	130	72,661
Singapore	273	180,248	679	203,378
Sweden	--	--	182	126,492
United Kingdom	15	34,482	--	--
Total	1,445	759,259	3,794	3,105,729

Source: Bureau of the Census.

Table 9.—U.S. import duties for germanium metal and germanium dioxide

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1985	Jan. 1, 1987	Jan. 1, 1985
Germanium dioxide	423.00	4.0% ad valorem	3.7% ad valorem	25% ad valorem.
Metal, unwrought and waste and scrap	628.25	do	do	Do.
Metal, wrought	628.30	6.4% ad valorem	5.5% ad valorem	45% ad valorem.

WORLD REVIEW

World refinery production was estimated at 80,000 kilograms.[25] Germanium was produced by MHO, Belgium; Société Minière et Métallurgique de Penarroya S.A., France; Società Mineraria e Metallurgica di Pertusola S.A., Italy; Bleiberger Bergwerks-Union AG, Austria; and Preussag Metall AG, Federal Republic of Germany. Germanium refineries also were in China, Japan, and the U.S.S.R.

Canada.—Telecom Canada, a consortium of nine telephone companies and Telesat Canada, announced plans to build a nationwide system of single-mode fiber-optic cable to carry long-distance telephone traffic. The system reportedly would span 7,000 kilometers.[26]

Finland.—Outokumpu Oy announced the purchase of Princeton Gamma-Tech, Princeton, NJ, which specialized in the ultrahigh purification of germanium and the growing of germanium crystals.

Japan.—Germanium metal production in Japan reached 10,277 kilograms, an increase of 25% compared with 1984 production levels. Germanium dioxide production was reported to be 14,083 kilograms in 1985 compared with 10,872 kilograms in 1984.[27]

Spain.—The world's first repeatered underwater fiber-optic communications system for commercial use was installed in the Canary Islands off North Africa by the American Telephone & Telegraph Co. and Compañia Telefónica Nacional de España, the Spanish national telephone company. The 72-mile cable system linking Tenerife and Gran Canaria reportedly would be used initially as a testing system to confirm the design of two similar but much larger systems that were planned for completion in the near future, namely, a 3,000-mile transatlantic cable, known as TAT-8, running from New Jersey to the United Kingdom and France and a 7,200-mile system linking California, Hawaii, Japan, Guam, and the Philippines. Upon completion of testing, the system would be turned over to the Spanish national telephone company for commercial use.[28]

Taiwan.—Siecor Corp., Hickory, NC, reported the signing of an agreement with GTE Communications Systems to supply single-mode fiber-optic cable for installation in Taiwan. This project was reportedly the largest fiber-optic project Taiwan had undertaken and the first to use single-mode technology.

TECHNOLOGY

A process was reportedly developed to recover unused germanium from effluents generated during the modified chemical vapor deposition process used to manufacture optical fibers. The process included a gas scrubber to incorporate the unreacted germanium into solution, a recirculation system to increase the germanium concentration in the solution, a reaction to form a germanium precipitate, and a filtration step to isolate the germanium-containing solids into a wet filter cake, which could be reprocessed to make germanium tetrachloride. The process reportedly was capable of recovering greater than 95% of the unreacted germanium.[29]

Sovonics Solar Systems, a joint venture of Energy Conversion Devices and Standard Oil Co. of Ohio, reported the development of a silicon-based amorphous alloy solar cell with an energy conversion efficiency of 12.2%. The 1-square-centimeter cell consisted of three vertically stacked subcells, each of which was sensitive to a different color in the solar spectrum. The subcells were made of a proprietary silicon material containing germanium, fluorine, and hydrogen.[30]

A method reportedly was developed for epitaxially growing high-quality thin films of germanium on sodium chloride substrates by plasma-enhanced chemical vapor deposition and then separating these germanium films by either melt-away or differential thermal shear stress techniques. The free-standing germanium films could be used as substrates for the growth of thin-film gallium arsenide solar cells. These solar cells could be used in large solar cell arrays for space applications because of their projected high power-to-weight ratio.[31]

INDIUM[32]

Indium was produced by the Arconium Corp., Providence, RI, and Indium Corp. of America, Utica, NY. Domestic production in 1985 remained about the same as that of 1984, and imports maintained a significant market share. The Bureau of Mines does not publish domestic production data on indium. Small quantities of secondary indium were available from specialty metal recycling firms.

CONSUMPTION AND USES

Indium usage remained about the same as that of 1984. Consumption in the categories of fusible alloys and solders remained strong. New indium solders were developed during the year. Consumption for nuclear control rods remained low, essentially at a replacement level. Research continued on a broad range of possible new applications, especially for solar cells and an indium-tin oxide coating for flat glass that would be transparent, electrically conductive, and prevent entry of infrared rays. Estimated consumption patterns for indium metal were electrical and electronic components, 40%; solders, alloys, and coating, 40%; and research and other uses, 20%.

PRICES

The producer price of indium, published in Metals Week, was $3.10 per troy ounce at the beginning of the year, lowered to $2.80 per troy ounce in February, and then lowered to $2.50 per troy ounce in March, at which price level it remained for the duration of the year.

FOREIGN TRADE

Imports of indium declined slightly but remained at the relatively high levels of recent years. Italy was the leading supplier in 1985, followed by France, the United Kingdom, and China.

Table 10.—U.S. imports for consumption of indium, by class and country

(Thousand troy ounces and thousand dollars)

Class and country	1983 Quantity	1983 Value	1984 Quantity	1984 Value	1985 Quantity	1985 Value
Unwrought and waste and scrap:						
Belgium-Luxembourg	218	556	263	837	99	257
Canada	33	135	26	98	16	100
China	(1)	10	7	19	128	423
France	278	521	231	844	140	308
Germany, Federal Republic of	(1)	1	13	43	2	30
Hong Kong	(1)	12	--	--	19	50
Italy	259	435	101	207	259	596
Jamaica	--	--	--	--	(1)	17
Japan	3	24	9	40	2	43
Netherlands	16	37	78	242	16	67
Peru	49	129	84	273	111	260
Switzerland	32	77	58	125	16	36
Taiwan	--	--	8	42	--	--
Tunisia	--	--	6	19	--	--
United Kingdom	182	780	130	1,575	147	1,009
Total[2]	1,071	2,719	1,015	4,365	955	3,197
Wrought:						
Belgium-Luxembourg	--	--	--	--	(1)	6
Canada	--	--	(1)	62	--	--
France	--	--	--	--	19	90
Germany, Federal Republic of	(1)	1	(1)	1	(1)	3
Hong Kong	(1)	5	--	--	--	--
Japan	1	11	2	40	3	60
United Kingdom	1	59	4	104	3	124
Other	--	--	1	5	--	--
Total	2	76	7	212	25	283

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 11.—U.S. import duties for indium

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Unwrought, waste, and scrap	628.45	0.6% ad valorem	Free	25% ad valorem.
Wrought indium	628.50	5.0% ad valorem	3.6% ad valorem	45% ad valorem.
Indium compounds	423.96	1.2% ad valorem	Free	25% ad valorem.

WORLD REVIEW

World production remained about the same as that of 1984. Major world refiners included Cominco in Canada, MHO in Belgium, Penarroya in France, Nippon Mining Co. Ltd. in Japan, Minero Perú Comercial in Peru, and Mining and Chemical Products Ltd. in the United Kingdom.

RHENIUM[33]

Rhenium was processed by two domestic firms in 1985. Consumption of rhenium increased an estimated 27% over that of 1984 to 13,000 pounds. Imports increased from 6,716 pounds (revised) in 1984 to 8,268 pounds in 1985. The major use continued to be bimetallic platinum-rhenium catalysts to produce low-lead and lead-free gasoline. The price of rhenium was level throughout the year, at $300 per pound for the metal and $200 per pound for ammonium perrhenate.

Domestic Data Coverage.—Domestic mine production data for byproduct rhenium are developed by the Bureau of Mines from a single voluntary survey of U.S. porphyry-copper-molybdenum operations. Of the 18 operations to which a survey request was made, all responded, representing 100% of the total production shown in table 12.

Table 12.—Salient U.S. rhenium statistics

(Pounds of contained rhenium)

	1981	1982	1983	1984	1985
Mine production[1]	15,800	11,200	8,100	8,600	10,500
Recovered[2]	W	W	W	W	W
Consumption[e]	6,600	5,900	8,800	10,200	13,000
Imports (metal)	580	176	623	1,962	4,943
Imports for consumption of ammonium perrhenate	9,089	5,193	5,947	[r]4,754	3,325
Stocks, Dec. 31	W	W	W	W	W

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Calculated rhenium contained in MoS_2 concentrates.
[2]In prior years, this was shown as mine production.

DOMESTIC PRODUCTION

Rhenium is contained in molybdenite (MoS_2) concentrates, which are produced as a byproduct of porphyry copper ores from seven mines in the Southwestern United States. Mine production in table 12 was calculated to be the rhenium content of MoS_2 concentrates.

Duval Corp. was the only domestic producer to recover rhenium in 1985.

CONSUMPTION AND USES

Domestic consumption of rhenium increased an estimated 27% over that of 1984 to 13,000 pounds. The increase in consumption was due to the increase in the manufacturing of catalysts for the petroleum industry. Platinum-rhenium bimetallic reforming catalysts are used by the petroleum industry to produce low-lead and lead-free high-octane gasoline. These catalysts compete with monometallic platinum catalysts and with other bimetallic catalysts that are used in the reforming process. Although the rhenium content ranges from 0.25% to 0.9% by weight, the majority of these catalysts contain 0.3% rhenium and 0.3% platinum, using alumina as the support medium.

Of the three basic types of bimetallic reforming catalysts, the semiregenerative type accounted for about 60% of the total reforming capacity in 1985. This type of catalyst requires process shutdown for regeneration at specified intervals. Cyclic and other types (nonregenerative, continuous, and moving-bed systems) accounted for 10% and 9%, respectively, of the total reforming capacity. An estimated 80% of the total reforming capacity employed platinum-rhenium catalysts. Other applications of reforming platinum-rhenium catalysts included the production of benzene, toluene, and xylenes.

About 10% of the total consumption of rhenium was used in the form of powder or alloys. The major portion of rhenium used in these forms was contained in tungsten-rhenium and molybdenum-rhenium alloys. When alloyed with other metals, rhenium improves their mechanical and electrical properties, acid and heat resistance, wear and corrosion resistance, and durability. Rhenium was used in manufacturing thermocouples, ionization gauges, electron tubes and targets, metallic coatings, semiconductors, heating elements, high-temperature nickel-based alloys, vacuum tubes, mass spectrographs, and electromagnets.

PRICES

The price of rhenium remained level during the year. The price of ammonium perrhenate was $200 per pound, and the average price of rhenium metal was about $300 per pound.

FOREIGN TRADE

U.S. imports for consumption of rhenium totaled 8,268 pounds, an increase of 23% over that of 1984. Ammonium perrhenate imports totaled 3,325 pounds of metal content. This represented a 30% decrease from that of 1984. The value of ammonium perrhenate imports was about $0.7 million. About 88% of the imports of ammonium perrhenate originated from Chile and 12% from the Federal Republic of Germany. Imports of rhenium metal totaled 4,943 pounds, which represented a 152% increase over that of 1984. The value of these imports totaled $1.2 million.

Table 13.—U.S. import duties for rhenium materials

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Unwrought metal	628.9000	4.0% ad valorem	3.7% ad valorem	25% ad valorem.
Wrought metal	628.9500	6.4% ad valorem	5.5% ad valorem	45% ad valorem.
Ammonium perrhenate	417.4420	3.3% ad valorem	3.1% ad valorem	25% ad valorem.
Perrhenic acid	416.4540	4.7% ad valorem	4.2% ad valorem	25% ad valorem.

Table 14.—U.S. imports for consumption of ammonium perrhenate, by country

(Rhenium content)

Country	1983		1984		1985	
	Quantity (pounds)	Value (thousands)	Quantity[r] (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Chile	4,057	$712	3,379	$740	2,918	$611
Germany, Federal Republic of	1,890	419	564	131	407	58
Italy	--	--	811	181	--	--
Total	5,947	1,131	4,754	1,052	3,325	669

[r]Revised.

Source: Bureau of the Census.

Table 15.—U.S. imports for consumption of rhenium metal, by country

Country	1983		1984		1985	
	Gross weight (pounds)	Value	Gross weight (pounds)	Value	Gross weight (pounds)	Value
Chile	--	--	--	--	3,300	$825,000
France	--	--	2	$920	--	--
Germany, Federal Republic of	613	$174,000	1,836	423,032	1,424	337,662
Italy	--	--	100	19,500	--	--
United Kingdom	--	--	2	417	193	54,065
Other[1]	10	6,000	22	5,590	26	8,378
Total	623	180,000	1,962	449,459	4,943	1,225,105

[1]Includes Haiti, Sweden, and Switzerland.

Source: Bureau of the Census.

WORLD REVIEW

World production of rhenium was estimated to be 30,000 pounds, exclusive of U.S. production. Rhenium was recovered from byproduct MoS_2 concentrates from porphyry copper deposits in Canada, Chile, Iran, Peru, the U.S.S.R., and the United States. In addition, the U.S.S.R. also recovered rhenium as a byproduct from the Dzhezkazgan sedimentary copper deposit in Kazakhstan. Rhenium metal and compounds were recovered from molybdenum concentrates in Chile, France, the Federal Republic of Germany, Sweden, the U.S.S.R., the United Kingdom, and the United States.

Canada.—The Island Copper Mine in British Columbia continued to be the sole producer of rhenium in Canada. MoS_2 concentrates, which contained approximately 7,700 pounds of rhenium, were exported.

Chile.—Chilean recovery of rhenium was estimated at 8,700 pounds, the largest amount produced by a market economy country.

SCANDIUM[34]

Domestic production and consumption of scandium were estimated to be higher than in 1984. Increased demand for scandium used in laser applications was reportedly responsible for the higher levels of production. Special-use light bulbs and high-energy laser crystals continued to be the major markets for scandium. Scandium was obtained as a byproduct from processing mine tailings at three domestic locations in the Western United States. The principal mine source closed its operations in August 1985.

Domestic Data Coverage.—Domestic production data for scandium are estimated by the Bureau of Mines based on discussions with domestic producers and processors.

DOMESTIC PRODUCTION

Three mines provided scandium concentrates for refining during the year. Concentrates were obtained as a byproduct of processing copper tailings for uranium by Westinghouse Electric Corp., Bingham Canyon, UT. Westinghouse closed its Bingham Canyon, UT, operations in August as a result of weak prices for uranium. Reportedly, Westinghouse was attempting to locate a purchaser for its uranium-scandium extraction plant. Scandium was also recovered as a byproduct of processing residual fluorite screenings for the scandium mineral thortveitite, previously mined at Crystal Mountain, MT, and from byproduct scandium-bearing tungsten concentrates derived from processing molybdenum ores at the Climax Mine, Climax, CO.

Refined scandium products were produced by Baldwin Metal Processing Co., Phoenix, AZ; Boulder Scientific Co., Mead, CO; Research Chemicals Div. of NUCOR Corp., Phoenix, AZ; and Sausville Chemical Co. Inc., Garfield, NJ.

CONSUMPTION AND USES

The apparent consumption of scandium in 1985 was estimated at 150 kilograms of equivalent scandium oxide. The major end use was in high-energy laser crystals of gadolinium-scandium-gallium garnets (GSGG) doped with chromium and neodymium; scandium accounts for up to 30% by weight of the crystal. The GSGG lasing medium is reportedly twice as efficient as yttrium-aluminum garnets with neodymium (Nd:YAG). Laser applications for GSGG are in communications and fusion research.

Scandium is used in high-intensity mercury vapor lights to produce a highly efficient, near-sunlight color emission that is important for indoor and nighttime color television transmission. Approximately 3 to 5 milligrams of scandium are added per bulb.

The radioactive isotope scandium-46 was used as a tracing agent in petroleum cracking refineries, in crude oil reservoirs during secondary recovery, and in oil wells after cementing and fracturing.

Small amounts of scandium metal were reportedly used in semiconductors, while minor amounts of the compound found use in petroleum catalyst reactions.

Additions of scandium carbide to titanium carbide reportedly create a binary carbide with a hardness close to that of diamond.

PRICES

No published prices were available for scandium. The yearend nominal prices, compiled by the Bureau of Mines based on information from several suppliers, for scandium oxide per kilogram were as follows: 95% purity, $6,800; 98% purity,

$7,400; 99.0% purity, $8,000; 99.9% purity, $9,000; 99.99% purity, $15,000; and 99.999% purity, $25,000. Scandium metal prices varied considerably depending on purity and amount.

FOREIGN TRADE

No trade data were available for scandium on an individual basis. Foreign countries reportedly producing scandium include China, France, and the U.S.S.R. The U.S.S.R. has historically been a major source of imported high-purity scandium oxide.

TECHNOLOGY

Researchers at NV Philips Corp., Eindhoven, Netherlands, developed a dual-anode tube using scandium and molybdenum or scandium and tungsten for improved detection of elements in X-ray fluorescence spectrometry. The anode is in the form of a thin layer of the light-element material scandium, deposited on a heavy-element base, molybdenum or tungsten. The new tube allows lower voltage excitation of X-rays from the scandium surface layer, while higher energy excitation penetrates to the underlying heavy-element material before radiating. Scandium is used because its excitation efficiency in detection of light elements up to titanium is twice that of the commonly used chromium tube.[35]

A sodium-scandium-phosphate compound, known as foskan, named from the three Russian words for the elements, is being studied in the U.S.S.R. The binary phosphate and its analogs exhibit several interesting properties, including a high fusion temperature, ferroelectricity, and high ion conductivity. Research showed that the high ion conductivity can be applied in sodium-sulfur storage batteries where sodium and sulfur are molten electrodes and the scandium-bearing binary phosphate functions as a thin ceramic membrane electrolyte. Foskan's three-dimensional open structure allows the small sodium cations to travel freely through the voids formed by interconnected omnidirectional conductivity channels. At temperatures above 166° C, the sodium cations flow freely creating a super ion exchanger electrolyte for use in the sodium-sulfur batteries. Battery energy capacities using this system are reportedly an order of magnitude higher than lead storage batteries.[36]

SELENIUM[37]

One of the four U.S. copper refineries with capacity for production of byproduct selenium did not produce any of the metal in 1985, and another discontinued its operations in the third quarter; therefore, domestic production decreased significantly. Consumption also declined and net imports fell slightly, while producers' stocks increased substantially.

Domestic Data Coverage.—Domestic data for selenium are developed by the Bureau of Mines from a voluntary survey of U.S. operations. The three domestic refiners of selenium responded to a survey of their stocks, primary refined production, and shipments of selenium to consumers. Data are withheld to avoid disclosing company proprietary data.

Table 16.—Salient selenium statistics

(Kilograms of contained selenium unless otherwise specified)

	1981	1982	1983	1984	1985
United States:					
Production, primary refined	251,949	242,996	353,860	p253,598	W
Shipments to consumers	207,854	307,610	374,030	224,401	W
Exports, metal, waste and scrap	60,523	117,267	93,368	122,929	154,122
Imports for consumption	311,566	347,329	297,029	376,946	400,658
Apparent consumption	458,898	537,672	577,691	478,418	W
Stocks, yearend, producer[1]	292,558	254,210	152,790	139,159	W
Dealers' price, average per pound, commercial-grade[2]	$4.38	$3.53	$3.87	$9.02	$6.00-$10.25
World: Refinery production	r1,285,238	r1,132,495	1,325,031	p1,350,702	e1,122,835

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
1Granular selenium, a semirefined form of selenium, is included in stocks.
2Metals Week.

DOMESTIC PRODUCTION

Most primary selenium was recovered from anode slimes generated in the electrolytic refining of copper. Selenium also was believed to have been recovered from lead slimes and nonferrous flue dusts.

Primary selenium was recovered from both domestic and imported materials at three U.S. copper refineries: Asarco at Amarillo, TX; Kennecott at Magna, UT; and Phelps Dodge Refining Corp. at El Paso, TX. Production at the Kennecott refinery was discontinued during the year owing to the cessation of copper mining in Utah. Selenium-bearing copper slimes from other domestic copper refiners were either shipped to the above refineries or exported for processing.

High-purity selenium metal and various selenium compounds were produced from commercial-grade metal by the three copper refineries and other processors.

Scrap xerographic materials containing selenium were exported to Canada and the United Kingdom for processing to recover selenium.

CONSUMPTION AND USES

Apparent consumption of refined selenium decreased from the 1984 level in all major end uses. Estimated consumption of selenium by end-use category was electronic and photocopier components, 35%; glass manufacturing, 30%; pigment and chemicals, 25%; and other, including metallurgy and agriculture, 10%.

The major electronic use of selenium was as a photoreceptor in plain paper electrophotographic copiers.

The U.S. automobile and construction industries contributed to a strong demand for selenium-containing pigments. The pigments, which range in color from light orange to maroon, depending on the selenium content, have good heat stability and are important colorants for plastics, glass, and ceramics. The primary use of selenium in the glass industry in 1985 was in container glass, where it was used to decolor the yellow-green tint imparted by ferrous ions. Also, selenium was used in architectural plate glass, where it was used in combination with cobalt oxide and iron oxide to reduce solar heat transmission.

PRICES

Standard commercial-grade selenium averaging 99.5% selenium was sold as powder, available in several mesh sizes or as small lumps or shot. High-purity selenium containing 99.99% selenium or better was marketed as pellets or sticks. Specifications for pigment-grade selenium powder generally required a selenium content of 99.8%. Other forms of selenium available included selenium dioxide, ferroselenium, sodium selenite, and sodium selenate.

The New York dealer price for commercial-grade selenium, quoted by Metals Week on a daily basis, ranged from $6.00 to $10.25 per pound.

FOREIGN TRADE

Exports increased to a record-high level of 154,122 kilograms. In 1985, the United Kingdom was the recipient of about one-third of the exported selenium materials, primarily scrap. Exports to Mexico and the Philippines accounted for most of the increased exports.

Imports of selenium were the highest since the peak year of 1975, when 403,000 kilograms of selenium was imported. Canada continued to be the largest supplier of imported selenium metal. Belgium-Luxembourg, Japan, and the United Kingdom were the other major import sources. Approximately 75,000 kilograms of the imported refined selenium, primarily from the United Kingdom, was recovered from scrap that had been exported from the United States for processing.

Table 17.—U.S. exports of selenium metal, waste and scrap, by country

Country	1983 Quantity (kilograms of contained selenium)	1983 Value	1984 Quantity (kilograms of contained selenium)	1984 Value	1985 Quantity (kilograms of contained selenium)	1985 Value
Argentina	--	--	1,089	$10,200	1,179	$22,750
Australia	2,211	$19,941	--	--	962	29,220
Belgium-Luxembourg	1,611	24,049	322	5,141	--	--
Brazil	--	--	254	8,100	650	10,400
Canada	1,448	23,146	2,462	39,365	2,207	40,595
Chile	--	--	5,517	24,313	--	--
Colombia	250	2,163	7,831	198,864	894	22,660
France	--	--	1,758	38,173	318	5,075
Germany, Federal Republic of	1,996	17,600	13,769	139,413	7,861	126,793
India	41	655	--	--	68	4,765
Ireland	8,375	24,955	--	--	--	--
Italy	--	--	--	--	1,456	20,015
Jamaica	100	1,488	91	3,000	--	--
Japan	10,048	75,287	27,255	186,992	36,951	289,592
Korea, Republic of	--	--	--	--	45	1,800
Mexico	9,979	97,010	1,799	28,750	19,265	308,481
Netherlands	8,052	64,368	6,822	82,744	7,711	106,360
Norway	--	--	--	--	236	6,760
Philippines	292	6,458	--	--	18,144	42,000
Portugal	635	4,810	--	--	91	1,950
Switzerland	1,996	15,400	7,983	71,060	4,990	75,350
Thailand	--	--	499	11,000	--	--
United Kingdom	46,334	393,801	45,480	739,450	51,096	316,177
Total[1]	93,368	771,131	122,929	1,586,565	154,122	1,430,743

[1]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 18.—U.S. imports for consumption of selenium, by class and country

Class and country	1983 Quantity (kilograms of contained selenium)	1983 Value	1984 Quantity (kilograms of contained selenium)	1984 Value	1985 Quantity (kilograms of contained selenium)	1985 Value
Unwrought and waste and scrap:						
Belgium-Luxembourg	34,643	$930,511	47,483	$1,084,424	63,353	$1,572,220
Canada	84,602	1,679,022	130,317	2,786,063	111,927	2,353,429
Chile	--	--	3,498	64,015	7,500	153,902
German Democratic Republic	--	--	--	--	45	14,743
Germany, Federal Republic of	20,901	373,953	23,364	402,088	5,550	126,877
Japan	54,651	1,340,519	46,074	1,904,155	72,609	2,056,694
Netherlands	--	--	2,755	64,610	15,239	30,851
Peru	8,941	66,313	2,994	32,605	--	--
Philippines	--	--	5,000	59,525	16,748	243,747
Sweden	853	27,096	1,032	26,258	100	3,750
Taiwan	1,100	8,036	--	--	--	--
United Kingdom	65,373	997,809	80,844	964,306	66,434	910,947
Total	271,064	5,423,259	343,361	7,388,049	359,505	7,467,160
Selenium dioxide:						
Belgium-Luxembourg	--	--	35	529	--	--
Germany, Federal Republic of	4,437	69,285	5,598	121,704	6,916	164,471
Sweden	142	10,514	71	4,500	--	--
United Kingdom	--	--	29	1,586	--	--
Total	4,579	79,799	5,733	128,319	6,916	164,471
Selenium salts:						
Belgium-Luxembourg	--	--	--	--	567	29,839
France	--	--	6,399	6,397	--	--
Japan	603	5,596	--	--	--	--
Korea, Republic of	5,168	8,524	4,429	6,197	4,847	4,962
Taiwan	--	--	50	400	--	--
United Kingdom	150	8,550	193	6,821	7,000	114,959
Total	5,921	22,670	11,071	19,815	12,414	149,760

Table 18.—U.S. imports for consumption of selenium, by class and country —Continued

Class and country	1983 Quantity (kilograms of contained selenium)	1983 Value	1984 Quantity (kilograms of contained selenium)	1984 Value	1985 Quantity (kilograms of contained selenium)	1985 Value
Sodium selenite:						
Canada	841	$36,794	460	$17,223	42	$2,090
Germany, Federal Republic of	10,090	257,357	1,154	28,745	3,013	80,091
Japan	--	--	450	29,592	1,058	29,575
Spain	--	--	1,150	20,939	--	--
Sweden	230	4,128	--	--	--	--
United Kingdom	3,801	77,975	9,968	249,974	13,835	332,551
Total	14,962	376,254	13,182	346,473	17,948	444,307
Other selenium compounds:						
Canada	--	--	--	--	1,105	3,394
Germany, Federal Republic of	--	--	13	1,548	22	1,443
Japan	25	1,735	2,574	133,671	1,588	81,559
Netherlands	--	--	42	482	--	--
Sweden	--	--	170	2,107	123	1,398
United Kingdom	478	18,208	800	33,400	1,037	44,072
Total	503	19,943	3,599	171,208	3,875	131,866
Grand total	297,029	5,921,925	376,946	8,053,864	400,658	8,357,564

Source: Bureau of the Census; figures adjusted by Bureau of Mines.

Table 19.—U.S. import duties for selenium

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1985	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1985
Selenium metal	632.40	Free	Free	Free.
Selenium dioxide and salts	420.50, 420.52	do	do	Do.
Sodium selenite and other selenium compounds	421.625, 420.54	4.0% ad valorem.	3.7% ad valorem.	25% ad valorem.

WORLD REVIEW

Estimated world refinery production of selenium was about the same as that of 1984 and was slightly higher than the estimated world demand of about 1,100 tons.

Table 20.—Selenium: World refinery production, by country[1]

(Kilograms of contained selenium)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Belgium[e]	60,000	60,000	60,000	60,000	60,000
Canada[3]	350,010	[r]222,000	266,000	[r] [e]354,000	350,000
Chile	33,665	23,011	43,869	25,450	25,000
Finland	[r]19,422	10,020	11,172	16,975	17,000
India	4,104	5,351	3,684	[e]4,000	4,000
Japan	428,081	410,490	433,122	464,524	[4]496,835
Mexico	12,000	29,000	24,000	44,000	40,000
Peru	22,478	20,851	19,553	20,800	22,000
Sweden[e]	[4]44,000	44,000	44,000	45,000	45,000
United States	251,949	242,996	353,860	253,598	W
Yugoslavia	35,600	42,323	43,720	[e]45,000	46,000
Zambia[5]	23,929	22,453	22,051	17,355	17,000
Total	[r]1,285,238	[r]1,132,495	1,325,031	1,350,702	1,122,835

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total."

[1]Insofar as possible, data relate to refinery output only; thus, countries that produced selenium contained in copper ores, copper concentrates, blister copper, and/or refinery residues, but did not recover refined selenium from these materials indigenously, were excluded to avoid double counting. Table includes data available through June 10, 1986.

[2]In addition to the countries listed, Australia, the Federal Republic of Germany, and the U.S.S.R. produced refined selenium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Australia is known to produce selenium in intermediate metallurgical products and has facilities to produce elemental selenium. In addition to having facilities for processing imported anode slimes for the recovery of selenium and precious metals, the United Kingdom has facilities for processing selenium scrap.

[3]Refinery output from all sources, including imported materials and secondary sources.

[4]Reported figure.

[5]Data for fiscal year ending Mar. 31. In addition to refined selenium produced, Zambia exported significant quantities of selenium contained in anode slimes.

TELLURIUM[38]

Domestic consumption, imports, and production decreased from the 1984 levels. Decreased consumption resulted in a slight decrease in prices. Estimated world refinery production was essentially the same as the 1984 level.

Domestic Data Coverage.—Domestic tellurium refinery production data were obtained from the only domestic producer on a voluntary survey form. Data are withheld to avoid disclosing company proprietary data.

Table 21.—Salient U.S. tellurium statistics[1]

(Kilograms of contained tellurium unless otherwise specified)

	1981	1982	1983	1984	1985
Refinery production	W	W	W	W	W
Shipments to consumers	W	W	W	W	W
Imports for consumption	37,953	16,602	11,829	[r]35,383	30,050
Apparent consumption	85,202	45,978	56,639	107,311	W
Stocks, yearend, producer	W	W	W	W	W
Producers' price, per pound, yearend, commercial grade	$14.00	$10.00	$9.00	$11.00-$11.50	$10.00

[r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]World refinery production for selected countries is given in table 24.

DOMESTIC PRODUCTION

Commercial-grade tellurium was recovered by Asarco, at Amarillo, TX, from copper anode slimes, a byproduct of electrolytic copper refining.

High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide.

CONSUMPTION AND USES

Estimated consumption of tellurium by end use was iron and steel products, 60%; nonferrous metal, 25%; chemicals, including rubber manufacturing, 10%; and other, including xerographic and electronic applications, 5%.

The principal end use of tellurium was as an alloying metal in the production of free-machining steels and free-machining copper alloys. The addition of up to 0.1% tellurium improves the machinability of steels; the addition of tellurium to copper alloys improves their corrosion resistance as well as their machinability.

Tellurium catalysts are used chiefly for the oxidation of a number of organic compounds, and to a lesser extent, for the hydrogenation of oils, and in chlorination and dehydrochlorination processes. Telluride salts can be used as an antioxidant in counteracting the formation of sludge in lubricating oils. Other tellurium compounds are used in germicides and fungicides and in the treatment of dermatitis. Tellurium has use as a glass former in combination with other metal oxides, as a color additive in metal-finishing operations, and in time-delay explosive detonators. Photoconductive mercury-cadmium-tellurium is the most widely used infrared sensing material for thermal imaging devices used in applications such as night vision and navigation systems. Such applications require detector-grade (99.99999%-pure) tellurium.

PRICES

With decreased consumption, prices for commercial-grade tellurium decreased slightly from the 1984 level. The price for commercial-grade tellurium quoted by Asarco was $10.00 per pound at yearend. Commercial grades of tellurium metal, containing a minimum of 99% or 99.5% tellurium, are marketed as minus 200-mesh powder, 1-pound ingots, or 5-pound slabs. Tellurium dioxide is sold as powder ranging from minus 40-mesh to minus 200-mesh and containing a minimum of 75% tellurium.

FOREIGN TRADE

Data on tellurium exports are not available. Canada was the major import source in 1985, accounting for 45% of total imports.

Table 22.—U.S. imports for consumption of tellurium, by class and country

Class and country	1983		1984		1985	
	Quantity (kilograms of contained tellurium)	Value	Quantity (kilograms of contained tellurium)	Value	Quantity (kilograms of contained tellurium)	Value
Unwrought and waste and scrap:						
Belgium-Luxembourg	992	$17,870	4,003	$68,764	5	$5,878
Canada	9,461	540,080	20,382	369,745	13,458	453,929
Germany, Federal Republic of	2	343	1,019	17,367	5	1,404
Japan	95	5,574	1,825	103,338	499	29,083
Netherlands	--	--	1,300	23,884	500	9,653
Peru	--	--	--	--	963	18,963
U.S.S.R	9	10,500	--	--	--	--
United Kingdom	1,001	27,419	5,892	105,026	4,999	107,398
Total	11,560	601,786	34,421	688,124	20,429	626,308
Compounds:						
Belgium-Luxembourg	--	--	724	21,112	726	15,381
Canada	215	5,533	200	5,753	73	1,904
Germany, Federal Republic of	4	1,378	23	3,408	51	3,369
Japan	(1)	887	--	--	82	10,900
Philippines	--	--	--	--	7,376	202,483
United Kingdom	50	12,064	14	6,572	17	5,536
Total	269	19,862	961	36,845	8,325	239,573
Salts:						
Germany, Federal Republic of	--	--	1	270	--	--
Netherlands	--	--	--	--	1,296	5,410
Total	--	--	1	270	1,296	5,410
Grand total	11,829	621,648	r35,383	r725,239	30,050	871,291

rRevised.
[1]Less than 1/2 unit.

Source: Bureau of the Census.

Table 23.—U.S. import duties for tellurium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1985	Jan. 1, 1987	Jan. 1, 1985
Tellurium metal	632.48	1.5% ad valorem	Free	2.5% ad valorem.
Tellurium compounds and salts.	421.90, 427.12	4.2% ad valorem	3.7% ad valorem	Do.

WORLD REVIEW

Estimated refinery production of tellurium outside of the United States remained about the same as 1984 levels at 100 tons.

Table 24.—Tellurium: World refinery production, by country[1]

(Kilograms of contained tellurium)

Country[2]	1981	1982	1983	1984[p]	1985[e]
Canada[3]	21,297	[r]18,000	16,000	[r e]21,000	20,000
India	[4]220	(5)	(5)	(5)	--
Japan	61,700	62,800	54,800	64,500	63,000
Peru	21,310	20,726	15,116	14,094	15,500
United States	W	W	W	W	W

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Insofar as possible, data relate to refinery output only; thus, countries that produced tellurium contained in copper ores, copper concentrates, blister copper, and/or refinery residues, but did not recover refined tellurium, are excluded to avoid double counting. Table is not totaled because of the exclusion of data from major world producers, notably the U.S.S.R. and the United States. Table includes data available through June 10, 1986.

[2]In addition to the countries listed, Australia, Belgium, the Federal Republic of Germany, and the U.S.S.R. are known to produce refined tellurium, but output is not reported, and available information is inadequate for formulation of reliable estimates of output levels. Moreover, the other major copper-refining nations such as Chile and Zambia may produce refined tellurium, but output in these nations is conjectural.

[3]Refinery output from all sources, including imports and secondary sources.

[4]Pilot plant production.

[5]Revised to zero.

THALLIUM[39]

Although thallium was contained in ores mined in the United States, it was not recovered domestically as a marketable product in 1985. In other countries, thallium was recovered as a byproduct from flue dusts and residues collected in the smelting of copper, zinc, and lead ores. Domestic requirements for thallium were met by imports and withdrawals from stocks.

Legislation and Government Programs.—Thallium was considered to be a toxic material and was controlled to prevent a threat to the environment or labor force. In 1985, the EPA issued interim guidelines to assist local communities in establishing programs to respond to accidental releases of acutely toxic chemicals. Six thallium compounds were among the 402 chemicals identified as acutely hazardous. A chemical profile outlining the chemical and physical properties, health hazards, and precautions for safe handling and use was provided for each chemical listed.[40]

CONSUMPTION AND USES

Based on import data, the domestic consumption of thallium was estimated to be 2,300 pounds in 1985. The uses of thallium included gamma radiation detection equipment, additives for changing the refractive index and density of glass, low-temperature mercury-thallium alloy switches, high-density liquids, alloys, photosensitive devices, and radioactive isotopes for cardiovascular diagnostic procedures. The largest single use in the rest of the world continued to be as an ingredient in rodenticides; however, this use has been banned in the United States.

PRICES

Metal traders reported that the price of imported thallium metal, 99% pure, was $20 per pound.

Table 25.—U.S. imports for consumption of thallium in 1985, by country

Country	Compounds			Unwrought and waste and scrap	
	Gross weight (pounds)	Content[1] (pounds)	Value	Gross weight (pounds)	Value
Belgium-Luxembourg	946	757	$19,698	440	$6,530
Canada	56	45	1,700	2	1,034
France	771	617	14,419	--	--
Germany, Federal Republic of	--	--	--	220	3,583
United Kingdom	--	--	--	220	3,098
Total	1,773	1,419	35,817	882	14,245

[1]Estimated by the Bureau of Mines.

Source: Bureau of the Census.

Table 26.—U.S. import duties for thallium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1985	Jan. 1, 1987	Jan. 1, 1985
Unwrought metal	632.50	1.3% ad valorem	Free	25% ad valorem.
Compounds	422.00	4.0% ad valorem	3.7% ad valorem	Do.

WORLD REVIEW

World production data for thallium were not available. However, Western European companies were thought to be the largest producers of thallium in 1985. World reserves of thallium contained in zinc ores were estimated to be 830,000 pounds of thallium.

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