Minerals yearbook: Metals and minerals 1984. Year 1984, Volume 1 1984

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Minerals Yearbook

1984

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.

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1985

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Washington, D.C. 20402

Foreword

This edition of the Minerals Yearbook discusses the performance of the worldwide minerals industry during 1984 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 130 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 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*

Contents

Nonfuel Minerals Survey Methods

By Staff, Branch 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.

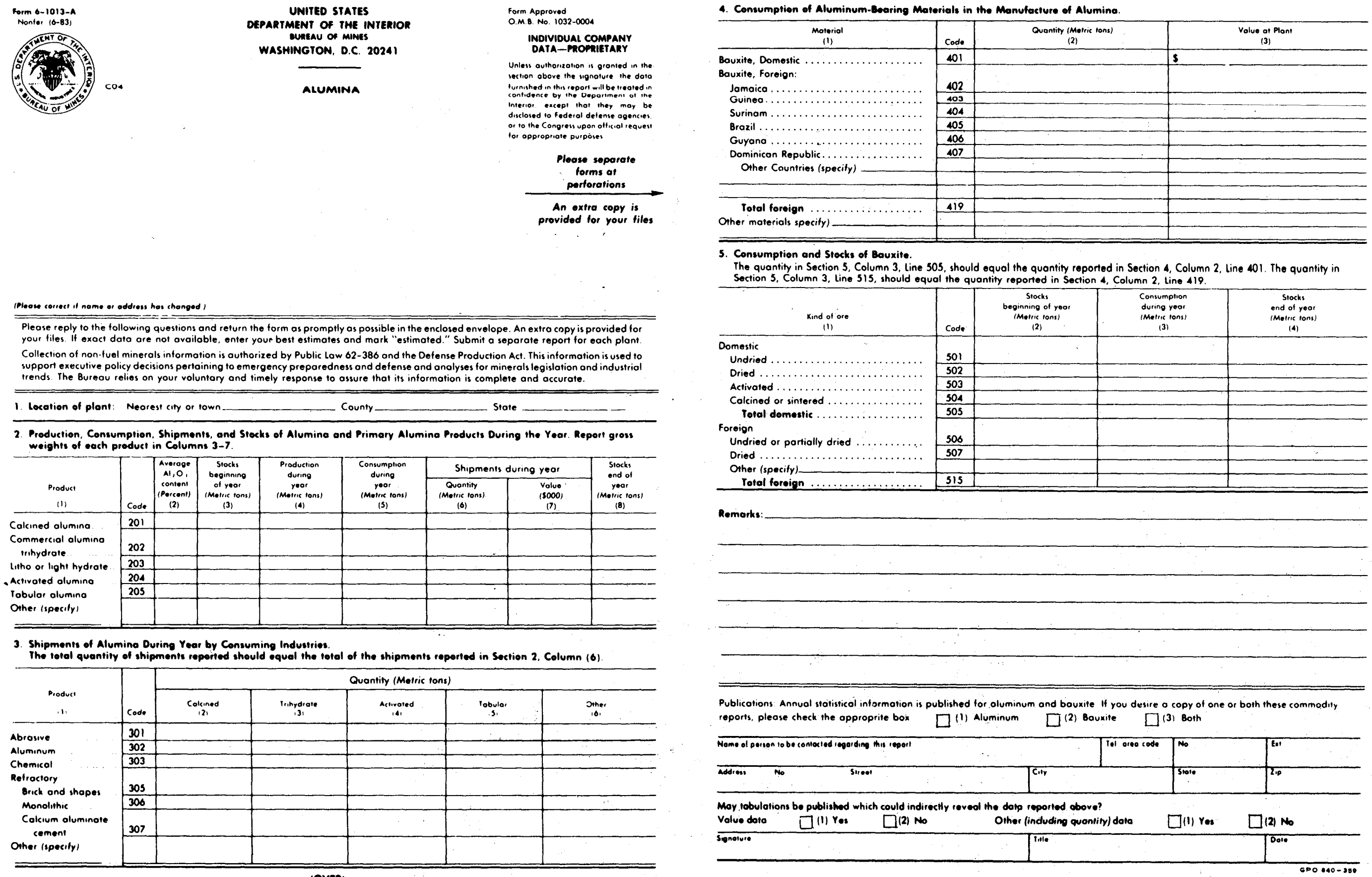
DATA COLLECTION SURVEYS

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 or 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 Branch of Statistical Standards, Division of Minerals Information Systems, 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 840-359

Figure 1.—A typical survey form.

SURVEY PROCESSING

The 166 surveys yield more than 61,000 responses from approximately 29,000 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 programmed 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 has an ongoing program to modernize and automate all of its survey processing methods. The focal point of this program is the development of the Automated Minerals Information System (AMIS). AMIS commodity data subsystems support the processing of individual surveys and the preparation of publication quality statistical tables. 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 rapidly 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 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 rates 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 "Mineral Facts and Problems," 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 1985 edition of "Mineral Facts and Problems" will be available in December 1985 from the U.S. Government Printing Office.

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, 2401 E Street, NW., Washington, DC 20241.

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 distributed on 5-1/4-inch floppy disks. 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 obtaining data on floppy disks or purchasing copies of mailing lists can be obtained from the Division of Minerals Information Systems, U.S. Bureau of Mines, 2401 E Street, NW., Washington, DC 20241.

Mining and Quarrying Trends in the Metal and Nonmetal Industries

By Robert J. Willard[1]

This chapter includes tables from 1983 that were not available in time for publication of the 1983 Minerals Yearbook, but does not include corresponding tables for 1984. The value of raw nonfuel minerals produced in the United States during 1984 was estimated at $23.2 billion, an increase of $2.1 billion over the value for 1983. This is the second consecutive year that the value has increased, and except for a decrease in 1982, the value for each year has increased since 1971, or 12 out of 13 years. In 1984, 16 out of 21 metal commodities increased in output while 5 metals decreased; 14 metals increased in value and 7 decreased. Of 46 nonmetal commodities, 37 increased in output while 7 decreased and 2 remained unchanged; 35 nonmetals increased in value and 11 decreased.

These statistics are grounds for continuing the cautious economic optimism expressed in 1983. Despite the note of optimism, however, numerous problems plague the mining industry, weakening its stability and inhibiting its growth potential. The problems are a complex mix of international and domestic factors that have been building in the recent past, but have become even more troublesome in 1984.

Extraction and processing of mineral resources continue their shift to foreign countries, and because the metals market is increasingly influenced by these countries, the United States has moved into a kind of international or global economy characterized by depressed metal prices and overproduction by foreign producers. It is doubtful that this situation will change in the foreseeable future, since some foreign countries must produce metals regardless of price in order to meet their debt servicing obligations. The strength of the economic recovery that began in 1983 among industrialized Western World nations, and particularly the United States, has been confined largely to the consumer. More recently, it has spread to capital goods that consume metals. This progression reemphasizes the traditional role of the metals industry as one of the last sectors to improve after a recession, and another aspect of why metal prices are depressed and will probably remain so for an extended period of time.

Gold has continued as the bright spot in domestic metal mining, and production is expected to expand further in the next few years. This suggests that gold and other precious metals will claim a high percentage of exploration costs, and as a result, ore reserves will probably be enlarged. Most production is from open pit mines with heap leaching becoming increasingly more popular. This method permits mining of low-grade ores at costs on a par with costs to mine higher grade, underground deposits, and is further aided by gold prices that are high in comparison with other metals.

As noted in 1983, the domestic industry has been seeking ways of cutting costs through technological improvements aimed at increasing productivity. This approach, however, may be reaching a point of no return. An undercurrent of change is taking place in the industry, according to some observers, apart from seeking Government protection. Since a global economic setting has emerged, and since the industry wants to remain competitive, it may consider diversifying efforts into such options as replacing reserves through acquisitions rather than through exploration and development, collaborating with other industries for new sources of revenue, curtailing production when market prices are unacceptable, and using innovative financing methods. Other factors may influence the undercurrent: namely, closing of less efficient operations, selling of assets to reduce operating costs, and effecting improvements in corporate debt positions. Still another factor is the interest shown by some in the industry in exporting in-house expertise to foreign operations as a means of preserving viability. The expertise includes every type of mining-related engineering service from initial survey and prospecting to processing and refining of mined ore. Benefits from such export help increase profits through service contracts and improved access to strategic materials produced in foreign countries. Despite such diversified efforts, most of the accomplishments reported in 1984 continue to be technically oriented, signifying that technological improvements are still a viable way of increasing productivity.

Legislation and Government Programs.—Several bills of concern to the mining and minerals industry were enacted in 1984. Included among these is the Critical Materials Act, attached as title II to the Arctic Research and Policy bill. Enacted on July 31, 1984, the act establishes a three-member National Critical Materials Council that reports on materials coordination and policy to the Executive Office of the President.

The President also signed into law a State Mining and Mineral Resources Research Institute program bill, extending authorization for the program for 5 years. Funding levels were set at $300,000 for each institute for the first year and $400,000 for each year thereafter. The grant money is to be matched on a basis of no less than $1.50 from non-Federal sources for each $1.00 from Federal sources during the first 2 years, and no less than $2.00 from non-Federal sources thereafter. New criteria were also established for determining whether a university qualifies as a mineral institute to become eligible for funding under the act. Membership on the advisory committee for program direction and recommendations was expanded to include representatives of academia, industry, labor, and the environmental community.

The second session of the 98th Congress included passage of a number of wilderness bills affecting some 20 States. Rapid movement of wilderness legislation through the Congress occurred only after a compromise was reached in May 1984 between Senate and House committees on releasing certain forest lands to multiple use. By yearend, over 70 wilderness bills had been introduced, 20 of which were passed and signed into law, adding over 7 million acres of land to the National Wilderness Preservation System.

Two measures were also passed that have an impact on National Defense Stockpile activities for fiscal year 1985. First, the Continuing Resolution, which was signed into law by the President in October 1984, contains a $10 million, 2-year authorization for "purchases and/or commitments to purchase metals, minerals, or other materials by the U.S. Department of Defense..." The General Services Administration (GSA) section of the Continuing Resolution designates $185 million, in addition to amounts previously appropriated, to the National Defense Stockpile Transaction Fund. A "Buy America" clause was included in the GSA appropriation requiring that none of the funds be used to purchase any stockpile materials not mined and refined in the United States, other than those not currently mined and refined in the United States or not available in quantities sufficient to fulfill the requirements of the Federal Emergency Management Agency. Second, the Department of Defense Authorization Act gives authority to the President to dispose of 19 materials currently held in the National Defense Stockpile that have been determined to be excess. These include 20,000 metric tons of tin, 225 metric tons of mercuric oxide, 10 million troy ounces of silver, 2,880 metric tons of antimony, 262,800 metric dry tons of metallurgical-grade manganese, and 1,080 metric tons of tungsten. No time limit was set for the disposal, as the effect of such sales on markets must first be considered. The act also requires the President to submit a report analyzing the appropriateness of placing all aspects of the stockpile under a single authority and the adequacy of existing legal authority for barter of surplus and excess materials. In addition, the act calls for 30% of all fiscal year 1985 money accruing from the naval petroleum and oil shale reserves to be credited to the National Defense Stockpile Transaction Fund.

The Trade and Tariff Act of 1984 was

adopted by the House and Senate and signed into law in October. In response to the President's decision not to impose countervailing duties or restrict quotas on imported copper and steel goods, the law, in a nonbinding "sense of Congress" suggestion, instructs the Administration to negotiate voluntary copper import reductions with major foreign producers. It also requests the President to reduce steel imports to between 17% and 20.2% of the U.S. market, and gives the President authority to enforce restraints on steel imports. This authority is linked to the steelmakers' commitment aimed at modernizing operations and retraining workers. It requires that "substantially all" the steelmakers' net cash flow be reinvested in equipment and modernization with 1% of the net cash flow for worker retraining programs. The President is also given the power to negotiate free trade arrangements with any country or group of countries if Congress gives advance approval of the negotiations. Both Houses of Congress, however, would have to approve the agreement.

Exploration.—Federal agencies continue to gather more on-site information on marine mineral deposits, largely as the result of the 1983 Presidential Proclamation of an Exclusive Economic Zone (EEZ). The efforts, conducted cooperatively by the U.S. Geological Survey (USGS) and National Oceanic and Atmospheric Administration have been focused on the polymetallic sulfide (PMS) deposits off the California-Oregon coast. The USGS has also collaborated with the State of Hawaii and the Federal Republic of Germany in assessing the cobalt-rich, manganese oxide pavement-like deposits south of the Hawaiian Archipelago. In support of these efforts, the Bureau of Mines has intensified its studies on the metallic concentrations in samples of offshore minerals such as the PMS deposits, the evaluation of extractive techniques, and the determination of engineering properties of pavement samples. Thus far, most of the exploratory work has been conducted under U.S. Government sponsorship with the present goals of locating and mapping the deposits and adding data to the body of scientific knowledge. None of the work thus far has been aimed at deposit delineation for tonnage and ore grade factors that would be necessary precursors to mining. Furthermore, commercial mining systems have not been developed to mine these kinds of deposits. Therefore, the likelihood is that future efforts will continue to focus on gathering more information on location and composition of known deposit areas, exploration for new areas, improvement of sampling techniques, and planning of mining scenarios. New exploratory, side-scan sonar tools are now in vogue, such as the SeaMARC, Sea Beam, and GLORIA systems that are able to provide considerable seafloor detail. The USGS's EEZ-SCAN program utilizes GLORIA, for example, to detect features less than 1-foot high separated by only 135 feet normal to or 300 feet parallel to ship direction.[2]

Although mineral exploration is clearly a critical factor in mining, it is a high-risk venture where chance often plays a lead role. As such it tends to become an early casualty of slowdowns in the economy that affect the metals market. Nevertheless, good management leadership in the timing of exploration activity and control of its high costs can make the difference between success and failure, and recognition and use of technological advancements in exploration tools can improve the quality of exploration. As a case in point, aeromagnetic surveying was the bright spot in mineral exploration in 1984, aided by new surveying tools and techniques.[3] E G and G Geometrics reported increased use of the horizontal aeromagnetic gradiometer for small, localized "bull's-eye" type deposits. The company uses three magnetic sensors per aircraft to provide better total field delineation between flight lines than does one sensor. In addition, the company has developed a method of producing vertical gradient maps from airborne horizontal gradiometer data, utilizing transverse and longitudinal gradient data to calculate the maps.

Development.—The ever important need for cost effectiveness in mining was noted in 1983 for its growing importance to this phase of mining. Foreign mining companies also have been seeking ways to minimize development costs, which may have application to the domestic industry. For example, in the Republic of South Africa, a handheld drill has been developed for use in hard rock that incorporates a completely new engineering technology and has the potential to improve productivity significantly.[4] The drill is hydraulically operated and is particularly effective in highly fractured and stressed rocks. For example, 55 holes per drill crew per shift were completed with 20 to 25 hydraulic drills operating on a 2,700-foot face. This compares favorably with an industry average of only 30 holes using pneumatic drills. With a powering medium of 95% water and 5% lubricants to avoid contamination costs, the drill consumes only a fraction of the electrical energy needed by pneumatic drills to do an equivalent amount of work, and it can be repaired and serviced quickly by personnel without high technical skills. In addition, the hydraulic drill is much quieter and provides better visibility at the rock face since it does not produce the fog associated with the use of compressed air. Several drills can be connected to a centralized power generation plant located away from the face, allowing easier maintenance, less stringent engineering requirement, and greater control over fluid filtration.

The recent recession (1980-82), from which the world economy is recovering, continues to exert an adverse effect on the mining industry through a flat or decreasing demand for minerals. During periods such as this, mine development becomes secondary to simply staying in business, and companies are more concerned with elimination of unprofitable operations.[5] Since mine development costs traditionally have involved financing by commercial banks, loan portfolios have generally looked good, but now there is much less demand for financing projects involving iron and copper, for example, and to a lesser extent gold and silver. Still, as depletion of reserves continues, and with major exploration at low levels, a backlog of new projects is awaiting development. These projects are being scrutinized carefully, particularly where newer technologies could be involved. These technologies could be expected to require more detailed pilot testing or even performance bonds, which will add to development costs. Hence, successfully financed development projects will be those that are well conceived and have high economic potential.

Interest in development of precious metal mines continues the trend reported in 1983. Golden Sunlight Mines Inc. has been expanding its pit operation in a low grade, gold mineralized breccia pipe near Butte, MT.[6] With reserves estimated at 25.8 million tons, an average grade of 0.05 troy ounce of gold per ton, and a cutoff grade of 0.02 troy ounce per ton, the company anticipates a recovery of 72,000 troy ounces per year. The mine design for the deepened pit involved a 2-to-1 strip ratio to reach 550 feet below a lower bench in the ore. Since the ore is of uniform grade, bulk or mass mining will be the likely method of removing the ore. This arrangement provides a net energy saving because of the downhill haul for loaded trucks over much of the mine's expected lifetime. Development costs were held to less than two-thirds of budget because of reduced interest rates, relatively low inflation rates, competitive bidding by contractors, and excellent project design and construction management.

Numerous other reports of advances in drilling technology have added to the trend toward more efficiency in development systems. A new drill design was introduced at the Magmont Mine in the lead belt of southeastern Missouri. Mine management switched to a more cost effective, highly efficient pneumatic drill, the PR-1000 Drifter.[7] Three drifters were fitted to a Universal III Jumbo in hopes of increasing productivity. Since compressor stations and pneumatic systems were already in place in the mine for use with older model, Jumbo-mounted pneumatic drills, management decided to hold its equipment upgrading costs to a minimum by acquiring the latest technological advances in pneumatic drills. The new drills proved to be better, because they increased total footage per shift by 31%, from 3,200 to 4,200 feet, a new mine record high for one shift.

Another drill design was developed,[8] tested, and marketed by Tround International Inc. of New Jersey. Known as the Tround Blast Hole Drilling System, the system incorporates a conventional drill with an innovative combination of a 3-barrel gun magazine, power unit, and controls, all sealed and self-contained in a drill collar. The system was designed to enhance conventional drill penetration through hard rock by firing continuous salvos of ceramic projectiles from a magazine containing up to 6,000 projectiles. Projectiles are fired at microsecond intervals to induce stress wave interactions that damage the rock and create fractures up to 20 inches beyond the bit. The operator controls the rate of fire, and with a full magazine can add an estimated 1,000 to 1,500 feet of rock drilling capability. Since the conventional drill operates in rock prefractured by projectiles, drilling rates are increased, and bit wear and drilling costs are reduced, resulting in increased productivity. The system has been tested successfully in both hard and soft rocks, and when the drill penetrates soft rock, the projectile gun can be shut down so that the conventional drill can still penetrate the rock but in a less expensive, energy conserving manner. Tround has an air drilling version of the system with 9-7/8- and 15-inch bit sizes already on the market.

New bit designs have been introduced by Atlas Copco to improve drilling efficiencies in abrasive and nonabrasive rock for down-the-hole drilling of blastholes, waterwells, etc. The bits feature redesigned sludge grooves to enhance uniform flushing. This feature is particularly attractive for use in high-pressure drilling, since it reduces bit steel erosion caused by high-velocity cuttings. Another feature is the redesigned button pattern that improves rock fragmentation, reduces bit stress, and promotes smoother running. Finally, the grade of bit steel has been improved to give greater button support and shank strength, thus lowering replacement costs associated with button failure and fatigue cracking in the shank.

Two handbooks on drilling technology published by Tamrock of Finland are being touted as valuable additions to libraries of managers and engineers involved with underground and surface excavations.[9] One of them, the "Handbook of Underground Drilling," covers the latest technology on drifting, tunneling, mining methods, shaft sinking, raise drilling, and rock scaling. The other, the "Handbook of Surface Drilling and Blasting," covers the latest surface drilling patterns, blasting practices, and blast planning and design. According to the handbooks, the use of hydraulics on drills and rigs has revolutionized the state of the art in rock drilling. Entire mining systems are now designed to take advantage of the development capabilities and productivity improvements afforded by modern, high-capacity, small- and large-diameter rock drills. Such drill systems are fast, efficient, and pose a challenge to mine operators to make maximum use of the time that the systems are mechanically available.

A dragline larger than the Ransomes and Rapier W2000 unit that was reported last year has been assembled at Saskatchewan Power Corp.'s Popular River Mine, continuing a trend to ever larger units in dragline technology. This unit, the Bucyrus-Erie 2570-W, has a 400-foot boom and a suspended load capacity of 126 tons. Featuring a 195-foot mast, it has an effective operating radius of 382 feet, a digging depth of 160 feet, and a dumping height of 150 feet. The dragline exceeds the W2000's boom length by 87 feet and its operating radius by 116 feet. Mine operators can move overburden greater distances from greater depths than before with the unit, thus increasing efficiency while holding overburden removal costs to a minimum.

John Deere Inc. claims that "bigger is not always better." Some users and manufacturers believe that smaller machines rather than larger ones can cut earthmoving costs.[10] This belief is particularly appropriate in open pit development where overburden removal costs can make or break a developing mine. With ever-increasing prices for earthmoving equipment, mine managers are seeking ways to hold their expenditures in-line while maintaining efficient operations. As an alternative to larger units that move massive amounts of material, a company representative recommends downsizing units to smaller, less expensive ones while adding some extra workers. Overall costs then can be held in check, since labor rates are not increasing as fast as equipment prices. In addition, smaller units of support equipment such as bulldozers, scrapers, and wheel tractors should make up to one-third of the earthmoving equipment used in smaller tasks, because their operational costs become insignificant in comparison with those of major units pulled off the production line to do smaller tasks.

Underground Mining.—Sunshine Mining Co.'s Sixteen-to-One Mine in Nevada's Silver Peak Mountains is an example of a highly efficient underground mine that has adapted mass mining to a small ore body.[11] The ore body was originally developed as a spiral and ramp operation, and the adaptation is a variation of vertical crater retreat and end slicing that significantly reduces labor requirements and enables Sunshine to operate profitably its first active project outside its famous mine in the Coeur d'Alene district. Vertical slices of ore are removed by drilling and blasting between sublevels into voids created by previous blasts. The fragmented ore is then removed from drawpoints at the bottom of the ore body. Explosive charges are placed near the collars of large-diameter holes, which crater out to the nearest face when shot. Perimeter holes are then shot into the craters to square up the new face. This sequence of operation is an equipment-intensive stoping method usually employed at much larger, multithousand-ton-per-day operations, but Sunshine has found that it can be applied successfully to a small mine in a remote location, as in the case of the Sixteen-to-One Mine. The company draws further benefit from a favorable precious metals market, since the mine produces about 1 million troy ounces per year of silver and 8,500 troy ounces per year of gold.

Continuous Mining Systems Ltd. (CMS) of Canada considers bulk mining methods to be more efficient, productive, and safer than other methods.[12] The equipment associated with such methods can convert hard-rock operations into a new generation of hard-rock mining equipment. For example, a down-the-hole drill enables less efficient cut-and-fill and under-and-fill stopes to be replaced with vertical crater retreat mining, thereby expanding use of large-diameter drilling for the bulk mining method. For example, an electrically operated, continuous-loading machine with a tight turning radius can replace a conventional underground loader, increasing by tenfold the muck handling capability. The machine has a patented oscillating lip to agitate the muckpile and feed a high-capacity (1,000 tons per hour) conveyor. In addition, a battery-powered, remote-controlled underground locomotive can be used to operate the haulage equipment, and is capable of delivering power for 16 hours. Finally, a new generation drill fitted with a microprocessor allows the drill to be operated unattended, and all rig functions are automated. Since the drill has a low profile, it can be moved through small openings, as is often necessary when converting pillars from under-and-fill to a bulk mining method. The CMS bulk mining method was introduced this year with initial production anticipated before yearend.

A radically redesigned drill rig has been developed for use in underground mining by Tamrock of Finland. Named Solo H8O8RA, the rig is applicable to most longhole drilling operations including vertical crater retreat, underground benching, and sublevel, open stoping.[13] The rig is considered to be competitive with in-the-hole and rotary drills, leading a trend to longer and larger holes in underground mining. Solo H808RA with its hydraulic drifter is considered to be the most powerful longhole percussive rock drill in the world. It can produce holes 5 to 6 inches in diameter routinely at lengths up to 150 feet, and even lengths up to 300 feet while consuming energy at amounts only a quarter of those required for in-the-hole drilling. The rig has improved ergonomic features such as orientation of the feed and drifter to face the operator's cabin so that the operator's functions, including mechanized rod changing, are performed from under the protection of a safety cabin or canopy. Other features include the special lights to identify reference lines painted on drift walls for alignment purposes, an accurate positioning capability aided by angle indicators on the boom and feed, and a patented alignment system to ensure accurate and straight longholes. Rig stability is enhanced during drilling as the front frame is used as a stabilizer.

A method for cutting deep slots in hard rock has been developed by the Bureau of Mines as part of its research to selectively mine ore from surrounding waste rock in underground mines. Cutting is achieved by means of a collimated water-jet system operated at a moderate pressure of 10,000 pounds per square inch. The jet system includes an abrasive entrainment assembly and a traversing system mounted on a drill carrier that permits the jet to traverse along a rock surface at standoff distances up to 4 feet from the nozzle. The jet retains its cutting ability through the range of distances, thus allowing the cutter head to follow into a kerf and extend the depth of cut. The range of distances is achieved by advancing the collimating pipe into the cut to increase the depth of cut; kerfs as deep as 4 feet have been cut in dolomite, limestone, granite, and other hard rocks. The method was tested at Vetter Stone Co.'s quarry in Kasota, MN, where a 12- by 30- by 33-inch block of dolomite was cut from a bench. The rock was then removed by wedging the block out between parallel cuts.

Surface Mining.—Computer-based production control systems are gaining recognition for their efficiency in quarrying operations. Genstar Stone Products Co. has doubled capacity at its Frederick, MD, plant by regulating a $12 million expansion with a programmable controller.[14] The principal components of the expansion included a new primary crusher, a new feed system for the original plant, a secondary-tertiary circuit, a 12-cubic-yard hydraulic shovel, and a new electrical distribution system. As the result of this expansion, output has risen from 450 to over 1,000 tons per hour. The controller, assisted by 110 new motors and 60 miles of wiring to operate the screening and conveying systems, is also used to regulate the plant's complex interlock system and the process control system, an approach new to the field of aggregate processing. From the time quarry material leaves the haulage trucks, passes through the various crushing units and emerges in finished product piles, its flow is regulated by the controller. The resulting piles consist of sized materials ranging from small riprap (4 by 7 inches) to minus 1/4 inch. Altogether, the expansion has resulted in a highly productive and cost effective crushed stone operation.

Another application of computer-based production control systems involved earthmoving equipment. The type of application is termed "mechatronics," by Komatsu Ltd., and is the merging of mechanical and electronic technologies to get the most beneficial effects of both.[15] For example, new generation excavators such as front-end loaders can have add-on sensors that relay information to microprocessors for making instantaneous operational decisions and monitoring precise operational control. Three major benefits of these systems are improved safety warning response, fuel efficiency, and ease of operation. Komatsu's largest front-end loader, the PC 1500, incorporates mechatronics capabilities. Its hydraulic system is controlled by a microprocessor; sensors on the bucket, arm, and boom relay information about their movement to the microprocessor, which activates only that pump capacity needed for a given task. This feature has resulted in an energy savings of as much as 23% and component life is extended. To illustrate this point, the positions of pistons in hydraulic cylinders are monitored by sensors feeding information to the microprocessor. This arrangement ensures that movement is automatically slowed gently as the pistons reach the end of strokes, and the resulting cushioning effect reduces wear and extends piston life.

Numerous advances have been reported this year in crushing operations. Kone Corp. introduced a new line of primary "BML-Jaw" crushers with a cost-saving geometry combining the best features of Blake and single-toggle crushers.[16] Single-toggle crushing action in the upper part of the jaw cuts blockages and production stoppages to a minimum, and permits effective crushing of relatively large blocks of rock. The Blake-type crushing action in the middle and lower part of the jaw is achieved by a perpendicular stroke against the fixed jaw, resulting in purely compressive crushing that minimizes jaw wear and power wastage. The two crushing actions are oriented in such a way that machine forces are small, allowing use of lightweight supports, which lower investment costs.

Newpoint Stone Co. of New Point, IN, solved its problem of oversized fragments of dolomitic limestone by installing a Kue-Ken 4860 oversize, primary jaw crusher.[17] Prior to installation, the company was continually troubled with oversized fragments due to geological structures that did not allow the stone to be shot small enough to fit into the preexisting crusher. The thickness of the limestone ledges made shooting difficult, causing the stone to break into thick slabs. The crusher is operated at 600 tons per hour to produce 5-1/2-inch fragments, but if a greater throughput were needed, the discharge size could be increased until the crusher reached about 1,200 tons per hour. The crusher has enabled the company to cope with oversized fragments and increase production, even though it exceeds the capacity of the secondary plant. To compensate for this imbalance, the company allows the surge pile to be built up to 5,000 tons, and then the crew is shifted from the crusher to the plant. Thus, crushed stone products are produced with one-half the labor that would normally be required if the entire plant were operating with a full crew, and as an added benefit, the electrical cost is halved when starting up the plant.

In another example of advances in crushing operations, Chemical Line Co. has switched to an in-pit crushing system and an overland conveyor in its limestone quarry at Clifton, TX.[18] This system replaces an all-truck haulage transport system, and as a result, diesel fuel costs have been reduced by one-half, production has tripled, and truck maintenance has been significantly reduced. Still another instance of reduced costs from changes in crusher operation occurred at the Crawford Quarry near Cedar Rapids, IA. A 5165 impact primary crusher, grizzly feeder, and hopper were set on the first level of the quarry and fed from the top. This arrangement permitted shorter truck hauls and cycle times resulting in more loads per day. In addition, fewer trucks and drivers were needed to keep the surge bins full.

Rock cutting methods are becoming more diversified in the quarrying industry. Vermeer Manufacturing Co. of Pella, IA, developed a rock cutter machine, the T-600, for use in Weber Stone Co.'s limestone quarry at Anamosa, IA.[19] Although an experimental machine in the 1970's, the T-600 soon proved its worth by dramatically increasing the amount of salable stone. Since it replaces the drilling and blasting cycle at the quarry, there is much less damage to good rock material. In actual operation, a carbide-tipped cutting wheel penetrates a layer of limestone to depths of 33 inches while an indicator aids in maintaining a constant depth of cut. The cut width of 4 inches creates minimal waste, and along with elimination of drilling and blasting, the company has realized a cost savings of almost 50% in labor and materials. Before using the T-600, the longest slabs that could be quarried were 8 feet, whereas 15 foot slabs are now commonplace.

Mine management continues to take a close look at truck haulage over a variety of mining situations in efforts to cut costs. Truck haulage of ore and waste from pits continues to be the dominant method of transport, because trucks are flexible enough to negotiate tight, narrow roadways and can climb relatively steep road grades. However, trucks account for one-half of all mining costs, and as pits are deepened and haul roads lengthened, mine operators are seeking ways to improve haulage efficiency or else use other less costly transport alternatives. Reserve Mining Co. has looked at truck haulage and devised a computer-controlled Mine Management System at its Peter Mitchell iron ore mine near Babbitt, MN.[20] Phase one of the system automatically dispatches trucks and provides operating statistics for adjusting dispatch intervals, thus reducing haulage costs by 17%. Phase 2 of the system is being developed to monitor the operational status of key equipment units such as haul trucks and other work-related activities. The system applies communication and data processing technology to gather and utilize data for generating messages that maintain an optimal equipment movement pattern throughout the mine. Such an approach was found to be the most cost-effective method to reduce waste motion and idle time and to redirect efforts toward greater resource utilization and more meaningful work.

Continuous belt haulage (CBH) systems have been scrutinized by mine management, and improvements in mining efficiency have been made with a combination mine-run-rock conveyor (MRRC) and a high-angle conveyor (HAC).[21] This combination is applicable to surface and underground mining, and is a viable alternative to the usual materials transport method of using large haul trucks. The Bureau of Mines also examined conveyor systems and completed a study of HAC applications, including such variations as the "Snake Sandwich," mechanically pressed conveyors, and MRRC applications including crib-and-cable designs. HAC's are more compact, mobile, and flexible than conventional out-of-pit conveying systems. The MRRC crib-and-cable system has demonstrated its mechanical feasibility, and CBH systems offer several important advantages over truck haulage in terms of cost cutting and mining efficiency. They include a more stable source of fuel (electricity versus diesel fuel), longer life, lower maintenance costs, greater efficiency in elevating materials from pit depths, and less excavation along pit slopes.

Duval Corp.'s Sierrita open pit copper mine estimated a savings of $8 to $10 million per year in truck haulage costs by using a large-scale portable crusher and an extra long mainline conveyor instead of trucks. The conveyor is equipped with portable, extendable, drive stations that propel the 152-centimeter-wide Flexsteel Belt along at a capacity of 4,536 tons per hour over a distance of 4 miles. This distance extends from the pit to the ore stockpile, and as the pit is deepened, the conveyor will be extended to follow the crusher, continuing the savings on haulage costs.

Front dump loaders have been around for many years, but they are taking on added importance because of a recent shovel modification. An automatic three-way loader attachment, the LIBU-AB, has been developed for rapid attachment in the field.[22] The attachment enables conversion of front-dump loaders to side-dump loaders with capacities from 1 to 10 cubic meters. Numerous economic advantages of this conversion include shorter travel distances with the loading cycle, reduced tire wear and fuel consumption, and faster cycle times. In some instances, the side-dump loaders have increased loading capacity up to one-third more and reduced loading costs by one-half on a cost-per-ton basis.

Precious metals such as gold and silver have enjoyed a reasonably favorable market, continuing the trend from 1983. As evidence of this trend, gold placer deposits in Yuba County, CA, have been undergoing a revival; participants include Placer Service Corp. and Yuba Natural Resources.[23] Redredging of older dredge sites is taking place with dredges modified to excavate greater depths. For example, the Yuba 21 bucketline dredge can now excavate alluvium to 140 feet below pond level, is ranked as one of the deepest onshore bucketline dredges in the Western World, and is the only gold mining dredge in the lower 48 States. Modification is being planned for another dredge, the Yuba 17, to reach 175 feet. Yuba 21 operates in an overall mining plan that includes conventional front-end loader stripping of 80-foot overburden tails from previous dredging and a 2,000-foot overland segmented conveyor to support the stripping work. Productive mining is enhanced by the plan, since the dredge is not required to handle overburden or previously processed, barren alluvium; the result is a more cost-effective operation.

Heap leaching continues to be regarded as a viable economic alternative to other more costly ways of mining precious metals, following the example reported last year at Nerco Minerals Co.'s Candelaria Mine. In the present example, Vanderbilt Gold Corp.'s Morning Star Mine in San Bernardino County, CA, is being converted from an underground operation to an open pit, heap leach operation.[24] An estimated 1 million tons of overburden is being removed to expose 700,000 tons of gold ore for the heap-leaching process. Leach pads are also being constructed with a total capacity for handling 2 million tons of ore. The conversion plan involves placement of 100,000 tons of ore in the pads. The company considers the ore as composed of richer grades averaging 0.06 ounce per ton and leaner grades averaging between 0.03 and 0.04 ounce per ton. The gold-bearing ore extends into adjacent properties held by the company that represent long-term prospects for future development and continued use of heap leaching.

Remote Mining.—Remote mining is introduced as a new title for trends and accomplishments that heretofore were assigned to a section entitled "In Situ Mining." The new title involves those kinds of mining methods that do not place miners underground, that do not require removal of overburden, and that involve physical separation of the miners from the ore body. Remote mining is normally accomplished through a borehole containing appropriate piping and fluids that are associated with such specific methods as in situ leach mining, solution mining, hydraulic mining, slurry mining, and water-jet mining. Renaming of this section thus serves the purpose of emphasizing the diversity of remote mining methods.

The Bureau of Mines has completed study of a mining method in which a water-jet cutter is combined with a downhole slurry pump to mine phosphate in northeastern Florida. The study, a cooperative venture with Agrico Mining Co. of St. Johns County, was aimed at converting untapped phosphate resources into recoverable reserves with a minimum of environmental damage.[25] The method utilizes a single borehole drilled from the surface into which a tool is inserted with openings for water jets. The jets break up the ore into a slurry, which flows into a pump inlet for lifting to the surface and into a pipeline for transfer to a mill. About 1,700 tons of phosphate was mined by this method at a rate of 26 tons per hour from a depth of 250 feet. Roof support for the resulting cavity was handled initially by water from the jet system that filled the cavity and provided hydrostatic head to keep the roof from collapsing. After mining, the cavities were backfilled with sand to provide long-term support and inhibit ground subsidence. As the result of this venture, Agrico is planning pilot-scale tests in 1985 to determine commercial feasibility.

The Bureau of Mines and Westinghouse Electric Corp. have devised a cooperative test program to promote the advantages of in situ leach mining and to investigate its applicability to a variety of mineral deposits. Program work this year involved an evaluation of the effectiveness of a well integrity system to locate leaks in the leaching system piping. The test work, completed in 43 well stations at the Irigaray uranium mine near Buffalo, WY, showed the system to be faster to operate and with fewer personnel than earlier leak-detecting systems. The faster leaks could be detected, the faster they could be repaired to maintain leaching efficiency, and only one operator was needed to test four wells in a day.

As an additional part of its research in remote mining methods, the Bureau of Mines has developed up-to-date, computer-based bibliographies on various techniques in in situ leach mining and solution mining. The bibliography on in situ leach mining covers those metal-bearing ores amenable to leaching, and the bibliography on solution mining covers nonmetallic deposits such as trona, potash, and rock salt that are amenable to dissolution. In addition to citation of publications, each bibliography includes patent references, and any reference can be retrieved by use of one or more key words in common usage throughout the mining industry. Included as key words are such terms as well construction, fluid flow, restoration, explosive fragmentation, specific metals, and geologic factors.

Leach solution flow through ore-bearing rock is often difficult to maintain in in situ leach mining, and the Bureau of Mines has been investigating ways to minimize this difficulty. A report completed on the investigation indicates that treatment of ore material with the proper stabilizing polymer can maintain permeability levels two to five times that of untreated ore.[26] Swelling and dispersion of clay particles were found to be the chief culprits in permeability reduction during leaching, and their effects can be substantially reduced by the polymers.

Beneficiation.—The economic pressures of the international marketplace have forced innovative, cost-reducing improvements in existing beneficiation technology. For example, angular spiral liners[27] for grate discharge ball mills are proving to be extremely important in commercial grinding circuits. When placed in service at the San Manuel, AZ, concentrator of Magma Copper Co., grinding medium consumption decreased by 19% and grinding energy consumption decreased by 16%. Similar savings were obtained after installation in the Corporación Nacional del Cobre de Chile mills. These are substantial savings in the two highest cost areas of mineral beneficiation—energy and grinding medium consumption.

Further savings have resulted from improved understanding of the mechanisms of grinding medium loss. Grinding media (balls, rods, and mill liners) are consumed through abrasion, corrosion, and fracture. Research has shown that the relative contribution of each of these factors depends on the metallurgical properties of the medium (usually steel), the type of ore being ground, and the grinding conditions (wet or dry).[28] Abrasive wear is influenced by the rheological properties of the ore slurry and is the dominant mechanism in the absence of sulfide minerals. If sulfides are present, 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,[29] creating an environmental problem in effluent disposal, and affecting water recyclability. As a result, research into grinding medium wear and the development of methods to reduce wear are also helping to reduce other production and environmental costs.

Increasing use is being made of advanced process control technology in grinding circuits. This use is largely the result of better on-line instrumentation for measuring process variables and a better understanding of the effects of these variables on process behavior. The ability to automatically compensate for variations in ore feed reduces overgrinding, which notoriously wastes energy and creates an excessive quantity of fine particles. Mineral fines often contain lost metal values that interfere with subsequent separations and create additional environmental costs. Before state-of-the-art computerized process control can be fully utilized, methods such as image analysis are needed to obtain mineral-specific on-line particulate data and classification of grind mill output with respect to mineral as well as particle size. Mineral-specific classification based on the data would then enable the removal of a mineral as soon as it is liberated, whether or not it has been reduced to a particular size. One method of mineral classification being evaluated involves placement of a flotation cell into the grinder output just ahead of the hydrocyclone size classifier. This method results in improved classification efficiency.

The search for more selective reagents is a dominant factor in industrial flotation research, because of their high production costs. The domestic minerals industry uses about $150 million worth of flotation reagents annually.[30] Even if the research produces a reagent suite that makes only a 1% improvement in recovery, the additional income generated can more than offset the total reagent cost.[31] Such an improvement makes flotation reagent research a continuing endeavor. The first comprehensive conference devoted exclusively to mineral processing reagents, "Reagents in the Minerals Industry," was held in Rome, Italy, in September 1984, attesting to their importance. Normally, after laboratory studies are complete, new reagents must be tested on actual equipment in order to determine economic viability, and it is this development area that is often prohibitively expensive for the small operator. Custom-designed reagents are generally made by chemical companies only for the larger deposits where the costs of research are small in comparison to the size of the market.

Column flotation cells, developed almost 20 years ago, are becoming more common in flotation plants. Improved efficiency over a wider particle size range and higher capacity per unit volume are the principal reasons for this increased usage.[32] Key to the broader particle size range is the ability to generate ultrafine bubbles by aspirating gas into surface tension-lowered water under extremely high shear forces.

Automatic control is being applied to more and more flotation concentrators,[33] even though fully automatic control using advanced computer technology has yet to be realized. Remaining problems include lack of appropriate sensors and a sufficiently detailed model of the processes being controlled. The most important sensor in current flotation control systems is the onstream X-ray analyzer, which provides chemical analyses of the metal content of process streams. However, mineral content, the parameter needed for control, can only be inferred from this chemical data, particularly 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 that require very different variable changes for optimum flotation. Nevertheless, 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.

External control of electrochemical potential continues to show promise as a method for separating mixtures of sulfide minerals.[34] The method is especially effective for controlling particle interaction with organic collectors. For instance, separations are achieved in mixes of sulfide minerals with different electrochemical potentials and collector adsorption levels. This is based on the notion that the electrochemical potential of mineral surfaces can be varied by adjusting the oxygen partial pressure of a closed system. In addition, use of oxygen pressure instead of cyanide for mineral depression may significantly reduce subsequent environmental disposal costs and reagent loading of subsequent flotation stages, thus simplifying sequential separation of minerals from complex ores. Flotation control by oxygen partial pressure is currently in the experimental stage, and research continues in an effort to transfer this technology to actual mineral separations.

A new dimension has been added to conventional magnetic separation technology. Separation depends on differences in the forces exerted on mineral particles by a magnetic field owing to differences in inherent magnetic properties of the minerals. Improved particle separating has recently been achieved by selective coating of nonmagnetic minerals or metallic particles with colloidal, chemically precipitated magnetite followed by magnetic separation.[35] The selective adherence of the coating to a particular mineral is obtained by controlling the surface properties of the particles. Mixtures that have been separated thus far include phosphate-carbonate, quartz-fluorite, and metallic lead-copper.

Health and Safety.—Preliminary injury statistics compiled by the Mine Safety and Health Administration revealed the 1984 nonfatal injury rate to be 4.81 per 200,000 employee hours in metal and nonmetal mines, close to the 4.86 rate of 1983. The fatal injury rate was 0.06, up from 0.05 in 1983.

Bureau of Mines reports have been released on two advances in the use of radar to detect hazardous ground conditions ahead of mining.[36] The first is an improvement of the borehole radar probe (BRP), which now can detect the direction of potential hazards, not simply their proximity. The second is a "synthetic pulse" radar (SPR) device for detecting underground mining hazards. Both devices are aimed at improving the detection of geologic anomalies such as faults or water-filled cavities and a variety of manufactured features that could endanger miners at underground working faces. The use of radar to spot hazardous conditions before they are encountered will allow timely changes in mine planning or appropriate safety measures to prevent accidents. Although both devices were developed for use in coal mines, they are just as applicable in metal and nonmetal mines. Their full potential has not yet been realized, since an upper limit on penetration distances is not known. BRP sends electromagnetic pulses into rock strata, and records and analyzes the reflected waves to detect geologic irregularities at distances up to 100 feet. SPR sends one frequency at a time into rock strata, and after a series of different frequencies have been transmitted, their response times are synthesized into a reconstructed pulse similar to the wave form of short-pulse radar; transmission distances in excess of 100 feet have been achieved thus far.

An encapsulated chemical rock splitter has been developed by FOSROC International Ltd. of England for application in the mining industry.[37] Although breakage from pressure induced by chemical hydration has been known for some time, the FOSROC splitter adds a new feature with its capsulated form. After soaking in water, the splitter is inserted in the drill hole and rammed forcibly inward, completely filling the hole and maximizing the chemical reaction's destructive forces. Alternatively, the chemical can be used in bulk powder form by mixing the powder with water and pouring down the hole. In either case, the splitting technique is useful in mining situations where blasting is dangerous, such as near transformers or electric cables, since the reaction safely fragments rock without the danger of flying fragments.

According to a Bureau of Mines study, methane gas hazards exist in a number of domestic mines that include Louisiana salt mines and Colorado oil shale mines.[38] Most of the salt mines have experienced gas outbursts in face areas during blasting, and some oil shale mines have had significant methane releases during blasting. Although methane emissions in face areas are clearly safety hazards, little was known about how released methane mixed with air at the face, how fast it mixed, or how rapidly its concentration was diluted to safe levels as the gas cloud traveled away from the face and through return airways. The Bureau found that a tracer gas, sulfur hexafluoride (SF_6), could shed light on these unknown behavior factors. The gas was used to simulate a cloud of methane gas so that downstream concentrations and distances could be evaluated. The readings that were obtained served as the basis for developing guidelines to select methane monitor locations and to decide where permissible equipment is needed, thus giving mine operators the opportunity to better control potential gas hazard problems.

The Bureau of Mines has developed a "roof sounder" device that provides a quantitative measure of roof rock stability in underground mines. The age-old qualitative method of tapping the roof and listening to the pitch of the resulting sound depends on a miner's experience to equate pitch with some degree of stability, and to accurately repeat the tapping action. The device replaces a miner's subjective approach with an objective, repeatable numerical measure of any instability in the overhead rock. The roof sounder operates on the well-known notion that unstable rock resonates at lower frequencies and for a longer time than does stable, solid rock. The sounder is also insensitive to background noise and nearby mining equipment, thus adding to the reliability of its readings. Besides providing quantitative information on roof rock, it offers miners additional safety because, unlike the currently used tapping method, it allows a miner to stand away from the area to be tested.

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[1]Staff engineer, Twin Cities Research Center. Statistical data compiled by Stephen D. Smith, Supervisory mineral data assistant, Division of Ferrous Metals.

[2]Gardner, J. V. Program EEZ-SCAN: A Reconnaissance View of the Western U.S. Exclusive Economic Zone. U.S. Geol. Surv. Circ. 938, 1984, pp. 125-132.

[3]Hood, P. Mineral Exploration: Trends and Developments in 1984. Can. Min. J., v. 106, No. 1, 1985, pp. 14-41.

[4]Mining Journal (London). New South African Hydraulic Rockdrill Boosts Output. V. 303, No. 7778, 1984, pp. 180-181.

[5]Wilson, W. W. Changes in Mine Financing Forecast. Amer. Min. Cong. J., v. 70, No. 21, Nov. 1984, p. 12.

[6]Dayton, S. H. Golden Sunlight Sheds Warming Rays on Placer U.S. Eng. and Min. J., v. 185, No. 7, 1984, pp. 34-36.

[7]Mining and Processing Equipment. Lead/Zinc Sets Record With New Drills. V. 9, No. 12, 1984, p. 7.

[8]The Mining Record Co. (Denver). The Mining Record. Announcing the Tround Blast Hole Drilling System. Dec. 5, 1984, p. 16.

[9]Engineering and Mining Journal. Two Drilling Handbooks. V. 185, No. 12, 1984, p. 54.

[10]World Mining Equipment. Ways To Cut Earthmoving Costs. June 1984, p. 21.

[11]Engineering and Mining Journal. Sunshine's New Sixteen-to-One Silver Mine. V. 185, No. 5, 1984, pp. 46-50.

[12]———. New Machines Designed for Bulk Mining. V. 185, No. 12, 1984, p. 56.

[13]———. New Drill Rig Is Designed To Provide Unmatched Longhole Versatility. V. 185, No. 3, 1984, p. 111.

[14]Robertson, J. L. Expansion Doubles Output. Rock Prod., v. 87, No. 5, 1984, pp. 34-37.

[15]Pit and Quarry. "Mechatronics"—Emerging High Technology for Earth-Moving Equipment? V. 77, No. 3, 1984, pp. 60-62.

[16]Engineering and Mining Journal. New Crushers Feature Unique Cost-Saving Geometry. V. 185, No. 3, 1984, p. 112.

[17]Robertson, J. L., and L. Penny. Portable Plants on Parade. Rock Prod., v. 87, No. 10, 1984, p. 51.

[18]Robertson, J. L. In-Pit Crusher Cuts Truck Haul. Rock Prod., v. 87, No. 8, 1984, pp. 40-42.

[19]Pit and Quarry. "Experimental" Machine Cuts Limestone and Costs at Weber Stone Quarry. V. 76, No. 12, 1984, pp. 64-67.

[20]Sassos, M. P. Reserve's Mine Management System. Eng. and Min. J., v. 185, No. 9, 1984, pp. 42-49.

[21]Frizzell, E. M., and T. W. Martin. Mine-Run-Rock and High-Angle Conveyors Increase Mining Efficiences. Min. Eng., v. 36, No. 10, 1984, pp. 1407-1412.

[22]Engineering and Mining Journal. Economic Advantages Cited for New Loader Attachment. V. 185, No. 6, 1984, p. 89.

[23]Lewis, A. (ed.). The Comeback of California Placers. Eng. and Min. J., v. 185, No. 2, 1984, pp. 36-39.

[24]North American Gold Mining Industry News (Wilsonville, OR, and Vancouver, British Columbia, Canada). Switch to Open Pit of Vanderbilt's Morning Star Advancing. V. 2, No. 21, Nov. 9, 1984, p. 10.

[25]Savanick, G. A. Borehole Mining of Deep Phosphate Ore in St. John's County, Florida. Min. Eng., v. 37, No. 2, 1985, pp. 144-148.

[26]Hjelmstad, K. E. Effect of Clay Stabilizers on Permeability of Clayey Ore. BuMines RI 8902, 1984, 13 pp.

[27]Dopson, G. W., and P. A. Korpi. The ASL System, Operation Update 1978-1984. Magma Copper Co., San Manuel, AZ; available from G. W. Dopson, Magma Copper Co., San Manuel, AZ.

[28]Iwasaki, I., K. A. Natarajan, S. C. Riemen, and J. N. Orlich. Corrosive and Abrasive Wear in Ore Grinding (Proc. Internat. Conf. Wear of Mater., Vancouver, British Columbia, Canada, Apr. 14-18, 1985, sponsored by Amer. Soc. Mech. Eng.). Elsevier Sequoia, Netherlands, v. 103, 1985, pp. 253-267.

[29]Adam, K., and I. Iwasaki. Pyrrhotite-Grinding Media Interaction and Its Effect on Floatability at Different Applied Potentials. Soc. Eng. AIME, preprint No. 84-9, 1984.

[30]Cooper, F. D. Mining and Quarrying Trends in the Metal and Nonmetal Industries. Ch. in BuMines Minerals Yearbook 1980, v. 1, p. 34.

[31]Crozier, R. D. Plant Reagents. Part 1: Changing Patterns in the Supply of Flotation Reagents. Min. Mag., Sept. 1984, p. 202.

[32]Zipperian, D. E. Charecteristics of Column Flotation Utilizing Aspirated Aeration. Soc. Min. Eng. AIME, preprint No. 84-394, 1984.

[33]Wills, B. A. Automatic Control of Flotation. Eng. and Min. J., June 1984, p. 62.

[34]Gebhardt, J. E., N. F. Dewsnap, and P. E. Richardson. Electrochemical Conditioning of a Mineral Particle Bed Electrode for Flotation. BuMines RI 8951, 1985.

[35]Parsonage, P. Selective Magnetic Coating for Mineral Separation. Inst. Min. and Metall. Trans., Sec. C, v. 93, Mar. 1984, p. C37.

[36]U.S. Department of the Interior, Bureau of Mines. Radar Technology Promises Better Detection of Geologic Hazards for Miners. News Release, Sept. 27, 1984.

[37]Mining Journal. Chemical Rock Splitter. V. 303, No. 7787, 1984, p. 344.

[38]Cecala, A. B., et al. How Gassy Noncoal Mines Can Simulate Methane Flow. Eng. and Min. J., v. 185, No. 2, 1984, pp. 51-52.

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:									
1979	580	1,350	1,930	93	10	103	673	1,360	2,030
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
Nonmetals:									
1979	2,360	590	2,950	81	([2])	81	2,440	590	3,040
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
Total metals and nonmetals:[1]									
1979	2,940	1,940	4,880	174	10	185	3,120	1,950	5,070
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

[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 because of biennial canvassing.

Table 2.—Material handled at surface and underground mines[1] in the United States in 1983, 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	1,620	5,990	7,610	--	--	--	1,620	5,990	7,610
Copper	175,000	258,000	433,000	21,400	1	21,400	196,000	258,000	455,000
Gold:									
Lode	28,800	79,000	108,000	2,920	1,570	4,490	31,800	80,600	112,000
Placer	8,560	8,820	17,400	W	W	W	8,560	8,820	17,400
Iron ore	128,000	77,200	205,000	W	W	W	128,000	77,200	205,000
Lead	W	--	W	8,410	2,270	10,700	8,410	2,270	10,700
Silver	4,530	6,570	11,100	4,920	956	5,880	9,450	7,530	17,000
Titanium (ilmenite)	W	W	W	--	--	--	W	W	W
Tungsten	W	--	W	253	50	303	253	50	303
Uranium	8,470	75,500	84,000	1,760	604	2,370	10,200	76,100	86,300
Zinc	--	--	--	5,700	566	6,270	5,700	566	6,270
Other[3]	25,500	45,600	71,000	1,650	319	1,970	27,200	45,900	73,100
Total metals[2]	380,000	557,000	938,000	47,100	6,330	53,400	427,000	564,000	991,000
NONMETALS									
Abrasives[4]	219	89	308	W	W	W	219	89	308
Asbestos	W	W	W	--	--	--	W	W	W
Barite	726	356	1,080	--	--	--	726	356	1,080
Clays	40,600	e35,200	75,800	W	W	W	40,600	e35,200	75,800
Diatomite	869	--	869	--	--	--	869	--	869
Feldspar	1,030	237	1,260	--	--	--	1,030	237	1,260
Fluorspar	W	W	W	141	34	175	141	34	175
Gypsum	10,100	4,830	15,000	2,820	--	2,820	13,000	4,830	17,800
Mica (scrap)	777	375	1,150	--	--	--	777	375	1,150
Perlite	608	1,120	1,720	--	--	--	608	1,120	1,720
Phosphate rock	141,000	34,400	176,000	W	W	W	141,000	34,400	176,000
Potassium salts	--	--	--	13,800	146	13,900	13,800	146	13,900
Pumice[5]	503	--	503	--	--	--	503	--	503

Salt	213	--	213	9,930	--	9,930	10,100	--	10,100
Sand and gravel[6]	27,000	--	27,000	--	--	--	27,000	--	27,000
Sodium carbonate (natural)	--	--	--	6,740	245	6,980	6,740	245	6,480
Stone:									
Crushed and broken	840,000	[e]68,800	909,000	27,900	[e]196	28,100	868,000	[e]69,100	937,000
Dimension	[e]2,590	[e]1,370	3,960	16	--	16	[e]2,610	[e]1,370	3,980
Talc, soapstone, pyrophyllite	1,030	3,790	4,820	W	W	W	1,030	3,790	4,820
Other[7]	3,370	4,380	7,750	390	15	404	3,706	4,390	8,150
Total nonmetals[2]	1,070,000	155,000	1,230,000	61,800	632	62,400	1,130,000	155,000	1,290,000
Grand total[2]	1,450,000	712,000	2,160,000	109,000	6,970	116,000	1,560,000	719,000	2,280,000

[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, 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 industrial sand and gravel. Construction sand and gravel data were not available for 1983 because of biennial canvassing.
[7]Includes aplite, boron minerals, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, olivine, vermiculite, wollastonite, and nonmetal items indicated by symbol W.

Table 3.—Material handled at surface and underground mines[1] (including industrial sand and gravel and stone) in the United States in 1983, 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	23,500	3,390	26,900	W	W	W	23,500	3,390	26,900
Alaska	6,400	9,140	15,500	W	W	W	6,400	9,140	15,500
Arizona	120,000	126,000	246,000	19,500	1	19,500	140,000	126,000	265,000
Arkansas	16,000	10,000	26,000	--	--	--	16,000	10,000	26,000
California	47,700	11,000	58,700	520	65	584	48,200	11,000	59,300
Colorado	8,330	15,500	23,800	964	319	1,280	9,290	15,800	25,100
Connecticut	7,980	727	8,700	--	--	--	7,980	727	8,700
Florida	208,000	40,000	248,000	--	--	--	208,000	40,000	248,000
Georgia	50,100	10,400	60,400	W	W	W	50,100	10,400	60,400
Hawaii	5,540	454	6,000	W	W	W	5,540	454	6,000
Idaho	8,300	18,500	26,800	907	387	1,290	9,200	18,900	28,100
Illinois	46,000	4,200	50,200	1,950	46	1,990	47,900	4,250	52,200
Indiana	24,300	2,570	26,900	1,870	6	1,880	26,200	2,570	28,700
Iowa	24,700	2,390	27,100	2,310	13	2,320	27,100	2,410	29,500
Kansas	12,500	1,590	14,100	2,660	8	2,660	15,200	1,600	16,800
Kentucky	24,700	2,660	27,400	9,470	69	9,540	34,200	2,730	36,900
Louisiana	6,710	927	7,640	4,100	--	4,100	10,800	927	11,700
Maine	906	111	1,020	--	--	--	906	111	1,020
Maryland	19,600	2,010	21,600	W	W	W	19,600	2,010	21,600
Massachusetts	8,170	900	9,070	--	--	--	8,170	900	9,070
Michigan	61,000	49,100	110,000	W	W	W	61,000	49,100	110,000
Minnesota	104,000	32,300	136,000	--	--	--	104,000	32,200	136,000
Mississippi	3,160	1,390	4,550	--	--	--	3,160	1,390	4,550
Missouri	38,300	4,350	42,700	13,000	2,270	15,200	51,300	6,620	57,900
Montana	14,300	7,440	21,800	3,670	18	3,690	18,000	7,460	25,400
Nebraska	3,490	415	3,910	1,120	8	1,130	4,610	423	5,030
Nevada	29,000	81,000	111,000	654	1,210	1,870	29,700	83,000	113,000
New Hampshire	1,080	154	1,240	W	W	W	1,080	154	1,240
New Jersey	14,800	1,060	15,800	W	W	W	14,800	1,060	15,800
New Mexico	27,400	48,100	75,500	15,100	780	15,900	42,500	48,900	91,400
New York	32,900	2,970	35,900	3,690	W	3,690	36,600	2,970	39,600
North Carolina	42,500	5,200	47,700	--	--	--	42,500	5,200	47,700
North Dakota	W	W	W	--	--	--	W	W	W
Ohio	36,100	4,200	40,300	1,900	W	1,900	38,000	4,200	42,200
Oklahoma	27,000	2,700	29,700	W	W	W	27,000	2,700	29,700
Oregon	13,500	1,240	14,800	3	3	6	13,500	1,240	14,800

Pennsylvania	51,600	4,950	56,600	2,150	19	2,170	53,800	4,970	58,800
Rhode Island	971	80	1,050	--	--	--	971	80	1,050
South Carolina	18,700	2,960	21,700	--	--	--	18,700	2,960	21,700
South Dakota	4,550	896	5,440	W	W	W	4,550	896	5,440
Tennessee	32,100	3,240	35,300	9,040	339	9,380	41,100	3,580	44,700
Texas	89,300	12,400	102,000	857	4	861	90,200	12,400	103,000
Utah	41,100	101,000	143,000	717	560	1,280	41,700	102,000	144,000
Vermont	2,630	806	3,440	W	W	W	2,630	806	3,440
Virginia	39,900	4,230	44,100	W	W	W	39,900	4,230	44,100
Washington	11,600	1,350	12,900	W	24	24	11,600	1,380	12,900
West Virginia	8,810	977	9,790	1,880	13	1,890	10,700	990	11,700
Wisconsin	14,800	1,190	16,000	W	W	W	14,800	1,190	16,000
Wyoming	10,400	73,200	83,500	6,900	W	6,900	17,200	73,200	90,400
Undistributed	6,290	659	6,950	3,900	806	4,800	10,280	1,470	11,700
Total[2 3]	1,450,000	712,000	2,160,000	109,000	6,970	116,000	1,560,000	719,000	2,280,000

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 1983

(Value per ton)

Ore	Surface: Principal mineral product	Surface: By-product	Surface: Total	Underground: Principal mineral product	Underground: By-product	Underground: Total	All mines: Principal mineral product	All mines: By-product	All mines: Total
METALS									
Bauxite	$6.98	$23.48	$30.46	--	--	--	$6.98	$23.48	$30.46
Copper	8.51	1.61	10.12	$9.93	$3.29	$13.22	8.67	1.79	10.46
Gold:									
Lode	24.54	2.10	26.64	52.69	14.00	66.69	28.18	3.64	31.82
Placer	2.30	.01	2.31	--	--	--	2.30	.01	2.31
Iron ore	14.56	W	14.56	W	W	W	14.56	W	14.56
Lead	--	--	--	23.57	13.28	36.85	23.57	13.28	36.85
Silver	7.15	4.62	11.77	61.23	10.44	71.67	35.15	7.63	42.78
Titanium (ilmenite)	1.42	1.47	2.89	--	--	--	1.42	1.47	2.89
Tungsten	W	--	W	33.30	W	33.30	33.30	W	33.30
Uranium	20.62	--	20.62	81.46	9.62	91.08	31.52	1.72	33.24
Zinc	--	--	--	31.83	W	31.83	31.83	W	31.83
Average[1]	11.56	1.09	12.65	27.47	6.24	33.71	13.38	1.68	15.06
NONMETALS									
Asbestos	16.13	--	16.13	--	--	--	16.13	--	16.13
Barite	33.40	W	33.40	--	--	--	33.40	W	33.40
Clays	22.69	--	22.69	W	--	W	22.69	--	22.69
Diatomite	117.86	--	117.86	--	--	--	117.86	--	117.86
Feldspar	20.74	66.31	87.05	--	--	--	20.74	66.31	87.05
Fluorspar	W	--	W	72.67	W	72.67	72.67	W	72.67
Gypsum	8.79	--	8.79	7.25	--	7.25	8.45	--	8.45
Mica (scrap)	6.87	--	6.87	--	--	--	6.87	--	6.87
Perlite	14.49	--	14.49	--	--	--	14.49	--	14.49
Phosphate rock	6.75	--	6.75	W	--	W	6.75	--	6.75
Potassium salts	--	--	--	12.90	--	12.90	12.90	--	12.90
Pumice	5.18	--	5.18	--	--	--	5.18	--	5.18

Salt	17.77	W	17.77	14.73	2.61	17.34	14.80	2.61	17.41
Sand and gravel[2]	11.12	1.32	12.44	--	--	--	11.12	1.32	12.44
Sodium carbonate (natural)	--	--	--	76.35	--	76.35	76.35	--	76.35
Stone:									
Crushed and broken	3.82	--	3.82	5.24	W	5.24	3.86	W	3.86
Dimension	56.00	W	56.00	267.85	--	267.85	57.32	W	57.32
Talc, soapstone, pyrophyllite	16.94	--	16.94	W	--	W	16.94	--	16.94
Average[1]	5.54	.11	5.65	16.66	.48	17.14	6.14	.13	6.27
Average, metals and nonmetals[1]	7.08	.36	7.44	21.40	3.01	24.41	8.09	.55	8.64
Average, nonmetals (excluding stone and sand and gravel)[1]	11.02	.37	11.39	26.02	.81	26.83	13.07	.43	13.50
Average, metals and nonmetals (excluding stone and sand and gravel)[1]	11.40	.83	12.23	26.87	4.00	30.87	13.31	1.22	14.53

W Withheld to avoid disclosing company proprietary data.
[1]Includes unpublished data.
[2]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1983 because of biennial canvassing.

Table 5.—Crude ore and total material handled at surface and underground mines in the United States in 1983, by commodity

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Antimony	--	100.0	6.5	93.5
Bauxite	100.0	--	100.0	--
Beryllium	100.0	--	100.0	--
Copper	89.1	10.9	95.3	4.7
Gold:				
Lode	90.8	9.2	96.0	4.0
Placer	100.0	--	100.0	--
Iron ore	98.9	1.1	99.3	.7
Lead	W	[1]100.0	W	[1]100.0
Manganiferous ore	100.0	--	100.0	--
Mercury	100.0	--	100.0	--
Molybdenum	[2]100.0	W	[2]100.0	W
Nickel	--	--	--	--
Platinum	100.0	--	100.0	--
Rare-earth metals	100.0	--	100.0	--
Silver	47.9	52.1	65.4	34.6
Titanium (ilmenite)	100.0	--	100.0	--
Tungsten	W	[1]100.0	W	[1]100.0
Uranium	82.8	17.2	97.3	2.7
Vanadium	--	--	--	--
Zinc	--	100.0	--	100.0
Average	89.0	11.0	94.6	5.4
NONMETALS				
Abrasives	--	--	--	--
Aplite	100.0	--	100.0	--
Asbestos	100.0	--	100.0	--
Barite	100.0	--	100.0	--
Boron minerals	--	--	--	--
Clays	[2]100.0	W	[2]100.0	W
Diatomite	100.0	--	100.0	--
Feldspar	100.0	--	100.0	--
Fluorspar	W	[1]100.0	W	[1]100.0
Gypsum	78.2	21.8	84.1	15.9
Iron oxide pigments (crude)	100.0	--	100.0	--
Kyanite	100.0	--	100.0	--
Lithium minerals	--	--	--	--
Magnesite	100.0	--	100.0	--
Mica (scrap)	100.0	--	100.0	--
Millstones	100.0	--	100.0	--
Olivine	100.0	--	100.0	--
Perlite	100.0	--	100.0	--
Phosphate rock	[2]100.0	W	[2]100.0	W
Potassium salts	--	100.0	--	100.0
Pumice	100.0	--	--	--
Salt	2.1	97.9	2.1	97.9
Sand and gravel[3]	100.0	--	100.0	--
Sodium carbonate (natural)	--	100.0	--	100.0
Stone:				
Crushed and broken	96.8	3.2	97.0	3.0
Dimension	99.4	.6	99.6	.4
Talc, soapstone, pyrophyllite	[2]100.0	W	[2]100.0	W
Vermiculite	100.0	--	100.0	--
Average	95.4	4.6	95.8	4.2
Average, metals and nonmetals	93.0	7.0	94.9	5.1

W Withheld to avoid disclosing company proprietary data; included with "Surface" or "Underground."

[1]Includes surface; the Bureau of Mines is not at liberty to publish separately.

[2]Includes underground; the Bureau of Mines is not at liberty to publish separately.

[3]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1983 because of biennial canvassing.

Table 6.—Crude ore and total material handled at surface and underground mines in the United States in 1983, by State

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	[1]100.0	W	[1]100.0	W
Alaska	100.0	--	100.0	--
Arizona	86.1	13.9	92.7	7.3
Arkansas	100.0	--	100.0	--
California	98.9	1.1	99.0	1.0
Colorado	89.6	10.4	94.9	5.1
Connecticut	100.0	--	100.0	--
Florida	100.0	--	100.0	--
Georgia	98.2	1.8	98.5	1.5
Hawaii	[1]100.0	W	[1]100.0	W
Idaho	90.1	9.9	95.4	4.6
Illinois	95.9	4.1	96.2	3.8
Indiana	92.9	7.1	93.5	6.5
Iowa	91.5	8.5	92.1	7.9
Kansas	82.5	17.5	84.1	15.9
Kentucky	72.3	27.7	74.2	25.8
Louisiana	98.1	1.9	98.1	1.9
Maine	100.0	--	100.0	--
Maryland	[1]100.0	W	[1]100.0	W
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	74.7	25.3	73.7	26.3
Montana	79.6	20.4	85.5	14.5
Nebraska	75.8	24.2	77.6	22.4
Nevada	97.8	2.2	98.3	1.7
New Hampshire	[1]100.0	W	[1]100.0	W
New Jersey	[1]100.0	W	[1]100.0	W
New Mexico	64.5	35.5	82.7	17.3
New York	89.9	10.1	90.1	9.9
North Carolina	100.0	--	100.0	--
North Dakota	100.0	--	100.0	--
Ohio	95.0	5.0	95.0	5.0
Oklahoma	[1]100.0	W	[1]100.00	W
Oregon	100.0	--	100.0	--
Pennsylvania	96.0	4.0	96.3	3.7
Rhode Island	100.0	--	100.0	--
South Carolina	100.0	--	100.0	--
South Dakota	[1]100.0	W	[1]100.0	W
Tennessee	78.0	22.0	79.0	21.0
Texas	99.1	.9	99.2	.8
Utah	98.3	1.7	99.1	.9
Vermont	[1]100.0	W	[1]100.0	W
Virginia	[1]100.0	W	[1]100.0	W
Washington	99.5	.5	99.3	.7
West Virginia	82.4	17.6	83.8	16.2
Wisconsin	[1]100.0	W	[1]100.0	W
Wyoming	60.0	40.0	92.1	7.9
Average	93.0	7.0	94.9	5.1

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.

Table 7.—Number of domestic metal and nonmetal mines[1] in the United States in 1983, 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	8	--	--	3	5	--	--
Copper	26	2	1	3	2	12	6
Gold:							
Lode	87	35	13	12	19	7	1
Placer	34	8	10	10	4	2	--
Iron ore	23	--	3	5	1	9	5
Lead	16	4	2	1	3	6	--
Silver	52	26	9	7	7	3	--
Titanium (ilmenite)	3	--	--	--	--	3	--
Tungsten	8	5	1	1	1	--	--
Uranium	102	19	26	35	21	1	--
Zinc	13	1	--	3	7	2	--
Other[2]	17	3	5	5	2	2	--
Total	389	103	70	85	72	47	12
NONMETALS							
Abrasives[3]	14	2	7	4	1	--	--
Asbestos	3	--	--	1	1	1	--
Barite	15	1	3	8	3	--	--
Clays	936	42	276	513	105	--	--
Diatomite	10	--	3	4	3	--	--
Feldspar	16	--	2	10	4	--	--
Fluorspar	5	2	2	--	1	--	--
Gypsum	70	2	6	26	36	--	--
Mica (scrap)	11	1	2	5	3	--	--
Perlite	12	--	4	6	2	--	--
Phosphate rock	38	--	--	4	15	15	4
Potassium salts	6	--	--	1	1	4	--
Pumice	23	4	10	7	2	--	--
Salt	18	--	2	4	7	5	--
Sand and gravel[4]	169	4	15	83	66	1	--
Sodium carbonate	5	--	--	--	2	3	--
Stone:							
Crushed and broken	3,851	115	430	1,603	1,546	157	--
Dimension	298	75	152	68	3	--	--
Talc, soapstone, pyrophyllite	32	4	7	18	3	--	--
Other[5]	31	11	4	12	4	--	--
Total	5,563	263	925	2,377	1,808	186	4
Grand total	5,952	366	995	2,462	1,880	233	16

[1]Excludes wells, ponds, or pumping operations.

[2]Includes antimony, beryllium, manganiferous ore, mercury, molybdenum, platinum-group metals, rare-earth metals, and tin.

[3]Includes abrasive stone, emery, garnet, and tripoli.

[4]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1983 because of biennial canvassing.

[5]Includes aplite, boron minerals, greensand marl, iron oxide pigments (crude), kyanite, magnesite, olivine, vermiculite, and wollastonite.

Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1983, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
		METALS		
Morenci	Arizona	Phelps Dodge Corp	Copper	Open pit.
Utah Copper	Utah	Kennecott	do	Do.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Sierrita	Arizona	Duval Sierrita Corp	Copper	Do.
Bagdad	do	Cyprus Bagdad Copper Co	do	Do.
San Manuel	do	Magma Copper Co	do	Caving.
Empire	Michigan	Empire Iron Mining	Iron ore	Open pit.
Hibbing Taconite	Minnesota	Pickands Mather & Co	do	Do.
Round Mountains	Nevada	Copper Range Co	Lode gold	Do.
Tilden	Michigan	Tilden Mining Co	Iron ore	Do.
Chino	New Mexico	Chino Mines Co	Copper	Do.
Thunderbird	Minnesota	Oglebay Norton Co	Iron ore	Do.
Tyrone	New Mexico	Phelps Dodge Corp	Copper	Do.
Green Cove	Florida	Associated Minerals Corp	Titanium	Dredging.
New Cornelia	Arizona	Phelps Dodge Corp	Copper	Open pit.
Minorca	Minnesota	Inland Steel Mining Co	Iron ore	Do.
Inspiration	Arizona	Inspiration Consolidated Copper Co.	Copper	Do.
Trail Ridge	Florida	E. I. du Pont de Nemours & Co. Inc.	Titanium	Dredging.
Berkeley pit	Montana	The Anaconda Company	Copper	Open pit.
Eisenhower	Arizona	ASARCO Incorporated	do	Do.
Highland	Florida	E. I. du Pont de Nemours & Co. Inc.	Titanium	Dredging.
National Pellet Project-Itasca.	Minnesota	The Hanna Mining Co	Iron ore	Open pit.
Erie Commercial	do	Pickands Mather & Co	do	Do.
National Pellet Project-St.Louis.	do	The Hanna Mining Co	do	Do.
Butler Taconite	do	do	do	Do.
		NONMETALS[2]		
Ft. Green	Florida	Williams Co	Phosphate rock.	Open pit.
Noralyn	do	International Minerals & Chemical Corp.	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Clear Spring	do	do	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Hookers	do	W. R. Grace & Co	do	Do.
Ft. Meade	do	Gardinier Inc	do	Do.
Lonesome	do	American Cyanamid Co	do	Do.
Suwanee, et al	do	Occidental Petroleum Corp	do	Do.
Georgetown	Texas	Texas Crushed Stone Co	Stone	Open quarry.
FEC Hialea	Florida	Rinker Materials Corp	do	Do.
Calcite	Michigan	United States Steel Corp	do	Do.
Bonny Lake	Florida	W. R. Grace & Co	Phosphate rock.	Open pit.
Thornton	Illinois	General Dynamics Corp	Stone	Quarry.
International	New Mexico	International Minerals & Chemical Corp.	Potassium salts.	Stopes.
McCook	Illinois	Vulcan Materials Co	Stone	Open quarry.
Wingate Creek	Florida	Becker Industries Corp	Phosphate rock.	Open pit.
Stoneport	Michigan	Presque Isle Corp	Stone	Open quarry.
New Braunfels	Texas	Parker Bros. & Co. Inc	do	Do.
Pennsuco	Florida	Lone Star Florida Inc	Phosphate rock.	Open pit.
Lee Creek	North Carolina	Texasgulf Inc	do	Do.
Hardee	Florida	C. F. Mining Corp	do	Do.
Norcross	Georgia	Vulcan Materials Co	Stone	Open quarry.
Brooksville	Florida	Florida Crushed Stone Co	do	Do.

[1]Excludes brines and materials from wells.
[2]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1983 because of biennial canvassing.

Table 9.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1983, in order of output of total materials handled

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott	Copper	Open pit.
Morenci	Arizona	Phelps Dodge Corp	do	Do.
Bagdad	do	Cyprus Bagdad Copper Co.	do	Do.
Empire	Michigan	Empire Iron Mining	Iron ore	Do.
Inspiration	Arizona	Inspiration Consolidated Copper Co.	Copper	Do.
Tyrone	New Mexico	Phelps Dodge Corp	do	Do.
Chino	do	Chino Mines Co	do	Do.
Sierrita	Arizona	Duval Sierrita Corp	do	Do.
Minntac	Minnesota	United States Steel Corp	Iron ore	Do.
Hibbing Taconite	do	Pickands Mather & Co.	do	Do.
Tonopah	Nevada	The Anaconda Company	Molybdenum	Do.
Thunderbird	Minnesota	Oglebay Norton Co	Iron ore	Do.
San Manuel	Arizona	Magma Copper Co	Copper	Caving and open pit.
Tilden	Michigan	Tilden Mining Co	Iron ore	Open pit.
Round Mountains	Nevada	Copper Range Co	Lode gold	Do.
Battle Mountain	do	Duval Corp.	do	Do.
Shirley Basin	Wyoming	Pathfinder Mines Corp	Uranium	Do.
Mission	Arizona	ASARCO Incorporated	Copper	Do.
Eisenhower	do	do	do	Do.
Trail Ridge	Florida	E. I. du Pont de Nemours & Co. Inc.	Titanium	Dredging.
Rock Hill-Red Horse	Wyoming	Union Carbide Corp	Uranium	Open pit.
Bear Creek	do	Rocky Mountain Energy Co.	do	Do.
Ray Pit	Arizona	Kennecott	Copper	Do.
Highland	Florida	E. I. du Pont de Nemours & Co. Inc.	Titanium	Dredging.
Climax	Colorado	Climax Molybdenum Co., a division of AMAX Inc.	Molybdenum	Caving and open pit.
		NONMETALS[2]		
Ft. Meade	Florida	Gardinier Inc	Phosphate rock.	Open pit.
Ft. Green	do	Williams Co	do	Do.
Noralyn	do	International Minerals & Chemical Corp.	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Clear Spring	do	do	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Hookers	do	W. R. Grace & Co	do	Do.
Lonesome	do	American Cyanamid Co	do	Do.
Georgetown	Texas	Texas Crushed Stone Co	Stone	Open quarry.
Suwannee, et al	Florida	Occidental Petroleum Corp	Phosphate rock.	Open pit.
Hardee	do	C. F. Mining Corp	do	Do.
FEC Hialea	do	Rinker Materials Corp	Stone	Open quarry.
Gay	Idaho	J. R. Simplot Co	Phosphate rock.	Open pit.
Calcite	Michigan	United States Steel Corp	Stone	Open quarry.
Thornton	Illinois	General Dynamics Corp	do	Do.
McCook	do	Vulcan Materials Co	do	Do.
International	New Mexico	International Minerals & Chemical Corp.	Potassium salts.	Stopes.
Bonny Lake	Florida	W. R. Grace & Co	Phosphate rock.	Open pit.
Stoneport	Michigan	Presque Isle Corp	Stone	Open quarry.
Wingate Creek	Florida	Becker Industries Corp	Phosphate rock.	Open pit.
Big Four	do	AMAX Phosphate Inc	do	Do.
New Braunfels	Texas	Parker Bros. & Co. Inc	Stone	Open quarry.
Pennsuco	Florida	Lone Star Florida Inc	Phosphate rock.	Open pit.
Lee Creek	North Carolina	Texasgulf Inc	do	Do.

[1]Excludes brines and materials from wells.
[2]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1983 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 1983, by commodity

Commodity	Surface: Ore treated (thousand short tons)	Surface: Marketable product (units)	Surface: Ratio of units of ore to units of marketable product	Underground: Ore treated (thousand short tons)	Underground: Marketable product (units)	Underground: Ratio of units of ore to units of marketable product	Total[2]: Ore treated (thousand short tons)	Total[2]: Marketable product (units)	Total[2]: Ratio of units of ore to units of marketable product
METALS									
Bauxite, thousand long tons	1,620	668	2.4:1	--	--	--	1,620	668	2.4:1
Copper, thousand short tons	175,000	971	179.9:1	21,900	142	154.1:1	197,000	1,110	176.6:1
Gold:									
Lode, thousand troy ounces	20,000	1,160	17.2:1	2,960	368	8.1:1	22,900	1,520	15.0:1
Placer, do.	8,570	47	184.1:1	--	--	--	8,570	47	184.1:1
Iron ore, thousand long tons	131,000	43,400	3.0:1	W	W	W	131,000	43,400	3.0:1
Lead, thousand short tons	--	--	--	8,300	451	18.4:1	8,300	451	18.4:1
Silver, thousand troy ounces	4,530	2,830	1.6:1	4,870	26,100	.1:1	9,400	28,900	.3:1
Titanium (ilmenite), thousand short tons	W	W	W	--	--	--	W	W	W
Uranium, do.	11,600	3	3,446.4:1	2,540	3	867.9:1	14,200	6	2,249.2:1
Zinc, do.	--	--	--	5,690	219	26.0:1	5,690	219	26.0:1
NONMETALS									
Asbestos, do.	W	W	W	--	--	--	W	W	W
Barite, do.	870	751	1.1:1	--	--	--	870	751	1.1:1
Clays, do.	40,700	40,500	1.0:1	W	W	W	40,700	40,500	1.0:1
Diatomite, do.	970	619	1.5:1	--	--	--	970	619	1.5:1
Feldspar, do.	1,010	655	1.5:1	--	--	--	1,010	655	1.1:1
Fluorspar, do.	W	W	W	141	59	2.3:1	141	59	2.3:1
Gypsum, do.	10,700	10,100	1.1:1	2,820	2,820	1.0:1	13,500	12,900	1.1:1
Mica (scrap), do.	737	100	7.3:1	--	--	--	737	100	7.3:1
Perlite, do.	1,080	474	2.2:1	--	--	--	1,080	474	2.2:1
Phosphate rock, do.	150,000	46,700	3.2:1	W	W	W	150,000	46,700	3.2:1
Potassium salts, do.	--	--	--	13,500	1,410	9.6:1	13,500	1,410	9.6:1
Pumice, do.	866	449	1.9:1	--	--	--	866	449	1.9:1
Salt, do.	220	251	.8:1	9,930	9,690	1.0:1	10,200	9,940	1.0:1
Sand and gravel[3], do.	27,000	23,900	1.1:1	--	--	--	27,000	23,900	1.1:1
Sodium carbonate (natural), do.	--	--	--	6,740	6,740	1.0:1	6,740	6,740	1.0:1
Stone:									
Crushed and broken, do.	840,000	840,000	1.0:1	27,900	27,500	1.0:1	868,000	867,000	1.0:1
Dimension, do.	e2,590	1,170	2.2:1	e16	16	1.0:1	e2,610	1,190	2.1:1
Talc, soapstone, pyrophyllite, do.	1,060	984	1.0:1	W	W	W	1,060	984	1.0:1

[e]Estimated. 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.
[3]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1983 because of biennial canvassing.

Table 11.—Material handled per unit of marketable product at surface and underground mines[1] in the United States in 1983, 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	7,290	668	6.9:1	--	--	--	7,290	668	6.9:1
Copper ---- thousand short tons	433,000	971	446.0:1	21,400	142	151.1:1	455,000	1,110	408.5:1
Gold:									
Lode ---- thousand troy ounces	108,000	1,160	78.2:1	4,490	368	8.4:1	112,000	1,520	61.3:1
Placer ---- do	17,400	47	281.5:1	--	--	--	17,400	47	281.5:1
Iron ore ---- thousand long tons	203,000	43,400	4.2:1	W	W	W	203,000	43,400	4.2:1
Lead ---- thousand short tons	W	--	W	10,700	451	19.4:1	10,700	451	19.4:1
Silver ---- thousand troy ounces	11,100	2,830	3.9:1	5,880	26,100	.2:1	17,000	28,900	.6:1
Titanium (ilmenite) ---- thousand short tons	W	W	W	--	--	--	W	W	W
Uranium ---- do	84,000	3	13,545.1:1	2,370	3	680.5:1	86,300	6	7,572.3:1
Zinc ---- do	--	--	--	6,270	219	27.3:1	6,270	219	27.3:1
NONMETALS									
Asbestos ---- do	W	W	W	--	--	--	W	W	W
Barite ---- do	1,080	751	1.4:1	--	--	--	1,080	751	1.4:1
Clays ---- do	e76,000	40,500	1.9:1	W	W	W	e76,000	40,500	1.9:1
Diatomite ---- do	869	619	1.4:1	--	--	--	869	619	1.4:1
Feldspar ---- do	1,260	655	1.8:1	--	--	--	1,260	655	1.8:1
Fluorspar ---- do	W	W	W	175	59	2.4:1	175	59	2.4:1
Gypsum ---- do	15,000	10,100	1.2:1	2,820	2,820	1.0:1	17,800	12,900	1.2:1
Mica (scrap) ---- do	1,150	100	11.5:1	--	--	--	1,150	100	11.5:1
Perlite ---- do	1,730	474	2.2:1	--	--	--	1,730	474	2.2:1
Phosphate rock ---- do	176,000	46,700	3.8:1	W	W	W	176,000	46,700	3.8:1
Potassium salts ---- do	--	--	--	13,900	1,410	9.9:1	13,900	1,410	9.9:1
Pumice ---- do	503	449	1.1:1	--	--	--	503	449	1.1:1

Salt	do	213	251	.8:1	9,930	9,690	1.0:1	10,100	9,940	1.0:1
Sand and gravel[5]	do	27,000	23,900	1.1:1	--	--	--	27,000	23,900	1.1:1
Sodium carbonate (natural)	do	--	--	--	6,980	6,740	1.0:1	6,980	6,740	1.0:1
Stone:										
Crushed and broken	do	909,000	840,000	1.1:1	28,100	27,500	1.0:1	937,000	867,000	1.1:1
Dimension	do	3,960	1,170	3.4:1	16	16	1.0:1	3,980	1,190	3.3:1
Talc, soapstone, pyrophyllite	do	4,820	984	3.4:1	W	W	W	4,820	984	3.4:1

[e]Estimated. 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.
[5]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1983 because of biennial canvassing.

Table 12.—Mining methods used in open pit mining in the United States in 1983, by commodity

(Percent)

Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting[1]
METALS		
Bauxite	100	--
Copper	94	6
Gold:		
Lode	97	3
Placer	--	100
Iron ore	95	5
Manganiferous ore	--	100
Mercury	10	90
Molybdenum	92	8
Rare-earth metals	100	--
Silver	99	1
Titanium (ilmenite)	--	100
Tungsten	18	82
Uranium	48	52
NONMETALS		
Aplite	100	--
Asbestos	100	--
Barite	98	2
Clays	--	100
Diatomite	--	100
Feldspar	100	--
Fluorspar	100	--
Gypsum	94	6
Iron oxide pigments (crude)	--	100
Kyanite	100	--
Magnesite	100	--
Mica (scrap)	24	76
Millstones	99	1
Olivine	100	--
Perlite	59	41
Phosphate rock	78	22
Pumice	--	100
Salt	--	100
Sand and gravel[2]	--	100
Stone:		
Crushed and broken	98	2
Dimension	--	100
Talc, soapstone, pyrophyllite	68	32
Vermiculite	55	45
Average	83	17

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

[2]Includes industrial sand and gravel. Construction sand and gravel data were not available for 1983 because of biennial canvassing.

Table 13.—Development and exploration activity in the United States in 1983, by method

Method	Metals		Nonmetals		Total[1]	
	Feet	Percent of total[2]	Feet	Percent of total[2]	Feet	Percent of total[2]
DEVELOPMENT						
Shaft and winze sinking	218,000	27.5	W	W	218,000	26.4
Raising	74,600	9.4	W	W	74,600	9.1
Drifting, crosscutting, or tunneling	311,000	39.2	35,600	100.0	346,000	41.8
Solution mining	189,000	23.8	--	--	189,000	22.8
Total[1]	792,000	100.0	35,600	100.0	827,000	100.0
EXPLORATION						
Diamond drilling	747,000	19.6	137,000	97.5	883,000	22.3
Churn drilling	29,500	.8	--	--	29,500	.7
Rotary drilling	1,580,000	41.4	3,550	2.5	1,580,000	40.1
Percussion drilling	1,160,000	30.4	W	W	1,160,000	29.3
Other drilling	267,000	7.0	W	W	267,000	6.8
Trenching	32,600	.8	W	W	32,600	.8
Total[1]	3,810,000	100.0	140,000	100.0	3,950,000	100.0
Grand total[1]	4,610,000	XX	176,000	XX	4,780,000	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 1983, by commodity

(Feet)

Commodity	Development: Shaft and winze sinking	Development: Raising	Development: Drifting, crosscutting, or tunneling	Development: Solution mining	Development: Total[1]	Exploration: Diamond drilling	Exploration: Churn drilling	Exploration: Rotary drilling	Exploration: Percussion drilling	Exploration: Other drilling	Exploration: Trenching	Exploration: Total[1]
METALS												
Copper	--	--	220	--	220	23,900	--	12,400	650	W	--	36,900
Gold	217,000	10,200	55,300	W	282,000	239,000	3,000	148,000	238,000	10,200	18,100	655,000
Iron ore	--	--	5,070	--	5,070	W	--	W	--	--	--	W
Lead	--	674	36,000	--	36,000	108,000	20,600	W	--	55,200	--	183,000
Molybdenum	--	W	W	--	W	24,100	--	W	--	--	--	24,100
Silver	624	5,350	45,800	--	51,800	178,000	1,030	47,300	12,300	700	8,870	248,000
Tungsten	W	--	--	--	W	--	--	--	W	--	W	W
Uranium	--	4,800	86,600	173,000	264,000	64,900	W	1,000,000	439,000	198,000	200	1,710,000
Zinc	W	42,200	53,100	--	95,200	31,100	--	4,500	W	2,000	5,000	42,600
Other[2]	195	11,400	28,600	15,900	56,200	78,700	5,050	365,000	468,000	600	354	917,000
Total[1]	218,000	74,600	311,000	189,000	792,000	747,000	29,500	1,580,000	1,160,000	267,000	32,600	3,810,000
NONMETALS												
All nonmetals[3]	W	W	35,600	--	35,600	137,000	--	3,550	W	W	W	140,000
Grand total[1]	218,000	74,600	346,000	189,000	827,000	883,000	29,500	1,580,000	1,160,000	267,000	32,600	3,950,000

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 antimony, bauxite, beryllium, mercury, platinum-group metals, tin, titanium (ilmenite), and items indicated by symbol W.
[3]Includes abrasives, barite, boron minerals, clays, diatomite, fluorspar, perlite, phosphate rock, sodium carbonate (natural), sulfur, and talc, soapstone, and pyrophyllite.

Table 15.—Development and exploration in the United States in 1983, 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	--	--	130	--	130	49,600	1,600	8,830	W	--	3,300	63,300
Arizona	--	--	200	--	200	35,600	W	35,000	2,200	938	1,700	75,500
California	102	182	1,770	--	2,060	125,000	--	W	31,600	1,680	440	158,000
Colorado	W	9,510	34,800	--	44,300	140,000	--	38,400	10,500	12,700	W	201,000
Idaho	W	2,932	17,700	--	20,700	11,200	--	13,000	W	--	150	24,300
Missouri	--	--	37,300	--	37,300	30,100	20,600	--	--	43,100	--	93,700
Montana	28	96	5,760	--	5,890	61,600	W	49,500	W	860	1,400	113,000
Nevada	217,000	1,420	5,420	W	223,000	33,500	--	128,000	63,400	W	10,900	236,000
New Mexico	70	10,000	89,400	W	99,400	16,900	--	318,000	363,000	192,000	4,100	894,000
Oregon	50	200	520	--	770	--	--	W	W	W	1,980	1,980
Utah	W	W	28,200	--	28,200	44,200	1,030	130,000	82,200	W	W	258,000
Washington	W	W	3,140	--	3,140	W	--	--	1,710	--	100	1,810
Wyoming	--	--	W	14,500	14,500	W	--	342,000	--	--	--	342,000
Undistributed[2]	940	50,200	122,000	174,000	347,000	336,000	6,250	522,000	604,000	16,000	8,500	1,490,000
Total[1]	218,000	74,600	346,000	189,000	827,000	883,000	29,500	1,580,000	1,160,000	267,000	32,600	3,950,000

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, Illinois, Kentucky, Michigan, Minnesota, New Hampshire, New York, North Carolina, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Wisconsin, and items indicated by symbol W.

Table 16.—Total material (ore and waste) produced by mine development in the United States in 1983, by commodity and State

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Stripping	Total[1]
COMMODITY					
METALS					
Copper	--	--	1	W	1
Gold	1,160	37	203	21,900	23,300
Iron ore	--	--	7	20,200	20,200
Lead	--	4	1,940	--	1,950
Silver	W	W	509	W	509
Uranium	--	W	359	38,200	38,600
Zinc	W	W	281	--	281
Other[2]	25	160	252	10,500	10,900
Total[1]	1,180	200	3,560	90,800	95,700
NONMETALS					
Gypsum	--	--	--	2,440	2,440
Talc, soapstone, pyrophyllite	--	W	W	1,490	1,490
Other[3]	8	6	274	1,810	2,100
Total[1]	8	6	274	5,740	6,030
Grand total[1]	1,190	206	3,830	96,500	102,000
STATE					
Alaska	--	--	(4)	4,280	4,280
Arizona	--	--	1	206	207
Arkansas	--	--	--	5,060	5,060
California	(4)	3	5	2,120	2,130
Colorado	W	57	196	W	253
Idaho	W	W	192	2,250	2,440
Illinois	W	W	W	--	W
Kentucky	--	W	W	--	W
Missouri	--	--	1,920	--	1,920
Montana	W	1	15	1,380	1,400
Nevada	1,160	W	40	16,000	17,200
New Mexico	1	W	451	W	452
New York	--	W	W	--	W
North Carolina	--	--	--	109	109
Oregon	(4)	1	2	W	3
Pennsylvania	--	--	W	--	W
South Dakota	--	W	W	--	W
Tennessee	--	W	W	--	W
Utah	W	2	314	W	316
Washington	W	W	W	--	W
Wyoming	--	--	W	38,300	38,300
Undistributed	33	142	690	26,800	27,600
Total[1]	1,190	206	3,830	96,500	102,000

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]Includes bauxite, beryllium, mercury, molybdenum, tungsten, vanadium, and items indicated by symbol W.
[3]Includes abrasives, barite, boron minerals, feldspar, fluorspar, mica (scrap), perlite, sodium carbonate (natural), vermiculite, and items indicated by symbol W.
[4]Less than 1/2 unit.

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

(Thousand pounds)

Year	Coal mining[1]	Metal mining[1]	Quarrying and nonmetal mining[1]	Total mineral industry	Construction work and other uses[2]	Total industrial
1979	2,237,393	612,820	653,033	3,503,246	587,212	4,090,458
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

[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 nonmetal mining."

Note.—Data for 1979-80 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 nonmetal mining	Total
PERMISSIBLE EXPLOSIVES				
1979	44,891	281	615	45,787
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
OTHER HIGH EXPLOSIVES				
1979	25,783	23,699	60,734	110,216
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
WATER GELS AND SLURRIES				
1979	74,739	238,738	107,280	420,757
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
AMMONIUM NITRATE: FUEL-MIXED AND UNPROCESSED				
1979	2,091,980	350,102	484,404	2,926,486
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
TOTAL				
1979	2,237,393	612,820	653,033	3,503,246
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

Statistical Summary

By Rose L. Ballard[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.

[1]Statistical specialist, Minerals Information.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
METALS						
Antimony ore and concentrate short tons, antimony content	503	W	838	W	557	W
Bauxite thousand metric tons, dried equivalent	732	$12,334	679	$11,309	856	$15,643
Copper (recoverable content of ores, etc.) metric tons	1,146,975	1,840,856	1,038,098	1,751,476	1,091,284	1,608,422
Gold (recoverable content of ores, etc.) troy ounces	1,465,686	550,968	[r]1,956,400	[r]829,514	2,058,784	742,517
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	35,751	1,491,705	44,295	1,938,496	W	W
Iron oxide pigments, crude short tons	[r]46,548	[r]2,059	[r]41,875	[r]2,427	53,017	2,819
Lead (recoverable content of ores, etc.) metric tons	512,516	288,579	[r]449,216	[r]214,708	321,897	181,305
Manganiferous ore (5% to 35% Mn) short tons, gross weight	31,509	293	33,523	216	88,423	860
Mercury 76-pound flasks	25,760	W	25,070	W	19,048	W
Molybdenum (content of concentrate) thousand pounds	76,135	504,089	[r]48,805	[r]166,612	102,405	326,780
Nickel (content of ore and concentrate) short tons	3,203	W	--	--	14,540	W
Silver (recoverable content of ores, etc.) thousand troy ounces	40,248	319,975	43,415	496,671	44,440	361,773
Titanium concentrate: Ilmenite short tons, gross weight	233,063	19,093	W	W	W	W
Tungsten ore and concentrate metric tons, contained W	1,575	22,062	1,016	10,528	1,173	13,409
Vanadium (recoverable in ore and concentrate) short tons	4,098	52,577	2,171	30,675	1,617	24,551
Zinc (recoverable content of ores, etc.) metric tons	303,160	257,116	275,294	251,204	252,768	270,833
Combined value of beryllium concentrates, magnesium chloride for magnesium metal, rare-earth metal concentrate, tin, titanium concentrate (rutile), zircon concentrate, and values indicated by symbol W	XX	154,917	XX	[r]133,220	XX	2,427,624
Total	XX	5,517,000	XX	[r]5,837,000	XX	5,977,000
NONMETALS (EXCEPT FUELS)						
Abrasive stones[2] short tons	1,285	553	1,101	482	1,290	602
Asbestos metric tons	63,515	24,917	69,906	27,866	57,422	24,238
Barite thousand short tons	1,845	69,522	754	29,203	775	25,445
Boron minerals do	1,234	384,597	1,303	439,181	1,367	456,687
Bromine thousand pounds	401,100	102,600	370,000	91,000	385,000	95,000
Calcium chloride short tons	[e]616,513	[e]61,483	W	W	[e]838,000	[e]93,000
Carbon dioxide, natural thousand cubic feet	2,067,500	3,399	--	--	--	--
Cement:						
Masonry thousand short tons	2,364	145,172	2,921	186,240	3,281	219,877
Portland do	61,080	3,084,439	67,183	3,315,690	74,376	3,810,446
Clays do	35,345	825,064	40,858	931,091	44,236	1,037,233
Diatomite do	613	107,619	619	114,279	627	120,926
Feldspar short tons	615,000	20,300	710,000	22,500	710,000	23,500
Fluorspar do	77,017	13,293	[e]61,000	[e]10,000	72,000	W
Garnet (abrasive) do	27,303	2,321	29,767	2,533	29,647	[e]2,487
Gem stones[e]	NA	7,150	NA	7,425	NA	7,450
Gypsum thousand short tons	10,538	89,131	12,884	101,361	14,319	113,671
Helium (Grade-A) million cubic feet	[3]1,248	[3]42,432	[3]1,299	[3]45,465	1,654	62,026
Lime thousand short tons	14,075	696,207	14,867	757,611	15,922	811,183
Magnesium compounds short tons	W	W	[r]618,227	[r]182,495	W	W
Mica (scrap) thousand short tons	106	6,398	140	6,479	161	7,139
Peat do	769	16,871	725	18,667	814	19,907
Perlite short tons	506,000	16,044	474,000	15,664	498,000	16,638
Phosphate rock thousand metric tons	37,414	950,326	42,573	[r]1,021,095	49,197	1,182,244
Potassium salts (K_2O equivalent) do	1,784	265,600	1,513	220,800	1,639	241,800

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
NONMETALS (EXCEPT FUELS) — Continued						
Pumice _____ thousand short tons__	416	$3,750	449	$4,486	502	$4,929
Pyrites ____ thousand metric tons__	676	41,943	W	W	W	W
Salt _______ thousand short tons__	37,894	671,424	34,573	597,081	39,225	675,099
Sand and gravel:						
Construction __________do____	594,000	1,674,000	e655,100	e1,935,000	773,900	2,244,000
Industrial ___________do____	27,400	323,800	26,620	335,200	29,380	377,200
Sodium sulfate (natural) ____do____	W	W	423	39,425	435	40,125
Stone:[4]						
Crushed _____________do____	e790,030	e2,918,300	r861,600	r3,327,000	e956,000	e3,755,600
Dimension ___________do____	r e1,089	r e137,671	r1,090	r147,843	e1,157	e154,949
Sulfur, Frasch process thousand metric tons__	3,598	434,660	4,111	r414,210	5,001	546,106
Talc and pyrophyllite thousand short tons__	1,135	20,671	1,066	20,280	1,170	24,745
Tripoli ____________short tons__	112,928	653	111,020	649	124,482	699
Vermiculite __ thousand short tons__	316	28,508	282	27,170	315	31,500
Combined value of aplite, asphalt (native), emery, graphite, helium (crude), iodine, kyanite, lithium minerals, magnesite, marl (greensand), olivine, sodium carbonate (natural), staurolite, wollastonite, and values indicated by symbol W _____	XX	959,269	XX	r867,486	XX	946,109
Total ___________________	XX	r14,150,000	XX	r15,263,000	XX	17,173,000
Grand total _______________	XX	r19,667,000	XX	r21,100,000	XX	23,150,000

eEstimated. rRevised. NA Not available. W Withheld to avoid disclosing company proprietary data; value 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 in nonmetals "Combined value" figure for 1982-83.

[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 1984

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., Ala., Ga.	
Beryllium concentrate	Utah and S. Dak.	
Boron minerals	Calif.	
Bromine	Ark. and Mich.	
Calcium chloride	Mich. and Calif.	
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., Miss., Wyo	All other States except Alaska, Del., Hawaii, R.I., Vt., Wis.
Copper (mine)	Ariz., N. Mex., Utah, Mont	Calif., Colo., Idaho, 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., Utah, Mont	Alaska, Ariz., Calif., Colo., Idaho, N. Mex., Oreg., Wash.
Gypsum	Tex., Okla., Mich., Iowa	Ariz., Ark., Calif., Colo., Idaho, 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., Calif., Ill., Mont., Nev., Tenn., Utah.
Lime	Ohio, Pa., Mo., Ky	All other States except Alaska, Del., Ga., 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., Fla., Tex	Del., N.J., Utah.
Manganiferous ore	Minn. and S.C.	
Marl, greensand	N.J. and Del.	
Mercury	Nev.	
Mica (scrap)	N.C., S. Dak., N. Mex., S.C	Conn., Ga., Pa., Tex.
Molybdenum	Colo., Ariz., Idaho, N. Mex	Calif., Nev., Utah.
Olivine	N.C. and Wash.	
Peat	Fla., Mich., Ind., Ill	Calif., Colo., Ga., Iowa, Maine, 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., Ariz., Calif., Colo., Kans., Mich., Nev., N. Mex., N. Dak., Okla., Utah, W. Va.
Sand and gravel:		
Construction	Calif., Tex., Mich., Ohio	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., Mont., Ariz	Alaska, Calif., Colo., Ill., Mo., N. Mex., N.Y., Oreg., S. Dak., Tenn., Utah, Wash.
Sodium carbonate (natural)	Wyo. and Calif.	
Sodium sulfate (natural)	Calif., Tex., Utah.	
Staurolite	Fla.	
Stone:		
Crushed	Tex., Fla., Pa., Ill	All other States except Del. and N. Dak.
Dimension	Ga., Ind., N.C., Vt	All other States except Alaska, Ark., Del., Fla., Hawaii, Ill., Iowa, Ky., La., Miss., Neb., Nev., N. Dak., Oreg., Utah, Wash., W. Va., Wyo.
Sulfur (Frasch)	Tex. and La.	
Talc and pyrophyllite	Tex., Mont., Vt., N.Y	Ark., Calif., Ga., N.C., Oreg., Va., Wash.
Tin	Alaska, Colo., Ariz.	
Titanium concentrate	Fla. and N.Y.	
Tripoli	Ill., Okla., Ark.	
Tungsten ore and concentrate	Calif., Colo., Nev., N. Mex.	
Vanadium	Colo., Idaho, Utah, Ark.	
Vermiculite	Mont., S.C., Va.	
Wollastonite	N.Y. and Calif.	
Zinc (mine)	Tenn., N.Y., Mo., Colo	Idaho, Ill., Ky., N.J., Utah.
Zircon concentrate	Fla.	

Table 3.—Value of nonfuel mineral production in the United States and principal nonfuel minerals produced in 1984

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$409,841	22	1.77	Cement, stone (crushed), lime, clays.
Alaska	88,683	42	.38	Sand and gravel (construction), stone (crushed), gold, cement.
Arizona	1,483,479	5	6.41	Copper, sand and gravel (construction), cement, molybdenum.
Arkansas	272,628	27	1.18	Bromine, cement, stone (crushed), sand and gravel (construction).
California	2,003,445	1	8.66	Cement, boron minerals, sand and gravel (construction), stone (crushed).
Colorado	436,082	20	1.88	Molybdenum, cement, sand and gravel (construction), stone (crushed).
Connecticut	79,696	43	.34	Stone (crushed), sand and gravel (construction), feldspar, sand and gravel (industrial).
Delaware	[1]2,813	50	.01	Magnesium compounds, sand and gravel (construction).
Florida	1,510,364	4	6.52	Phosphate rock, stone (crushed), cement, sand and gravel (construction).
Georgia	940,492	7	4.06	Clays, stone (crushed), cement, stone (dimension).
Hawaii	51,247	44	.22	Stone (crushed), cement, sand and gravel (construction), lime.
Idaho	412,295	21	1.78	Silver, phosphate rock, molybdenum, gold.
Illinois	471,861	18	2.04	Stone (crushed), cement, sand and gravel (construction), sand and gravel (industrial).
Indiana	293,236	25	1.27	Stone (crushed), cement, sand and gravel (construction), lime.
Iowa	253,445	29	1.10	Stone (crushed), cement, sand and gravel (construction), gypsum.
Kansas	312,010	24	1.35	Cement, salt, stone (crushed), helium (Grade-A).
Kentucky	256,998	28	1.11	Stone (crushed), lime, cement, sand and gravel (construction).
Louisiana	511,470	16	2.21	Sulfur (Frasch), salt, sand and gravel (construction), cement.
Maine	37,939	46	.16	Sand and gravel (construction), cement, stone (crushed), peat.
Maryland	241,701	32	1.04	Cement, stone (crushed), sand and gravel (construction), clays.
Massachusetts	107,332	39	.46	Sand and gravel (construction), stone (crushed), lime, stone (dimension).
Michigan	1,408,607	6	6.08	Iron ore, cement, magnesium compounds, salt.
Minnesota	1,676,247	3	7.24	Iron ore, sand and gravel (construction), stone (crushed), sand and gravel (industrial).
Mississippi	94,178	41	.41	Sand and gravel (construction), clays, cement, stone (crushed).
Missouri	731,897	8	3.16	Cement, lead, stone (crushed), lime.
Montana	249,363	30	1.08	Gold, silver, copper, cement.
Nebraska	100,368	40	.43	Cement, sand and gravel (construction), stone (crushed), lime.
Nevada	615,753	11	2.66	Gold, silver, diatomite, molybdenum.
New Hampshire	23,112	47	.10	Sand and gravel (construction), stone (dimension), stone (crushed), clays.
New Jersey	156,236	35	.68	Stone (crushed), sand and gravel (industrial), sand and gravel (construction), zinc.
New Mexico	619,144	10	2.68	Copper, potassium salts, molybdenum, cement.
New York	612,490	12	2.65	Cement, stone (crushed), salt, sand and gravel (construction).
North Carolina	451,480	19	1.95	Stone (crushed), phosphate rock, lithium compounds, sand and gravel (construction).
North Dakota	21,794	48	.10	Sand and gravel (construction), lime, salt, clays.
Ohio	552,903	13	2.39	Stone (crushed), salt, sand and gravel (construction), lime.
Oklahoma	245,732	31	1.06	Cement, stone (crushed), sand and gravel (construction), gypsum.
Oregon	120,402	37	.52	Stone (crushed), sand and gravel (construction), cement, lime.
Pennsylvania	708,356	9	3.06	Cement, stone (crushed), lime, sand and gravel (construction).
Rhode Island	11,568	49	.05	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), stone (dimension).
South Carolina	275,850	26	1.19	Cement, stone (crushed), clays, sand and gravel (construction).
South Dakota	193,407	34	.84	Gold, cement, stone (dimension), stone (crushed).
Tennessee	478,321	17	2.07	Stone (crushed), zinc, cement, pyrites.
Texas	1,715,407	2	7.41	Cement, stone (crushed), sulfur (Frasch), sand and gravel (construction).
Utah	524,162	15	2.26	Copper, gold, cement, sand and gravel (construction).
Vermont	45,098	45	.20	Stone (dimension), sand and gravel (construction), stone (crushed), asbestos.
Virginia	341,589	23	1.48	Stone (crushed), cement, sand and gravel (construction), lime.
Washington	202,624	33	.88	Cement, sand and gravel (construction), stone (crushed), lime.

See footnotes at end of table.

Table 3.—Value of nonfuel mineral production in the United States and principal nonfuel minerals produced in 1984 —Continued

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
West Virginia	$112,187	38	0.48	Stone (crushed), cement, sand and gravel (industrial), salt.
Wisconsin	129,348	36	.56	Stone (crushed), sand and gravel (construction), lime, sand and gravel (industrial).
Wyoming	549,292	14	2.37	Sodium carbonate, clays, cement (portland), sand and gravel (construction).
Total	23,150,000	XX	100.00	

XX Not applicable.
[1]Incomplete total.

Table 4.—Value of nonfuel mineral production per capita and per square mile in 1984, by State

State	Area (square miles)	Population (thousands)	Value of mineral production				
			Total (thousands)	Per square mile		Per capita	
				Dollars	Rank	Dollars	Rank
Alabama	51,705	3,990	$409,841	7,926	23	103	20
Alaska	591,004	500	88,683	150	50	177	10
Arizona	114,000	3,053	1,483,479	13,013	10	486	3
Arkansas	53,187	2,349	272,628	5,126	30	116	17
California	158,706	25,622	2,003,445	12,624	12	78	25
Colorado	104,091	3,178	436,082	4,190	36	137	15
Connecticut	5,018	3,154	79,696	15,882	7	25	45
Delaware	2,044	613	[1]2,813	1,376	45	5	50
Florida	58,664	10,976	1,510,364	25,746	1	138	14
Georgia	58,910	5,837	940,492	15,965	6	161	11
Hawaii	6,471	1,039	51,247	7,920	24	49	36
Idaho	83,564	1,001	412,295	4,934	32	412	5
Illinois	56,345	11,511	471,861	8,374	21	41	39
Indiana	36,185	5,498	293,236	8,104	22	53	34
Iowa	56,275	2,910	253,445	4,504	35	87	22
Kansas	82,277	2,438	312,010	3,792	37	128	16
Kentucky	40,409	3,723	256,998	6,360	26	69	28
Louisiana	47,751	4,462	511,470	10,711	15	115	18
Maine	33,265	1,156	37,939	1,140	48	33	42
Maryland	10,460	4,349	241,701	23,107	3	56	33
Massachusetts	8,284	5,798	107,332	12,957	11	19	48
Michigan	58,527	9,075	1,408,607	24,068	2	155	12
Minnesota	84,402	4,162	1,676,247	19,860	5	403	6
Mississippi	47,689	2,598	94,178	1,975	43	36	40
Missouri	69,697	5,008	731,897	10,501	16	146	13
Montana	147,046	824	249,363	1,696	44	303	8
Nebraska	77,355	1,606	100,368	1,298	46	62	29
Nevada	110,561	911	615,753	5,569	29	676	2
New Hampshire	9,279	977	23,112	2,491	41	24	46
New Jersey	7,787	7,515	156,236	20,064	4	21	47
New Mexico	121,593	1,424	619,144	5,092	31	435	4
New York	49,108	17,735	612,490	12,472	13	35	41
North Carolina	52,669	6,165	451,480	8,572	19	73	27
North Dakota	70,703	686	21,794	308	49	32	43
Ohio	41,330	10,752	552,903	13,378	9	51	35
Oklahoma	69,956	3,298	245,732	3,513	38	75	26
Oregon	97,073	2,674	120,402	1,240	47	45	38
Pennsylvania	45,308	11,901	708,356	15,634	8	60	31
Rhode Island	1,212	962	11,568	9,545	17	12	49
South Carolina	31,113	3,300	275,850	8,866	18	84	24
South Dakota	77,116	706	193,407	2,508	40	274	9
Tennessee	42,144	4,717	478,321	11,350	14	101	21
Texas	266,807	15,989	1,715,407	6,429	25	107	19
Utah	84,899	1,652	524,162	6,174	27	317	7
Vermont	9,614	530	45,098	4,691	33	85	23
Virginia	40,767	5,636	341,589	8,379	20	61	30
Washington	68,138	4,349	202,624	2,974	39	47	37
West Virginia	24,231	1,952	112,187	4,630	34	57	32
Wisconsin	56,153	4,766	129,348	2,304	42	27	44
Wyoming	97,809	511	549,292	5,616	28	1,075	1
Total[2] or average	3,618,701	235,538	23,150,000	6,397	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 623,000.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
ALABAMA						
Cement:						
Masonry ----- thousand short tons--	150	$9,086	210	$13,417	259	$17,247
Portland ---------------do----	2,558	104,461	3,279	150,255	3,656	167,191
Clays[2] -----------------do----	1,323	13,193	1,863	20,758	1,906	30,500
Gem stones ----------------------	NA	1	NA	1	NA	1
Lime --------- thousand short tons--	907	42,380	981	41,149	1,163	50,560
Sand and gravel:						
Construction --------------do----	7,019	17,226	[e]8,600	[e]23,500	10,348	26,188
Industrial ---------------do----	960	8,096	418	3,256	442	3,600
Stone:						
Crushed ---------------do----	[e]21,200	[e]89,600	20,558	95,374	[e]22,000	[e]98,500
Dimension ---------------do----	[r] [e]4	[r] [e]2,094	7	2,661	[e]8	[e]2,674
Combined value of bauxite, clays (bentonite), phosphate rock (1982-83), and salt ------	XX	13,025	XX	[r]10,956	XX	13,380
Total --------------------	XX	[r]299,162	XX	[r]361,327	XX	409,841
ALASKA						
Gem stones ----------------------	NA	$60	NA	$60	NA	$60
Gold (recoverable content of ores, etc.) troy ounces--	30,513	11,470	[r]39,523	[r]16,758	23,232	8,379
Sand and gravel (construction) thousand short tons--	40,832	74,895	[e]45,200	[e]97,200	30,861	66,883
Silver (recoverable content of ores, etc.) thousand troy ounces--	2	17	4	47	W	W
Stone (crushed) --- thousand short tons--	[e]5,100	[e]25,200	1,981	9,460	[e]2,500	[e]10,800
Combined value of cement (portland, 1984), copper (1982-83), lead (1982-83), tin, and value indicated by symbol W ---------	XX	1,269	XX	971	XX	2,561
Total --------------------	XX	112,911	XX	[r]124,496	XX	88,683
ARIZONA						
Clays --------- thousand short tons--	143	$998	151	$1,425	138	$819
Copper (recoverable content of ores, etc.) metric tons--	769,521	1,235,055	678,216	1,144,285	746,453	1,100,182
Gem stones ----------------------	NA	2,800	NA	2,800	NA	2,700
Gold (recoverable content of ores, etc.) troy ounces--	61,050	22,949	61,991	26,284	51,548	18,591
Gypsum -------- thousand short tons--	175	1,205	265	1,929	261	2,332
Lead (recoverable content of ores, etc.) metric tons--	359	202	[r]155	[r]74	W	W
Lime --------- thousand short tons--	326	17,080	340	16,700	359	17,304
Molybdenum (content of concentrate) thousand pounds--	20,445	89,928	23,934	[r]80,210	24,013	76,112
Pumice -------- thousand short tons--	1	7	2	15	2	21
Sand and gravel:						
Construction --------------do----	19,124	58,375	[e]23,200	[e]75,000	30,439	101,959
Industrial ---------------do----	107	1,617	W	W	W	W
Silver (recoverable content of ores, etc.) thousand troy ounces--	6,309	50,159	4,492	51,383	4,093	33,320
Stone:						
Crushed ------ thousand short tons--	[e]5,200	[e]22,200	4,755	24,079	[e]5,200	[e]27,300
Dimension ---------------do----	[r] [e](3)	[r] [e]1	(3)	1	[e](3)	[e](3)
Combined value of cement, perlite, pyrites, salt, tin (1984), and values indicated by symbol W --------------------	XX	79,105	XX	87,449	XX	102,839
Total --------------------	XX	[r]1,581,681	XX	[r]1,511,634	XX	1,483,479

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
ARKANSAS						
Abrasives ---- short tons	1,085	$469	W	W	W	W
Clays ---- thousand short tons	629	6,658	879	$9,956	1,019	$7,838
Gem stones	NA	200	NA	200	NA	200
Sand and gravel:						
Construction ---- thousand short tons	6,936	18,700	[e]6,900	[e]19,600	8,334	23,786
Industrial ---- do	471	5,625	386	4,796	459	6,207
Stone:						
Crushed ---- do	[e]13,100	[e]48,500	13,448	51,267	[e]15,200	[e]59,800
Dimension ---- do	[r] [e]9	[r] [e]574	9	573	--	--
Talc ---- do	13	92	7	66	W	W
Combined value of barite (1982), bauxite, bromine, cement, gypsum, lime, tripoli, vanadium (1982 and 1984), and values indicated by symbol W	XX	169,754	XX	159,972	XX	174,797
Total	XX	[r]250,572	XX	246,430	XX	272,628
CALIFORNIA						
Boron minerals ---- thousand short tons	1,234	$384,597	1,303	$439,181	1,367	$456,687
Cement, portland ---- do	6,464	401,883	7,567	420,949	8,715	520,026
Clays ---- do	1,762	15,642	[2]1,816	[2]18,255	[2]2,100	[2]23,868
Diatomite ---- do	340	68,139	W	W	W	W
Gem stones	NA	250	NA	300	NA	500
Gold (recoverable content of ores, etc.) troy ounces	10,547	3,965	38,443	16,300	85,858	30,965
Gypsum ---- thousand short tons	1,088	10,614	1,213	10,668	1,382	12,443
Lime ---- do	364	23,000	358	22,994	406	26,827
Peat ---- do	W	W	13	612	W	W
Pumice ---- do	59	1,285	65	1,582	80	1,600
Sand and gravel:						
Construction ---- do	81,147	270,995	[e]91,000	[e]308,700	102,420	360,427
Industrial ---- do	2,167	27,528	2,150	34,066	2,281	39,176
Silver (recoverable content of ores, etc.) thousand troy ounces	34	271	27	308	W	W
Stone:						
Crushed ---- thousand short tons	[e]28,500	[e]105,400	35,582	146,289	[e]38,600	[e]158,000
Dimension ---- do	[r] [e]20	[r] [e]2,727	20	2,839	[e]22	[e]2,990
Talc ---- do	85	1,699	71	1,289	74	1,642
Combined value of asbestos, calcium chloride, carbon dioxide (1982), cement (masonry), clays (fire clay, 1983-84), copper, feldspar, iron ore, lead, magnesium compounds, molybdenum (1982 and 1984), perlite, potassium salts, rare-earth metal concentrate, salt, sodium carbonate, sodium sulfate, tungsten ore and concentrate, wollastonite, and values indicated by symbol W	XX	293,851	XX	[r]359,218	XX	368,294
Total	XX	[r]1,611,846	XX	[r]1,783,550	XX	2,003,445
COLORADO						
Clays ---- thousand short tons	201	$1,124	459	$2,650	308	$2,111
Copper (recoverable content of ores, etc.) metric tons	575	922	W	W	W	W
Gem stones	NA	80	NA	80	NA	80
Gold (recoverable content of ores, etc.) troy ounces	64,584	24,278	63,063	26,739	60,010	21,643
Gypsum ---- thousand short tons	184	1,571	W	W	291	W
Molybdenum ---- thousand pounds	41,691	360,626	[r]W	[r]W	W	W
Peat ---- thousand short tons	47	275	W	W	W	W
Sand and gravel:						
Construction ---- do	18,590	58,465	[e]21,200	[e]81,600	28,024	87,324
Industrial ---- do	222	3,266	212	3,233	149	2,213
Silver (recoverable content of ores, etc.) thousand troy ounces	1,934	15,378	2,146	24,546	2,200	17,909

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
COLORADO—Continued						
Stone:						
Crushed thousand short tons	[e]6,900	[e]$27,800	6,790	$22,749	[e]7,200	[e]$26,200
Dimension do.	[e]1	[r] [e]86	1	86	[e]1	[e]87
Combined value of beryllium concentrate (1982), carbon dioxide (1982), cement, iron ore, lead, lime, perlite, pyrites (1982 and 1984), salt (1982 and 1984), tin (1982 and 1984), tungsten ore and concentrate, vanadium, zinc, and values indicated by symbol W	XX	142,049	XX	[r]175,969	XX	278,515
Total	XX	[r]635,920	XX	337,652	XX	436,082
CONNECTICUT						
Clays thousand short tons	56	$329	86	$515	99	$565
Lime do.	8	568	5	400	W	W
Sand and gravel:						
Construction do.	4,887	16,237	[e]5,000	[e]17,900	6,718	22,817
Industrial do.	80	1,746	W	W	W	W
Stone:						
Crushed do.	[e]6,100	[e]32,700	7,692	45,890	[e]8,300	[e]49,400
Dimension do.	[r] [e]16	[r] [e]923	18	1,028	[e]18	[e]1,080
Combined value of feldspar, gem stones, mica (scrap), and values indicated by symbol W	XX	3,299	XX	5,480	XX	5,834
Total	XX	[r]55,802	XX	71,213	XX	79,696
DELAWARE						
Marl (greensand) thousand short tons	--	--	--	--	1	$18
Sand and gravel (construction) do.	1,300	$3,197	[e]1,400	[e]$3,200	1,003	2,795
Total[4]	XX	3,197	XX	3,200	XX	2,813
FLORIDA						
Cement:						
Masonry thousand short tons	231	$16,267	313	$19,557	383	$24,624
Portland do.	2,651	136,190	3,329	164,048	3,564	172,548
Clays do.	672	[2]31,339	684	31,566	772	34,048
Gem stones	NA	6	NA	6	NA	6
Lime thousand short tons	103	5,828	W	13,881	171	9,379
Peat do.	120	1,575	114	1,999	263	5,454
Sand and gravel:						
Construction do.	13,616	30,081	[e]14,900	[e]31,500	21,032	48,494
Industrial do.	341	4,257	329	3,447	1,533	9,815
Stone (crushed) do.	[e]53,100	[e]182,300	57,282	235,700	[e]68,500	[e]290,000
Combined value of clays (kaolin, 1982), magnesium compounds, phosphate rock, rare-earth metal concentrate, staurolite, titanium concentrates (ilmenite and rutile), and zircon concentrates	XX	815,155	XX	[r]774,122	XX	915,996
Total	XX	1,222,998	XX	[r]1,275,826	XX	1,510,364
GEORGIA						
Clays thousand short tons	6,773	$475,768	7,859	$560,005	8,679	$600,029
Gem stones	NA	20	NA	20	NA	20
Sand and gravel:						
Construction thousand short tons	3,166	8,361	[e]3,800	[e]9,400	5,347	13,623
Industrial do.	541	6,793	539	7,298	478	6,795
Stone:						
Crushed do.	[e]34,800	[e]153,500	41,100	[r]186,193	[e]45,900	[e]220,000
Dimension do.	[r] [e]182	[r] [e]19,375	[r]183	[r]21,019	[e]202	[e]20,007
Talc do.	20	141	14	101	15	104
Combined value of barite, bauxite, cement, feldspar, iron oxide pigments (crude), kyanite, mica (scrap), and peat	XX	54,880	XX	65,536	XX	79,914
Total	XX	[r]718,838	XX	[r]849,572	XX	940,492

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
HAWAII						
Cement:						
Masonry ----- thousand short tons--	6	$554	6	$641	5	$792
Portland ---do---	227	18,122	216	20,673	186	18,282
Sand and gravel (construction) ----do---	449	1,221	e440	e1,000	436	2,031
Stone:						
Crushed ---do---	e4,500	e26,600	5,532	29,703	e5,400	e29,700
Dimension ---do---	e(3)	e4	(3)	3	--	--
Combined value of gem stones, lime, and pumice	XX	388	XX	391	XX	442
Total	XX	46,889	XX	52,411	XX	51,247
IDAHO						
Antimony ore and concentrate, antimony content ---short tons--	294	W	585	W	557	W
Clays --- thousand short tons--	8	$101	6	$91	51	$243
Copper (recoverable content of ores, etc.) metric tons--	3,074	4,933	3,556	6,000	3,701	5,455
Gem stones	NA	75	NA	100	NA	150
Lead (recoverable content of ores, etc.) metric tons--	W	W	r25,893	r12,376	W	W
Lime --- thousand short tons--	W	W	85	7,686	87	5,616
Phosphate rock -- thousand metric tons--	W	W	W	W	4,722	126,586
Sand and gravel (construction) thousand short tons--	2,340	6,258	e3,000	e9,800	4,725	13,509
Silver (recoverable content of ores, etc.) thousand troy ounces--	14,830	117,901	17,684	202,308	18,869	153,608
Stone (crushed) --- thousand short tons--	e1,200	e6,000	1,935	7,480	e1,800	e7,100
Combined value of cement, garnet (abrasive), gold, gypsum, molybdenum (1984), perlite, pumice, sand and gravel (industrial), stone (dimension), tungsten ore and concentrate (1982-83), vanadium, zinc, and values indicated by symbol W	XX	r168,041	XX	169,318	XX	100,028
Total	XX	r303,309	XX	415,159	XX	412,295
ILLINOIS						
Cement, portland -- thousand short tons--	1,757	$78,444	1,857	$74,975	1,997	$82,622
Clays[2] ---do---	455	2,305	717	3,360	253	940
Gem stones	NA	15	NA	15	NA	15
Peat --- thousand short tons--	W	W	W	W	49	W
Sand and gravel:						
Construction ---do---	21,557	59,149	e21,100	e58,400	25,969	72,477
Industrial ---do---	3,989	45,665	4,060	42,871	4,100	52,197
Stone:						
Crushed ---do---	e42,900	e148,300	42,761	166,860	e48,500	e191,600
Dimension ---do---	e2	r e43	2	71	--	--
Combined value of barite, cement (masonry), clays (fuller's earth), fluorspar, lead, lime, silver, tripoli, zinc, and values indicated by symbol W	XX	55,618	XX	60,355	XX	72,010
Total	XX	r389,539	XX	406,907	XX	471,861
INDIANA						
Cement, portland -- thousand short tons--	1,523	$58,055	W	W	W	W
Clays ---do---	501	1,221	2558	2$1,421	2653	2$2,085
Gem stones	NA	1	NA	1	NA	1
Peat --- thousand short tons--	89	2,243	81	1,973	61	1,358
Sand and gravel:						
Construction ---do---	13,097	34,579	e14,400	e37,900	16,071	44,744
Industrial ---do---	W	W	W	W	194	1,129
Stone:						
Crushed ---do---	e20,300	e65,500	24,051	82,782	e26,700	e99,400
Dimension ---do---	r e127	r e11,626	144	11,015	e159	e14,269
Combined value of abrasives (natural), cement (masonry), clays (fire clay, 1983-84), gypsum, lime, and values indicated by symbol W	XX	40,199	XX	115,450	XX	130,250
Total	XX	r213,424	XX	250,542	XX	293,236

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
IOWA						
Cement:						
Masonry ----- thousand short tons--	W	W	37	$3,425	42	$3,260
Portland ---------------do----	1,622	$82,225	1,644	87,836	1,730	92,699
Clays ---------------do----	437	2,392	576	3,258	623	2,695
Gem stones	NA	1	NA	1	NA	W
Gypsum-------- thousand short tons--	1,177	11,345	1,612	13,518	1,527	12,421
Peat ---------------do----	W	W	W	W	11	400
Sand and gravel (construction) ----do----	10,064	25,618	[e]11,800	[e]32,800	13,882	37,027
Stone (crushed) ---------------do----	[e]22,600	[e]88,800	24,844	101,097	[e]23,800	[e]100,000
Combined value of lime, sand and gravel (industrial, 1982), stone (dimension, 1982-83), and values indicated by symbol W ---	XX	[r]8,028	XX	5,425	XX	4,943
Total	XX	[r]218,409	XX	247,360	XX	253,445
KANSAS						
Cement:						
Masonry ----- thousand short tons--	46	$2,628	W	W	W	W
Portland ---------------do----	1,549	79,558	W	W	W	W
Clays ---------------do----	664	3,656	718	$3,921	918	$5,537
Gem stones	NA	1	NA	1	NA	1
Helium:						
Crude --------- million cubic feet--	--	--	188	3,572	402	8,844
Grade-A ---------------do----	790	26,860	775	27,125	1,015	38,063
Salt[6] ---------- thousand short tons--	1,601	72,146	1,719	67,195	1,712	71,558
Sand and gravel:						
Construction ---------------do----	9,720	20,612	[e]12,400	[e]26,600	11,796	26,358
Industrial ---------------do----	331	3,635	199	2,184	W	W
Stone:						
Crushed ---------------do----	[e]14,400	[e]41,100	[r]12,687	[r]45,121	[e]13,600	[e]48,500
Combined value of gypsum, lime, pumice, salt (brine), stone (dimension), and values indicated by symbol W ---	XX	[r]6,728	XX	91,866	XX	113,149
Total	XX	[r]256,924	XX	[r]267,585	XX	312,010
KENTUCKY						
Clays --------- thousand short tons--	[2]579	[2]$2,039	[2]669	[2]$2,142	802	$7,277
Gem stones	NA	1	NA	1	NA	1
Sand and gravel:						
Construction--- thousand short tons--	6,499	15,936	[e]5,500	[e]13,000	7,839	18,252
Industrial ---------------do----	7	116	10	124	W	W
Stone (crushed) ---------------do----	[e]29,500	[e]104,300	33,399	117,842	[e]37,300	[e]133,000
Combined value of cement, clays (ball clay, 1982-83, fire clay, 1983), lime, and zinc ---	XX	84,555	XX	91,408	XX	98,468
Total	XX	206,947	XX	224,517	XX	256,998
LOUISIANA						
Clays --------- thousand short tons--	326	[2]$6,216	[2]505	$10,793	547	[2]$10,858
Gem stones	NA	1	NA	1	NA	1
Salt ---------- thousand short tons--	12,171	117,569	11,544	100,936	13,101	112,142
Sand and gravel:						
Construction ---------------do----	16,558	50,966	[e]14,200	[e]46,600	17,040	54,664
Industrial ---------------do----	378	4,590	291	4,252	266	3,757
Stone (crushed) ---------------do----	W	W	5,758	25,702	[e]4,100	[e]19,500
Sulfur (Frasch) -- thousand metric tons--	1,239	W	1,643	W	2,007	W
Combined value of cement, clays (bentonite, 1982 and 1984), gypsum, lime, and values indicated by symbol W ---	XX	238,325	XX	258,477	XX	310,548
Total	XX	417,667	XX	446,761	XX	511,470

See footnotes at end of table.

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

Mineral	1982		1983		1984	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MAINE						
Clays ---------- thousand short tons--	37	$76	43	$93	43	$97
Peat ---------- do----	8	508	W	W	W	W
Sand and gravel (construction) ---- do----	6,701	15,118	[e]4,800	[e]12,100	7,885	19,228
Stone (crushed) ---------- do----	[e]1,200	[e]4,000	848	2,851	[e]1,300	[e]4,400
Combined value of other nonmetals and values indicated by symbol W ----------	XX	[r]16,003	XX	11,319	XX	14,214
Total ----------	XX	[r]35,705	XX	26,363	XX	37,939
MARYLAND						
Clays[2] ---------- thousand short tons--	405	$1,346	484	$1,747	347	$1,484
Gem stones ----------	NA	2	NA	2	NA	2
Lime ---------- thousand short tons--	7	396	7	383	7	419
Peat ---------- do----	4	W	4	W	5	W
Sand and gravel (construction) ---- do----	9,720	32,386	[e]10,600	[e]37,800	14,234	46,671
Stone:						
Crushed ---------- do----	[e]15,100	[e]73,500	19,284	80,429	[e]22,100	[e]94,000
Dimension ---------- do----	[r][e]10	[r][e]470	12	682	[e]17	[e]864
Combined value of cement, clays (ball clay), sand and gravel (industrial, 1984), and values indicated by symbol W ----------	XX	62,891	XX	78,366	XX	98,261
Total ----------	XX	[r]170,991	XX	199,409	XX	241,701
MASSACHUSETTS						
Clays ---------- thousand short tons--	210	$1,115	237	$1,298	240	$1,212
Lime ---------- do----	135	9,414	156	10,671	171	12,426
Sand and gravel:						
Construction ---------- do----	12,003	34,438	[e]10,400	[e]36,200	14,168	42,139
Industrial ---------- do----	140	1,615	W	W	W	W
Stone:						
Crushed ---------- do----	[e]6,900	[e]33,500	7,740	36,002	[e]8,400	[e]39,000
Dimension ---------- do----	[r][e]55	[r][e]11,399	51	10,488	[e]57	[e]11,657
Combined value of gem stones, peat, and values indicated by symbol W ----------	XX	62	XX	1,016	XX	898
Total ----------	XX	[r]91,543	XX	95,675	XX	107,332
MICHIGAN						
Cement:						
Masonry ----- thousand short tons--	136	$8,752	W	W	W	W
Portland ---------- do----	3,254	149,533	W	W	W	W
Clays ---------- do----	1,022	4,370	1,199	$5,693	1,321	$5,052
Gem stones ----------	NA	15	NA	15	NA	15
Gypsum ---------- thousand short tons--	682	5,150	1,097	8,104	1,534	10,304
Iron ore (usable) ----- thousand long tons, gross weight--	W	W	10,713	W	13,263	W
Lime ---------- thousand short tons--	571	26,823	503	23,142	622	30,092
Peat ---------- do----	241	4,917	215	4,286	227	4,341
Salt ---------- do----	2,002	106,303	1,355	93,306	1,491	93,860
Sand and gravel:						
Construction ---------- do----	20,567	47,726	[e]23,000	[e]52,300	36,071	76,540
Industrial ---------- do----	2,920	21,934	3,545	27,577	3,400	33,060
Stone:						
Crushed ---------- do----	[e]20,700	[e]67,100	24,763	82,152	[e]28,100	[e]92,000
Dimension ---------- do----	[e]4	[r][e]95	4	112	[e]4	[e]129
Combined value of bromine, calcium chloride, copper (1982), iodine, iron oxide pigments (crude), magnesium compounds, silver (1982), and values indicated by symbol W --	XX	592,451	XX	[r]882,239	XX	1,063,214
Total ----------	XX	[r]1,035,169	XX	[r]1,178,926	XX	1,408,607
MINNESOTA						
Gem stones ----------	NA	$5	NA	$5	NA	$5
Iron ore (usable) ----- thousand long tons, gross weight--	23,715	1,021,056	30,699	1,342,455	35,602	1,561,516
Lime ---------- thousand short tons--	133	4,694	W	W	W	W

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
MINNESOTA—Continued						
Manganiferous ore ---------short tons--	16,307	W	11,314	W	68,019	W
Peat ---------- thousand short tons--	W	W	W	W	24	W
Sand and gravel:						
Construction -------------do----	20,276	$44,222	[e]24,600	[e]$53,000	22,612	$49,087
Industrial --------------do----	694	5,903	685	12,932	W	W
Stone:						
Crushed ---------------do----	[e]7,100	[e]20,900	8,580	25,320	[e]8,900	[e]25,800
Dimension --------------do----	[r][e]29	[r][e]10,956	28	11,365	[e]39	[e]13,369
Combined values of clays and values indicated by symbol W --------------	XX	1,406	XX	9,953	XX	26,470
Total --------------------	XX	[r]1,109,142	XX	1,455,030	XX	1,676,247
MISSISSIPPI						
Clays --------- thousand short tons--	805	$21,181	1,446	$23,846	2,398	$30,565
Sand and gravel (construction) ----do----	9,455	27,115	[e]11,000	[e]34,600	12,205	34,955
Stone (crushed) -------------do----	W	W	1,651	4,377	[e]2,000	[e]5,800
Combined value of cement, sand and gravel (industrial), and value indicated by symbol W ---------------------	XX	24,389	XX	26,882	XX	22,858
Total --------------------	XX	72,685	XX	89,705	XX	94,178
MISSOURI						
Barite --------- thousand short tons--	107	$5,703	W	W	W	W
Cement:						
Masonry ---------------do----	88	4,855	146	$7,339	143	$7,033
Portland ---------------do----	3,205	120,339	3,499	157,249	3,981	178,225
Clays[2] ------------------do----	1,383	13,409	1,418	11,848	1,575	14,666
Copper (recoverable content of ores, etc.) metric tons--	7,941	12,745	7,725	13,033	5,818	8,575
Gem stones ---------------------	NA	10	NA	10	NA	10
Iron ore --------- thousand long tons--	717	W	877	27,054	1,370	W
Lead (recoverable content of ores, etc.) metric tons--	474,460	267,150	409,280	195,620	278,329	156,766
Sand and gravel:						
Construction --- thousand short tons--	6,359	14,477	[e]7,700	[e]17,700	7,967	19,364
Industrial --------------do----	750	8,997	600	7,541	614	8,129
Silver (recoverable content of ores, etc.) thousand troy ounces--	2,241	17,817	2,021	23,124	1,401	11,406
Stone:						
Crushed ----- thousand short tons--	[e]38,600	[e]113,300	39,454	120,700	[e]41,600	[e]137,000
Dimension --------------do----	[e]([3])	[e]13	W	W	W	W
Zinc (recoverable content of ores, etc.) metric tons--	63,680	54,009	57,044	52,052	45,458	48,707
Combined value of clays (fuller's earth and kaolin, 1984), iron oxide pigments (crude), lime, stone (dimension), and values indicated by symbol W --------------	XX	[r]100,032	XX	[r]92,598	XX	142,016
Total --------------------	XX	[r]732,856	XX	[r]725,868	XX	731,897
MONTANA						
Antimony -------------short tons--	209	W	253	W	--	--
Barite --------- thousand short tons--	W	W	10	$750	W	W
Clays ------------------do----	[2]218	[2]$8,064	194	6,205	397	$15,260
Copper (recoverable content of ores, etc.) metric tons--	64,951	104,245	33,337	56,245	W	W
Gem stones ---------------------	NA	225	NA	300	NA	450
Gold (recoverable content of ores, etc.) troy ounces--	75,171	28,258	161,436	68,449	181,190	65,348
Lead (recoverable content of ores, etc.) metric tons--	661	372	1,163	556	W	W
Lime --------- thousand short tons--	45	2,331	86	W	89	5,097
Sand and gravel (construction) ----do----	5,338	12,794	[e]5,000	[e]10,200	7,776	21,269
Silver (recoverable content of ores, etc.) thousand troy ounces--	6,169	49,041	5,708	65,299	5,653	46,018

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
MONTANA—Continued						
Stone (crushed) ___ thousand short tons__	[e]1,400	[e]$4,700	872	[r]$2,320	[e]950	[e]$2,400
Zinc (recoverable content of ores, etc.) metric tons__	W	W	--	--	--	--
Combined value of cement, clays (fire clay, 1982), graphite, gypsum, iron ore, molybdenum (1983), peat, phosphate rock, sand and gravel (industrial), stone (dimension), talc, tungsten ore and concentrate (1982), vermiculite, and values indicated by symbol W	XX	[r]60,701	XX	[r]81,644	XX	93,521
Total	XX	[r]270,731	XX	[r]291,968	XX	249,363
NEBRASKA						
Clays ________ thousand short tons__	134	$392	164	$501	180	$556
Sand and gravel:						
Construction ______ do____	9,713	23,851	[e]10,100	[e]25,000	11,839	27,791
Industrial ______ do____	14	105	4	W	W	W
Stone (crushed) ______ do____	[e]3,100	[e]14,300	[r]4,442	[r]22,612	[e]4,500	[e]23,400
Combined value of cement, gem stones, lime, and values indicated by symbol W______	XX	36,632	XX	39,296	XX	48,621
Total	XX	75,280	XX	[r]87,409	XX	100,368
NEVADA						
Barite ________ thousand short tons__	1,575	$52,727	663	$21,736	615	$14,924
Clays ______ do____	103	2,640	58	2,348	[2]20	[2]1,191
Gem stones	NA	1,200	NA	1,200	NA	1,300
Gold (recoverable content of ores, etc.) troy ounces__	757,099	284,601	[r]914,531	[r]387,761	997,508	359,759
Gypsum ______ thousand short tons__	656	4,523	998	7,896	1,192	8,860
Iron ore ______ thousand long tons__	77	1,119	W	W	W	W
Lead (recoverable content of ores, etc.) metric tons__	W	W	14	7	W	W
Mercury ________ 76-pound flasks__	25,760	W	25,070	W	19,048	W
Sand and gravel:						
Construction ___ thousand short tons__	6,027	11,724	[e]7,500	[e]16,200	8,202	20,505
Industrial ______ do____	W	W	W	W	489	W
Silver (recoverable content of ores, etc.) thousand troy ounces__	3,142	24,981	5,164	59,073	6,477	52,727
Stone (crushed) ___ thousand short tons__	[e]1,300	[e]4,500	1,269	5,358	[e]1,100	[e]4,700
Combined value of cement (portland), clays (fuller's earth and kaolin, 1984), copper, diatomite, fluorspar, lime, lithium, magnesite, molybdenum, perlite, salt, tungsten ore and concentrate (1982 and 1984), and values indicated by symbol W ________	XX	144,448	XX	[r]111,178	XX	151,787
Total	XX	532,463	XX	[r]612,757	XX	615,753
NEW HAMPSHIRE						
Sand and gravel (construction) thousand short tons__	4,332	$12,593	[e]4,000	[e]$12,100	5,637	$16,054
Stone:						
Crushed ______ do____	[e]600	[e]3,100	946	2,853	[e]850	[e]2,700
Dimension ______ do____	[r] [e]55	[r] [e]3,593	58	4,032	[e]59	[e]4,198
Combined value of other nonmetals ______	XX	101	XX	101	XX	160
Total	XX	[r]19,387	XX	19,086	XX	23,112
NEW JERSEY						
Clays ________ thousand short tons__	63	$566	62	$596	61	$611
Gem stones	NA	1	NA	1	NA	1
Peat ________ thousand short tons__	W	W	W	W	5	128

See footnotes at end of table.

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

Mineral	1982		1983		1984	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEW JERSEY—Continued						
Sand and gravel:						
Construction ___ thousand short tons__	7,940	$25,722	[e]10,800	[e]$34,300	9,545	$31,878
Industrial ______________do____	2,140	28,151	2,386	31,819	2,712	32,287
Stone (crushed) _____________do____	[e]10,700	[e]57,800	12,301	70,421	[e]13,500	[e]75,000
Zinc (recoverable content of ores, etc.) metric tons__	16,800	14,248	16,475	15,033	W	W
Combined value of magnesium compounds (1982-83), marl (greensand), stone (dimension), titanium concentrate (ilmenite, 1982), and values indicated by symbol W______	XX	[r]5,845	XX	2,445	XX	16,331
Total____________________	XX	[r]132,333	XX	154,615	XX	156,236
NEW MEXICO						
Clays _________ thousand short tons__	[2]60	[2]$112	50	$115	67	$143
Gem stones_____________________	NA	200	NA	200	NA	200
Gypsum________ thousand short tons__	198	887	169	1,016	318	1,622
Lead (recoverable content of ores, etc.) metric tons__	W	W	258	123	--	--
Lime _________ thousand short tons__	W	W	17	W	--	--
Perlite __________________do____	408	13,355	394	13,297	416	14,115
Potassium salts __ thousand metric tons__	1,497	204,600	1,278	174,700	1,418	204,100
Pumice ________ thousand short tons__	97	809	110	1,070	132	1,269
Sand and gravel (construction) ____do____	5,616	17,670	[e]7,000	[e]20,000	8,363	22,389
Silver (recoverable content of ores, etc.) thousand troy ounces__	805	6,397	W	W	W	W
Stone:						
Crushed______ thousand short tons__	[e]2,800	[e]13,700	4,730	[r]15,118	[e]4,700	[e]17,000
Dimension _______________do____	[e]18	[r] [e]141	18	141	[e]19	[e]149
Combined value of carbon dioxide (1982), cement, clays (fire clay, 1982), copper, gold, helium (Grade-A), mica (scrap), molybdenum, salt, sand and gravel (industrial, 1982), tungsten ore and concentrate (1984), and values indicated by symbol W______	XX	171,432	XX	291,411	XX	358,157
Total____________________	XX	[r]429,303	XX	[r]517,191	XX	619,144
NEW YORK						
Clays[2]_________ thousand short tons__	352	$897	371	$869	543	$2,435
Gem stones_____________________	NA	30	NA	30	NA	30
Lead (recoverable content of ores, etc.) metric tons__	1,065	600	1,299	621	W	W
Peat ___________ thousand short tons__	W	W	18	W	W	W
Salt _____________________do____	6,205	117,718	4,859	100,119	5,644	123,755
Sand and gravel:						
Construction_____________do____	17,338	46,871	[e]18,700	[e]54,200	25,968	80,866
Industrial _______________do____	45	512	W	W	25	260
Silver (recoverable content of ores, etc.) thousand troy ounces__	27	216	33	379	W	W
Stone:						
Crushed______ thousand short tons__	[e]28,700	[e]132,800	[r]31,991	[r]134,752	[e]33,100	[e]135,000
Dimension _______________do____	[e]22	[r] [e]3,952	24	4,310	[e]15	[e]4,271
Zinc (recoverable content of ores, etc.) metric tons__	52,237	44,303	56,748	51,783	W	W
Combined value of cement, clays (ball clay), emery, garnet (abrasive), gypsum, iron ore (1982), lime, talc, titanium concentrate (ilmenite), wollastonite, and values indicated by symbol W _______________	XX	155,959	XX	156,351	XX	265,873
Total____________________	XX	[r]503,858	XX	[r]503,414	XX	612,490

See footnotes at end of table.

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

Mineral	1982		1983		1984	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NORTH CAROLINA						
Clays thousand short tons	[2]1,573	[2]$5,243	[2]2,068	[2]$6,681	2,327	$8,987
Feldspar short tons	428,755	12,255	508,641	13,610	510,275	13,994
Gem stones	NA	50	NA	50	NA	50
Mica (scrap) thousand short tons	67	4,793	69	4,266	79	3,762
Sand and gravel:						
Construction do	5,198	15,395	[e]5,600	[e]16,900	6,312	18,159
Industrial do	716	4,878	1,066	11,689	1,158	12,864
Stone:						
Crushed do	[e]27,500	[e]117,600	33,694	[r]145,001	[e]38,100	[e]168,000
Dimension do	[r e]165	[r e]8,457	87	8,267	W	W
Talc and pyrophyllite do	83	1,266	89	1,452	87	1,587
Combined value of cement, clays (kaolin, 1982-83), lithium compounds, olivine, peat, phosphate rock, and value indicated by symbol W	XX	135,142	XX	190,641	XX	224,077
Total	XX	[r]305,079	XX	[r]398,557	XX	451,480
NORTH DAKOTA						
Gem stones	NA	$2	NA	$2	NA	$2
Lime thousand short tons	W	W	57	6,798	60	5,912
Sand and gravel (construction) do	2,347	4,873	[e]3,800	[e]15,000	6,426	11,351
Combined value of clays, peat, salt, and value indicated by symbol W	XX	8,102	XX	3,570	XX	4,529
Total	XX	12,977	XX	25,370	XX	21,794
OHIO						
Cement:						
Masonry thousand short tons	86	$6,170	97	$7,454	101	$8,092
Portland do	1,326	59,598	1,575	71,599	1,525	69,810
Clays do	1,451	6,100	1,716	8,061	1,960	10,473
Gypsum do	109	1,335	W	W	W	W
Lime do	1,666	76,370	1,906	84,928	1,859	87,951
Peat do	5	144	W	W	13	345
Salt do	3,514	90,572	2,565	85,988	W	W
Sand and gravel:						
Construction do	26,160	83,015	[e]27,200	[e]84,600	31,748	104,709
Industrial do	1,223	17,816	1,226	17,848	1,506	20,829
Stone:						
Crushed do	[e]30,300	[e]105,200	32,937	114,059	[e]38,500	[e]139,000
Dimension do	[r e]48	[r e]2,765	49	2,923	[e]37	[e]3,454
Combined value of abrasives, gem stones, and values indicated by symbol W	XX	[r]35	XX	1,684	XX	108,240
Total	XX	[r]449,120	XX	479,144	XX	552,903
OKLAHOMA						
Cement:						
Masonry thousand short tons	W	W	45	$3,074	49	$3,506
Portland do	W	W	1,719	83,685	1,732	84,701
Clays do	752	$1,907	862	2,288	979	2,498
Gem stones	NA	2	NA	2	NA	2
Gypsum thousand short tons	1,254	10,089	1,351	11,571	1,549	13,485
Pumice do	1	W	1	W	W	W
Sand and gravel:						
Construction do	7,490	17,733	[e]7,500	[e]17,300	10,984	26,582
Industrial do	1,222	13,114	1,184	13,221	W	W
Stone:						
Crushed do	[e]30,100	[e]84,200	23,865	76,941	[e]25,500	[e]86,000
Dimension do	[r e]8	[r e]589	10	737	[e]12	[e]771
Combined value of feldspar, iodine, lime, salt, tripoli, and values indicated by symbol W	XX	97,031	XX	17,367	XX	28,187
Total	XX	[r]224,665	XX	226,186	XX	245,732

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
OREGON						
Clays thousand short tons	149	$212	188	$275	189	$288
Gem stones	NA	500	NA	600	NA	400
Gold (recoverable content of ores, etc.) troy ounces	W	W	322	137	W	W
Nickel (content of ores and concentrates) short tons	3,203	W	--	--	14,540	W
Sand and gravel (construction) thousand short tons	9,513	30,629	e11,000	e37,000	12,776	37,117
Silver (recoverable content of ores, etc.) thousand troy ounces	--	--	1	10	W	W
Stone (crushed) thousand short tons	e14,200	e41,900	13,089	r39,873	e12,500	e37,500
Talc and soapstone do	(3)	82	(3)	123	(3)	66
Combined value of cement, copper (1983), diatomite, lead (1983), lime, pumice, sand and gravel (industrial, 1983), stone (dimension, 1982-83), and values indicated by symbol W	XX	r34,517	XX	32,922	XX	45,031
Total	XX	r107,840	XX	r110,940	XX	120,402
PENNSYLVANIA						
Cement:						
Masonry thousand short tons	256	$14,048	262	$17,095	298	$20,849
Portland do	4,800	212,945	5,154	218,539	5,735	281,590
Clays[2] do	931	5,616	916	4,311	963	4,050
Gem stones	NA	5	NA	5	NA	5
Lime thousand short tons	1,297	70,902	1,507	81,682	1,620	90,182
Peat do	27	669	22	628	24	693
Sand and gravel:						
Construction do	13,081	55,527	e11,800	e52,000	14,472	64,285
Industrial do	969	13,589	W	W	W	W
Stone:						
Crushed do	e50,400	e200,900	51,523	226,948	e56,200	e228,000
Dimension do	r e42	r e5,033	53	5,799	e44	e6,001
Zinc (recoverable content of ores, etc.) metric tons	24,762	21,001	16,792	15,322	--	--
Combined value of clays (kaolin), mica (scrap), tripoli (1982), and values indicated by symbol W	XX	1,094	XX	12,812	XX	12,701
Total	XX	r601,329	XX	635,141	XX	708,356
RHODE ISLAND						
Sand and gravel:						
Construction thousand short tons	1,146	$3,671	e1,000	e$2,400	1,483	$5,282
Industrial do	5	52	--	--	W	W
Stone (crushed) do	e130	e1,100	971	5,507	e1,000	e5,800
Combined value of other nonmetals and value indicated by symbol W	XX	r25	XX	23	XX	486
Total	XX	r4,848	XX	7,930	XX	11,568
SOUTH CAROLINA						
Cement, portland thousand short tons	1,624	$66,385	W	W	2,319	$103,891
Clays[2] do	1,535	28,166	1,813	$34,830	1,834	36,809
Gem stones	NA	10	NA	10	NA	10
Manganiferous ore thousand short tons	15	W	22	W	20	W
Peat do	5	W	W	W	5	W
Sand and gravel:						
Construction do	4,727	13,170	e5,200	e15,000	5,845	17,097
Industrial do	720	10,902	842	13,169	882	14,889
Stone:						
Crushed do	e14,000	e53,000	15,786	61,054	e17,900	e72,500
Dimension do	r e17	r e1,164	17	1,165	e16	e1,092
Combined value of cement (masonry), clays (fuller's earth), mica (scrap), vermiculite, and values indicated by symbol W	XX	22,181	XX	105,366	XX	29,562
Total	XX	r194,978	XX	230,594	XX	275,850

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
SOUTH DAKOTA						
Cement:						
Masonry ----- thousand short tons--	4	$383	4	$359	5	$283
Portland ---------------do----	520	27,978	603	37,435	619	30,773
Clays[2] ---------------do----	128	346	123	353	119	343
Feldspar ---------------short tons--	W	W	7,109	107	7,219	124
Gem stones----------------	NA	70	NA	70	NA	70
Gold (recoverable content of ores, etc.) troy ounces--	185,038	69,558	309,784	131,348	310,527	111,994
Sand and gravel (construction) thousand short tons--	3,816	8,604	e5,100	e11,500	5,786	12,168
Silver (recoverable content of ores, etc.) thousand troy ounces--	26	209	62	713	50	407
Stone:						
Crushed------ thousand short tons--	e2,600	e7,400	3,906	12,982	e3,800	e12,800
Dimension ---------------do----	r e39	r e14,805	r42	r15,794	e60	e18,642
Combined value of beryllium, clays (bentonite), gypsum, lime, mica (scrap), and value indicated by symbol W---------	XX	4,855	XX	11,432	XX	5,803
Total--------------------	XX	r134,208	XX	r222,093	XX	193,407
TENNESSEE						
Cement, portland -- thousand short tons--	763	$36,689	W	W	W	W
Clays ---------------do----	766	20,107	1,066	$26,516	1,267	$30,207
Gem stones----------------	NA	5	NA	5	NA	5
Phosphate rock -- thousand metric tons--	897	11,596	1,193	r29,073	1,368	33,275
Sand and gravel:						
Construction--- thousand short tons--	5,051	15,917	e6,100	e18,700	6,304	19,830
Industrial ---------------do----	468	4,826	483	5,455	650	6,903
Stone:						
Crushed---------------do----	W	W	30,578	r111,573	e36,200	e138,000
Dimension ---------------do----	r e8	r e1,238	7	1,161	e7	e1,097
Zinc (recoverable content of ores, etc.) metric tons--	121,306	102,882	109,958	100,336	116,526	124,854
Combined value of barite, cement (masonry), copper, lead (1984), lime, pyrites, silver, and values indicated by symbol W --------	XX	185,453	XX	114,493	XX	124,150
Total--------------------	XX	r378,713	XX	r407,312	XX	478,321
TEXAS						
Cement:						
Masonry ----- thousand short tons--	236	$16,440	276	$19,704	291	$24,409
Portland ---------------do----	9,732	545,679	9,760	534,298	10,423	557,421
Clays ---------------do----	4,193	26,497	3,955	22,575	3,594	23,051
Gem stones----------------	NA	200	NA	225	NA	175
Gypsum-------- thousand short tons--	1,954	16,681	2,049	16,357	2,166	19,431
Helium (Grade-A)---- million cubic feet--	458	15,572	524	18,340	W	W
Lime --------- thousand short tons--	1,125	62,277	1,067	60,193	1,157	61,214
Salt ---------------do----	7,421	82,805	8,028	65,670	8,184	69,672
Sand and gravel:						
Construction---------------do----	45,527	154,515	e58,500	e208,000	62,389	199,461
Industrial ---------------do----	2,201	35,974	1,788	29,637	2,028	29,282
Stone:						
Crushed---------------do----	e68,000	e205,000	r76,328	r239,187	e89,200	e300,000
Dimension ---------------do----	r e41	r e7,702	50	11,071	e47	e11,236
Sulfur (Frasch) -- thousand metric tons--	2,360	W	2,468	W	2,994	W
Talc and pyrophyllite thousand short tons--	205	3,024	250	3,933	283	5,703
Combined value of asphalt (native, 1984), fluorspar, helium (crude), iron ore, magnesium chloride, magnesium compounds, mica (scrap, 1984), sodium sulfate, and values indicated by symbol W -----------	XX	374,912	XX	r279,291	XX	414,352
Total--------------------	XX	r1,547,278	XX	r1,508,481	XX	1,715,407

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
UTAH						
Beryllium concentrate ______ short tons__	W	W	W	W	6,030	$6
Clays[2] _________ thousand short tons__	183	$994	227	$1,569	315	2,223
Copper (recoverable content of ores, etc.) metric tons__	189,090	r303,483	169,751	286,403	W	W
Gem stones ______________________	NA	80	NA	80	NA	80
Gold (recoverable content of ores, etc.) troy ounces__	174,940	65,762	238,459	101,107	W	W
Gypsum ________ thousand short tons__	231	2,363	305	2,736	277	2,671
Lime ____________________do____	286	15,121	315	16,771	297	16,471
Salt _____________________do____	1,227	23,210	936	23,184	1,246	28,651
Sand and gravel:						
Construction ______________do____	7,579	14,920	e9,800	e19,800	15,217	34,507
Industrial _______________do____	W	W	24	W	11	W
Silver (recoverable content of ores, etc.) thousand troy ounces__	4,342	34,522	4,567	52,242	W	W
Stone:						
Crushed ______ thousand short tons__	e2,500	e9,800	4,407	14,636	e5,200	e16,400
Dimension ________________do____	rW	rW	W	W	--	--
Combined value of asphalt (native), cement, clays (fuller's earth), iron ore (usable, 1982-83), lead (1982 and 1984), magnesium compounds, molybdenum, perlite (1983), phosphate rock, potassium salts, sodium sulfate, vanadium, zinc (1984), and values indicated by symbol W __________________	XX	r145,837	XX	138,051	XX	423,153
Total ____________________	XX	r616,092	XX	656,579	XX	524,162

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
VERMONT						
Sand and gravel (construction) thousand short tons__	3,218	$6,854	e3,000	e$6,200	3,802	$8,071
Stone:						
Crushed _________________do____	e1,200	e5,300	1,339	5,579	e1,800	e7,000
Dimension ________________do____	r e109	r e18,358	r116	19,995	e116	e20,462
Combined value of talc and other nonmetals_	XX	8,550	XX	10,355	XX	9,565
Total ____________________	XX	r39,062	XX	42,129	XX	45,098

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
VIRGINIA						
Clays _________ thousand short tons__	422	$2,237	784	$5,467	712	$6,004
Gem stones ______________________	NA	20	NA	20	NA	20
Iron oxide pigments _______ short tons__	1,269	372	W	W	W	W
Lime _________ thousand short tons__	641	29,118	557	24,637	562	24,799
Sand and gravel (construction) ____do____	6,978	28,522	e7,200	e30,800	8,860	37,359
Stone:						
Crushed _________________do____	e35,200	e142,300	37,959	r159,553	e47,200	e196,000
Dimension ________________do____	e4	r e1,151	93	r2,238	e22	e3,052
Combined value of aplite, cement, gypsum, kyanite, sand and gravel (industrial), talc (soapstone), vermiculite, and values indicated by symbol W _______________	XX	59,484	XX	66,629	XX	74,355
Total ____________________	XX	r263,204	XX	289,344	XX	341,589

See footnotes at end of table.

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

Mineral	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
WASHINGTON						
Cement, portland ---- thousand short tons--	1,154	$75,988	W	W	W	W
Clays ---- do----	251	1,829	[2]282	[2]$1,715	292	$1,646
Gem stones----	NA	200	NA	200	NA	200
Sand and gravel:						
Construction---- thousand short tons--	15,190	40,295	[e]15,800	[e]50,300	23,369	61,070
Industrial ---- do----	242	2,809	337	4,581	356	5,201
Stone:						
Crushed---- do----	[e]8,600	[e]23,800	10,451	29,607	[e]10,400	[e]31,700
Dimension ---- do----	[r] [e]([3])	[r] [e]20	1	37	--	--
Talc ---- do----	8	20	W	W	W	W
Combined value of barite, clays (fire clay, 1983), cement (masonry), diatomite, gold, gypsum, lead (1982), lime, olivine, peat, silver, and values indicated by symbol W -	XX	24,766	XX	101,025	XX	102,807
Total----	XX	[r]169,727	XX	187,465	XX	202,624
WEST VIRGINIA						
Clays ---- thousand short tons--	[2]210	[2]$583	[2]249	[2]$532	381	$3,410
Salt ---- do----	942	W	1,026	W	1,004	W
Sand and gravel (construction) ---- do----	751	3,392	[e]700	[e]3,400	976	3,198
Stone (crushed) ---- do----	[e]5,900	[e]22,700	9,439	37,962	[e]9,100	[e]37,300
Combined value of cement, clays (fire clay, 1982-83), lime, sand and gravel (industrial), and values indicated by symbol W----	XX	48,945	XX	62,079	XX	68,279
Total----	XX	75,620	XX	103,973	XX	112,187
WISCONSIN						
Iron ore (usable)---- thousand long tons, gross weight--	263	W	--	--	--	--
Lime ---- thousand short tons--	312	$17,685	319	$17,624	373	$19,892
Peat---- do----	9	W	9	W	9	W
Sand and gravel:						
Construction---- do----	14,515	29,218	[e]14,200	[e]28,800	17,785	38,245
Industrial ---- do----	788	9,662	621	7,208	1,060	11,821
Stone:						
Crushed---- do----	[e]11,400	[e]36,100	14,252	39,896	[e]15,800	[e]45,000
Dimension ---- do----	[r] [e]18	[r] [e]2,815	24	2,884	[e]24	[e]2,863
Combined value of abrasive stone, cement, and values indicated by symbol W----	XX	16,400	XX	4,779	XX	11,527
Total----	XX	[r]111,880	XX	101,191	XX	129,348
WYOMING						
Clays ---- thousand short tons--	2,561	$73,696	2,140	$49,059	2,397	$67,290
Gem stones----	NA	250	NA	250	NA	225
Gypsum---- thousand short tons--	283	2,805	382	2,963	376	2,618
Sand and gravel (construction) ---- do----	3,382	10,279	[e]2,400	[e]8,000	4,586	13,372
Stone (crushed) ---- do----	[e]2,300	[e]7,300	2,019	7,769	[e]1,900	[e]7,600
Combined value of beryllium concentrate (1982-83), cement (portland), iron ore (1982-83), lime, and sodium carbonate ----	XX	573,865	XX	561,860	XX	458,187
Total----	XX	668,195	XX	629,901	XX	549,292

[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 in "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 salt in brines; value included in "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	1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value
American Samoa: Stone	NA	NA	NA	NA	NA	NA
Guam: Stone	NA	NA	329	2,192	e345	e2,280
Virgin Islands: Stone	NA	NA	237	2,305	e249	e2,397

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

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

(Thousand short tons and thousand dollars)

Mineral	1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value
Cement (portland)	986	81,822	931	82,509	997	87,568
Clays	162	298	125	251	128	266
Lime	37	1,906	35	3,885	35	4,531
Sand and gravel	NA	NA	NA	NA	43	W
Stone:						
Crushed	NA	NA	5,536	26,611	e5,813	e27,675
Dimension	r e10	r e130	W	W	e35	e455
Total[2]	XX	r84,156	XX	113,256	XX	120,495

eEstimated. rRevised. 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.

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

Mineral	1983		1984	
	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS				
Aluminum:				
Ingots, slabs, crude ---- metric tons	360,704	$534,048	259,598	$396,798
Scrap ---- do	237,827	249,156	258,404	275,686
Plates, sheets, bars, etc ---- do	162,294	388,679	198,399	496,841
Castings and forgings ---- do	9,518	55,346	11,590	69,845
Aluminum sulfate ---- do	14,094	1,593	2,789	1,185
Other aluminum compounds ---- do	49,706	36,447	37,616	31,700
Antimony, metals and alloys, crude ---- short tons	304	1,039	511	915
Bauxite including bauxite concentrate thousand metric tons	74	10,561	82	12,735
Beryllium ---- pounds	37,477	2,693	39,315	2,562
Bismuth, metals and alloys ---- do	306,128	703	311,511	1,091
Cadmium metal ---- metric tons	170	351	106	208
Chromium:				
Ore and concentrate:				
Exports ---- thousand short tons	11	1,874	55	2,957
Reexports ---- do	5	1,350	4	864
Ferrochromium ---- do	4	4,822	15	10,542
Cobalt (content) ---- thousand pounds	r757	5,715	670	7,661
Copper:				
Ore, concentrate, composition metal, unrefined (copper content) ---- metric tons	57,126	67,759	74,528	91,558
Scrap ---- do	47,986	66,929	80,810	96,266
Refined copper and semimanufactures ---- do	157,664	532,595	135,885	351,999
Other copper manufactures ---- do	r11,281	r30,893	13,817	30,438
Ferroalloys not elsewhere listed:				
Ferrophosphorus ---- short tons	26,933	3,716	39,603	5,279
Ferroalloys, n.e.c ---- do	5,775	7,965	27,485	16,158
Gold:				
Ore and base bullion ---- troy ounces	1,257,800	501,016	1,498,617	528,284
Bullion, refined ---- do	1,881,233	825,418	3,482,473	1,284,718
Iron ore ---- thousand long tons	3,781	182,744	4,993	239,257

See footnotes at end of table.

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

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
METALS —Continued				
Iron and steel:				
Pig iron ---short tons--	6,364	$528	56,674	$5,685
Iron and steel products (major):				
Steel mill products ---do---	1,198,623	1,054,794	977,284	904,011
Other steel products---do---	246,642	553,894	261,246	513,942
Iron and steel scrap: Ferrous scrap including rerolling materials, ships, boats, other vessels for scrapping thousand short tons--	7,752	650,540	9,840	938,402
Lead:				
Ore and concentrate ---metric tons--	20,119	7,502	11,858	4,760
Pigs, bars, anodes, sheets, etc ---do---	20,449	19,090	7,445	15,214
Scrap ---do---	50,918	13,139	45,097	11,575
Magnesium, metal and alloys, scrap, semimanufactured forms, n.e.c ---short tons--	46,690	124,714	48,337	136,661
Manganese:				
Ore and concentrate ---do---	19,314	1,972	237,606	15,643
Ferromanganese ---do---	8,433	5,765	6,764	4,397
Silicomanganese ---do---	6,426	1,746	5,333	2,237
Metal ---do---	6,391	8,531	4,082	5,915
Molybdenum:				
Ore and concentrate (molybdenum content) thousand pounds--	47,068	185,122	63,366	242,770
Metal and alloys, crude and scrap ---do---	577	1,860	306	1,209
Wire---do---	610	7,085	474	5,954
Semimanufactured forms, n.e.c---do---	216	4,589	257	6,368
Powder ---do---	396	2,737	461	3,272
Ferromolybdenum ---do---	171	687	650	1,567
Compounds---do---	8,597	22,158	26,602	56,453
Nickel:				
Alloys and scrap including unwrought metal, ingots, bars, sheets, anodes, etc ---short tons--	38,344	154,536	44,590	199,108
Catalysts ---do---	3,165	13,940	2,718	15,156
Wire---do---	1,039	8,831	1,119	11,166
Semifabricated forms, n.e.c ---do---	1,365	14,420	2,218	19,991
Platinum-group metals:				
Ore and scrap ---troy ounces--	782,967	193,463	565,543	123,349
Palladium, rhodium, iridium, osmiridium, ruthenium, osmium (metal and alloys including scrap) ---do---	261,188	45,799	375,802	74,748
Platinum (metal and alloys)---do---	184,599	70,652	220,885	76,749
Rare-earth metals: Ferrocerium and alloys ---short tons--	73	393	34	309
Selenium ---kilograms--	93,369	771	122,929	1,587
Silicon:				
Ferrosilicon ---short tons--	11,338	10,712	29,364	21,185
Silicon carbide, crude and in grains (including reexports) do---	5,590	7,164	6,023	8,613
Silver:				
Ore, concentrate, waste, sweepings thousand troy ounces--	18,294	208,066	14,108	119,965
Bullion, refined ---do---	13,658	169,383	10,340	86,339
Tantalum:				
Ore, metal, other forms ---thousand pounds--	332	r13,994	508	24,603
Powder ---do---	123	14,397	151	17,026
Tin:				
Ingots, pigs, bars, etc ---metric tons--	1,340	17,305	1,429	14,409
Tinplate and terneplate ---do---	171,121	83,827	154,679	93,033
Titanium:				
Ore and concentrate ---short tons--	4,391	1,006	8,651	1,936
Unwrought and scrap metal ---do---	5,676	9,173	4,484	9,359
Intermediate mill shapes and mill products, n.e.c---do---	2,154	52,197	2,849	61,502
Pigments and oxides ---do---	93,521	92,132	108,247	102,828
Tungsten (tungsten content):				
Ore and concentrate ---thousand pounds--	2	11	284	1,240
Carbide powder ---do---	729	9,277	987	12,415
Alloy powder---do---	785	7,692	2,249	17,329
Vanadium:				
Ore and concentrate (vanadium content)---do---	117	273	24	109
Pentoxide, etc ---do---	5,297	7,871	7,423	14,514
Ferrovanadium ---do---	1,550	6,144	938	5,205
Zinc:				
Slabs, pigs, or blocks ---metric tons--	427	801	760	975
Sheets, plates, strips, other forms, n.e.c---do---	957	2,142	975	2,421
Waste, scrap, dust (zinc content) ---do---	r30,169	r18,389	42,079	23,871
Semifabricated forms, n.e.c ---do---	1,708	3,257	1,428	2,349
Ore and concentrate ---do---	60,168	22,868	30,579	13,353

See footnotes at end of table.

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

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
METALS —Continued				
Zirconium:				
Ore and concentrate ---short tons--	13,222	$3,316	9,528	$2,647
Oxide ---do---	698	1,898	422	1,263
Metals, alloys, other forms ---do---	747	39,514	808	42,523
NONMETALS				
Abrasives (includes reexports):				
Industrial diamond, natural or synthetic:				
Powder or dust ---thousand carats--	42,312	82,499	47,992	74,337
Other ---do---	3,185	34,065	3,301	30,441
Diamond grinding wheels ---do---	467	4,910	536	5,141
Other natural and artificial metallic abrasives and products -	NA	r [1]88,627	NA	[1]99,719
Asbestos:				
Exports:				
Unmanufactured ---metric tons--	54,236	19,398	39,779	18,221
Products---	NA	128,584	NA	162,690
Reexports:				
Unmanufactured ---metric tons--	398	285	140	125
Products---	NA	998	NA	657
Barite: Natural barium sulfate---short tons--	22,816	3,514	1,449	574
Boron:				
Boric acid---do---	38,498	20,688	44,728	24,402
Sodium borates, refined ---do---	224,672	51,000	500,537	134,000
Bromine compounds ---thousand pounds--	61,300	21,600	53,200	16,200
Calcium:				
Other calcium compounds including precipitated calcium carbonate ---short tons--	20,000	13,700	37,000	17,000
Chloride ---do---	40,597	9,550	34,062	20,568
Dicalcium phosphate---do---	48,000	32,600	40,000	33,000
Cement: Hydraulic and clinker---do---	118,393	17,360	80,007	13,496
Clays:				
Kaolin or china clay ---thousand short tons--	1,338	157,882	1,418	170,137
Bentonite---do---	554	42,580	563	45,375
Other ---do---	592	53,775	718	80,221
Diatomite---do---	146	31,569	127	29,461
Feldspar, leucite, nepheline syenite ---short tons--	9,360	856	10,080	920
Fluorspar---do---	9,236	962	12,266	1,292
Gem stones (including reexports):				
Diamond ---thousand carats--	2,489	622,411	2,273	574,719
Pearls---	NA	4,985	NA	8,265
Other ---	NA	104,020	NA	98,150
Graphite, natural---short tons--	9,435	3,455	7,096	2,807
Gypsum:				
Crude, crushed or calcined ---thousand short tons--	117	13,621	131	12,711
Manufactured, wallboard and plaster articles---	NA	18,467	NA	17,141
Helium ---million cubic feet--	368	19,626	392	21,461
Lime---short tons--	28,154	4,815	24,714	6,805
Lithium compounds:				
Lithium carbonate[2]---thousand pounds--	17,779	23,953	18,069	24,487
Lithium hydroxide ---do---	5,719	10,159	8,198	14,108
Other lithium compounds---do---	4,278	8,183	5,430	9,765
Magnesium compounds:				
Magnesite, dead-burned ---short tons--	10,855	1,955	17,275	3,641
Magnesite, crude, caustic-calcined, lump or ground--do---	16,621	8,426	32,053	14,026
Mica:				
Waste, scrap, ground---thousand pounds--	20,416	2,657	15,306	2,038
Block, film, splittings---do---	70	109	348	549
Manufactured, cut or stamped, built-up---	NA	4,001	NA	4,519
Mineral-earth pigments, iron oxide, natural and synthetic short tons--	12,661	20,692	32,428	31,832
Nitrogen compounds (major) ---thousand short tons--	7,484	1,050,061	10,439	1,635,430
Phosphate rock ---thousand metric tons--	r12,010	r327,345	11,528	324,784
Phosphatic fertilizers:				
Phosphoric acid ---do---	1,219	322,146	1,721	396,568
Superphosphates ---do---	r69,804	r166,177	2,847	1,629
Diammonium phosphates ---do---	4,758	729,233	6,346	1,200,579
Elemental phosphorus ---metric tons--	21,752	34,116	14,852	22,375
Pigments and compounds: Zinc oxide (metal content) --do---	330	492	288	627
Potash:				
Potassium chloride ---do---	385,980	30,700	621,820	57,200
Potassium sulfate---do---	86,320	16,390	67,320	13,940
Quartz, crystal:				
Cultured ---thousand pounds--	80	3,258	277	11,021
Natural---do---	28	156	42	234

See footnotes at end of table.

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

Mineral	1983		1984	
	Quantity	Value (thousands)	Quantity	Value (thousands)
NONMETALS —Continued				
Salt:				
Crude and refined thousand short tons	517	$12,368	820	$15,299
Shipments to noncontiguous territories do	30	4,101	19	2,301
Sand and gravel:				
Construction:				
Sand do	934	4,620	1,210	8,094
Gravel do	369	1,810	635	2,231
Industrial sand do	1,047	26,057	1,193	27,656
Sodium compounds:				
Sodium sulfate do	91	11,380	76	9,587
Sodium carbonate do	1,636	154,584	1,648	160,774
Stone:				
Crushed do	2,413	23,021	2,378	23,970
Dimension	NA	21,185	NA	26,318
Sulfur, crude thousand metric tons	992	109,298	1,334	156,067
Talc, crude and ground thousand short tons	218	12,916	256	16,162
Total	XX	r12,235,430	XX	13,992,604

rRevised. NA Not available. XX Not applicable.
[1]Silicon carbide (crude and refined) has been deducted and is shown separately elsewhere in this table.
[2]Before 1982, lithium carbonate exports were included with "Other lithium compounds."

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

Mineral	1983		1984	
	Quantity	Value (thousands)	Quantity	Value (thousands)
METALS				
Aluminum:				
Metal metric tons	742,691	$1,021,273	881,956	$1,292,724
Scrap do	88,472	87,468	137,675	145,748
Plates, sheets, bars, etc do	260,012	537,319	457,562	1,027,631
Aluminum oxide (alumina) thousand metric tons	4,030	811,021	4,466	976,364
Antimony:				
Ore and concentrate (antimony content) short tons	2,770	2,335	4,299	6,798
Sulfide including needle or liquated do	47	58	72	157
Metal do	1,282	1,987	3,898	8,037
Oxide do	10,604	13,318	17,884	26,348
Arsenic:				
White (As_2O_3 content) do	10,186	8,406	13,985	9,454
Metallic do	243	1,401	304	2,127
Bauxite, crude thousand metric tons	7,601	NA	9,428	NA
Beryllium ore short tons	2,194	2,755	1,332	1,177
Bismuth, metals and alloys (gross weight) pounds	1,971,956	3,121	1,948,394	5,892
Cadmium metal metric tons	2,196	3,842	1,889	5,133
Calcium metal pounds	332,834	866	248,973	670
Cesium compounds and chloride do	19,227	617	53,652	1,552
Chromium:				
Ore and concentrate (Cr_2O_3 content) thousand short tons	86	10,390	134	15,477
Ferrochromium (gross weight) do	280	109,012	426	183,451
Ferrochromium-silicon do	1	670	8	3,736
Metal do	3	13,687	5	24,073
Cobalt:				
Metal thousand pounds	15,853	110,076	23,316	202,954
Oxide (gross weight) do	403	1,813	706	5,285
Salts and compounds (gross weight) do	1,671	2,244	2,284	5,371
Columbium ore do	1,482	3,316	3,265	6,030
Copper (copper content):				
Ore and concentrate metric tons	90,597	81,695	11,056	9,863
Matte do	r3,286	r4,318	2,094	2,586
Blister do	46,371	66,027	38,949	52,950
Refined in ingots, etc do	459,568	700,564	444,699	620,674
Scrap do	r23,086	r32,183	23,005	28,925
Ferroalloys not elsewhere listed, including spiegeleisen short tons	3,098	15,801	5,321	27,304
Gallium kilograms	7,294	3,195	9,669	4,050
Germanium do	20,916	10,527	116,719	7,539

See footnotes at end of table.

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

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
METALS —Continued				
Gold:				
Ore and base bullion ____troy ounces__	r993,768	$401,548	1,837,052	$653,307
Bullion, refined ____do____	3,559,188	1,575,570	6,031,550	2,293,606
Hafnium____short tons__	(1)	50	1	115
Indium____thousand troy ounces__	1,073	2,795	1,022	4,577
Iron ore ____thousand long tons__	13,246	445,731	17,187	529,065
Iron and steel:				
Pig iron ____short tons__	242,114	31,917	702,355	83,985
Iron and steel products (major):				
Steel mill products ____do____	17,034,388	6,333,636	26,169,313	10,201,206
Other products ____do____	804,095	795,481	1,145,868	1,155,254
Scrap including tinplate ___ thousand short tons__	641	48,219	572	46,946
Lead:				
Ore, flue dust, matte (lead content)___ metric tons__	19,753	5,712	29,888	11,923
Base bullion (lead content) ____do____	53	23	43	57
Pigs and bars (lead content) ____do____	134,357	64,225	161,489	86,189
Reclaimed scrap, etc. (lead content)____do____	4,212	1,340	5,026	2,029
Sheets, pipes, shot ____do____	496	1,632	1,667	4,044
Magnesium:				
Metal and scrap ____short tons__	3,969	7,174	5,296	12,260
Alloys (magnesium content) ____do____	2,143	6,151	3,596	10,791
Sheets, tubing, ribbons, wire, other forms (magnesium content)____do____	238	2,939	489	2,620
Manganese:				
Ore (35% or more contained manganese) ___do____	368,297	19,867	338,094	16,024
Ferromanganese____do____	341,608	93,083	409,310	117,678
Ferrosilicon-manganese (manganese content) do____	91,992	40,117	91,339	44,746
Metal ____do____	5,950	5,323	13,314	12,978
Mercury:				
Compounds ____pounds__	135,758	717	89,519	465
Metal ____76-pound flasks__	12,786	3,813	25,327	7,274
Molybdenum:				
Ore and concentrate (molybdenum content) thousand pounds__	1,673	3,528	28	183
Waste and scrap (gross weight) ____do____	NA	2,141	NA	2,565
Metal:				
Unwrought (molybdenum content) ____do____	97	1,398	142	2,170
Wrought (gross weight) ____do____	94	2,331	132	3,023
Ferromolybdenum (gross weight)____do____	1,157	3,189	2,086	4,438
Material in chief value molybdenum (molybdenum content)____do____	3,445	12,985	5,266	19,441
Compounds (gross weight) ____do____	5,791	9,425	3,437	6,251
Nickel:				
Pigs, ingots, shot, cathodes____short tons__	90,839	418,943	103,017	461,371
Plates, bars, etc ____do____	4,105	84,553	8,650	58,120
Slurry ____do____	62,454	83,613	82,509	116,956
Scrap____do____	6,071	17,691	6,199	20,542
Powder and flakes____do____	12,725	65,747	15,829	78,736
Ferronickel____do____	45,134	65,264	43,048	68,429
Oxide____do____	4,209	19,083	5,526	22,413
Platinum-group metals:				
Unwrought:				
Grains and nuggets (platinum) ____troy ounces__	8,513	2,145	19,786	5,647
Sponge (platinum)____do____	1,005,208	r435,330	1,527,841	617,888
Sweepings, waste, scrap ____do____	417,431	44,308	526,738	61,920
Iridium ____do____	23,266	r7,151	18,225	7,472
Palladium ____do____	1,223,951	151,149	1,795,939	273,222
Rhodium ____do____	119,958	48,171	155,671	83,979
Ruthenium____do____	163,623	5,379	198,257	16,652
Other platinum-group metals____do____	22,875	7,248	10,602	3,796
Semimanufactured:				
Platinum ____do____	109,376	36,663	60,140	22,682
Palladium ____do____	108,247	12,643	158,012	24,192
Rhodium ____do____	11,245	1,539	2,389	516
Other platinum-group metals____do____	r4,329	r1,030	506	122
Rare-earth metals:				
Ferrocerium and other cerium alloys __ kilograms__	104,696	1,185	138,128	1,651
Monazite ____metric tons__	4,028	1,517	5,661	2,202
Metals including scandium and yttrium_ kilograms__	801	182	4,316	619
Rhenium:				
Metal including scrap____pounds__	623	180	1,962	450
Ammonium perrhenate ____do____	5,947	1,131	6,790	1,052
Selenium and selenium compounds (selenium content) kilograms__	297,029	5,922	376,946	8,054
Silicon:				
Metal (over 96% silicon content) ____short tons__	28,173	52,026	25,221	55,381
Ferrosilicon____do____	159,443	67,445	143,651	72,874

See footnotes at end of table.

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

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
METALS —Continued				
Silver:				
Ore and base bullion ---- thousand troy ounces--	13,911	$145,419	13,018	$105,587
Bullion, refined ----do----	161,199	1,926,102	93,546	784,838
Sweepings, waste, doré ----do----	4,781	52,048	8,402	72,772
Tantalum ore ---- thousand pounds--	536	4,017	2,199	19,054
Tellurium (tellurium content) ---- kilograms--	11,829	622	35,382	725
Thallium ----pounds--	3,110	448	2,964	96
Tin:				
Concentrate (tin content) ---- metric tons--	969	9,549	3,272	20,862
Dross, skimmings, scrap, residue, tin alloys, n.s.p.f. do----	1,193	1,219	1,211	1,318
Tinfoil, powder, flitters, etc ----	NA	10,728	NA	3,292
Tin scrap and other tin-bearing material excluding tinplate scrap ----	NA	NA	NA	NA
Tin compounds ---- metric tons--	642	4,120	838	5,301
Titanium:				
Ilmenite[2] ----short tons--	398,036	29,423	619,444	43,846
Rutile ----do----	111,578	23,532	180,508	44,910
Metal ----do----	3,787	27,899	5,533	35,469
Ferrotitanium and ferrosilicon titanium ---do----	893	1,288	579	861
Pigments ----do----	174,857	165,495	193,501	186,952
Tungsten ore and concentrate (tungsten content) thousand pounds--	6,307	25,717	12,802	51,715
Vanadium (vanadium content):				
Ferrovanadium ----do----	r1,361	r6,254	2,341	11,839
Pentoxide ----do----	754	2,363	297	1,269
Vanadium-bearing materials ----do----	115	86	1,266	552
Zinc:				
Ore (zinc content) ---- metric tons--	63,156	16,548	86,172	29,186
Blocks, pigs, slabs ----do----	617,679	503,888	639,228	635,940
Sheets, etc ----do----	319	426	850	1,308
Fume (zinc content) ----do----	631	420	314	171
Waste and scrap ----do----	3,900	1,676	6,259	3,940
Dross and skimmings ----do----	6,508	3,314	5,027	3,161
Dust, powder, flakes ----do----	6,533	7,126	7,572	9,505
Manufactured ----	NA	543	NA	927
Zirconium:				
Ore including zirconium sand ----short tons--	44,487	4,420	66,436	7,548
Metal, scrap, compounds ----do----	1,687	15,901	1,844	20,330
NONMETALS				
Abrasives:				
Diamond (industrial) ---- thousand carats--	24,877	88,617	43,710	113,632
Other ----	NA	201,248	NA	268,062
Asbestos ---- metric tons--	196,387	57,956	209,963	64,749
Barite:				
Crude and ground ---- thousand short tons--	1,397	67,404	1,776	74,945
Witherite ----short tons--	50	16	226	153
Chemicals ----do----	27,832	16,093	35,208	20,524
Boron:				
Boric acid ----do----	7,881	3,456	7,748	3,449
Calcium borate, crude[3] ----do----	40,000	8,309	51,334	12,123
Calcium chloride ----do----	13,784	r1,317	22,078	1,817
Cement: Hydraulic and clinker - thousand short tons--	4,268	161,439	8,846	249,207
Clays ----short tons--	20,864	3,488	31,585	4,868
Cryolite ----do----	7,199	4,784	22,722	13,124
Feldspar:				
Crude ----do----	18	6	2	1
Ground and crushed ----do----	46	25	23	14
Fluorspar ----do----	453,314	47,032	703,711	65,241
Gem stones:				
Diamond ---- thousand carats--	6,265	2,275,373	8,227	2,905,317
Emeralds ----do----	2,117	134,130	4,410	154,644
Other ----	NA	446,951	NA	591,555
Graphite, natural ----short tons--	43,586	11,921	58,246	14,579
Gypsum:				
Crude, ground, calcined ---- thousand short tons--	8,035	r57,265	8,915	74,357
Manufactured ----	NA	30,614	NA	95,310
Iodine, crude ---- thousand pounds--	6,218	34,039	5,067	24,312
Lime:				
Hydrated ----short tons--	58,811	3,431	59,906	3,669
Other ----do----	223,752	11,345	187,579	9,722
Lithium:				
Ore ----do----	8	4	60	24
Compounds ----do----	189	1,978	462	2,313

See footnotes at end of table.

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

Mineral	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
NONMETALS —Continued				
Magnesium compounds:				
Crude magnesite short tons	r66	$25	745	$232
Lump or ground caustic-calcined magnesia do	r31,429	5,476	54,026	9,594
Refractory magnesia, dead-burned, fused magnesite, dead-burned dolomite do	80,429	14,340	155,162	26,187
Compounds do	50,029	9,780	46,153	10,036
Mica:				
Waste, scrap, ground thousand pounds	14,091	2,189	23,198	3,251
Block, film, splittings do	1,899	986	1,480	644
Manufactured, cut or stamped, built-up do	735	2,583	856	2,836
Mineral-earth pigments, iron oxide:				
Ocher, crude and refined short tons	(1)	3	7	31
Siennas, crude and refined do	141	56	160	72
Umber, crude and refined do	6,640	996	6,401	1,012
Vandyke brown do	769	309	659	244
Other natural and refined do	841	342	996	444
Synthetic do	22,356	14,978	30,015	19,720
Nepheline syenite:				
Crude do	212	13	410	17
Ground, crushed, etc do	407,139	13,984	377,535	14,201
Nitrogen compounds (major) including urea thousand short tons	6,281	793,574	8,476	984,524
Peat:				
Fertilizer-grade short tons	371,486	46,001	453,387	53,491
Poultry- and stable-grade do	47,220	6,066	31,685	4,318
Phosphates, crude and apatite thousand metric tons	9	r305	9	274
Phosphatic fertilizers:				
Fertilizer and fertilizer materials do	36	3,622	119	7,536
Elemental phosphorus do	r2,122	r3,362	4,222	6,482
Other do	r11	r1,618	11	1,550
Pigments and salts:				
Lead pigments and compounds metric tons	15,667	11,444	19,081	15,022
Zinc pigments and compounds do	40,876	34,709	52,432	48,178
Potash do	7,322,100	600,600	7,947,700	658,100
Pumice:				
Crude or unmanufactured short tons	2,699	113	16,703	402
Wholly or partly manufactured do	181,606	1,166	276,023	1,933
Manufactured, n.s.p.f	NA	106	NA	148
Quartz crystal (Brazilian lascas) thousand pounds	153	121	569	373
Salt thousand short tons	5,997	60,194	7,545	74,100
Sand and gravel:				
Industrial sand do	58	1,619	26	926
Other sand and gravel do	123	1,047	151	1,603
Sodium compounds:				
Sodium carbonate do	20	2,704	17	2,301
Sodium sulfate do	343	27,921	265	21,198
Stone:				
Crushed do	r2,279	10,709	2,923	15,071
Dimension	NA	195,378	NA	231,678
Calcium carbonate fines thousand short tons	r384	r1,901	292	2,471
Strontium:				
Minerals short tons	49,796	r3,707	48,852	4,293
Compounds do	r1,137	r1,099	4,755	3,386
Sulfur and compounds, sulfur ore and other forms, n.e.s thousand metric tons	1,695	129,110	2,557	200,189
Talc, unmanufactured thousand short tons	44	7,691	45	9,156
Total	XX	r23,891,382	XX	31,440,437

rRevised. NA Not available. XX Not applicable.
[1]Less than 1/2 unit.
[2]Includes titanium slag averaging about 70% TiO_2. For details, see "Titanium" chapter.
[3]Owing to a change of reporting, 1982 calcium borate, crude, imports are not comparable with those of previous years.

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

(Thousand short tons unless otherwise specified)

Mineral	1983			1984[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						
Antimony (content of ore and concentrate) short tons	55,526	838	2	58,857	557	1
Arsenic trioxide[2] metric tons	26,210	W	NA	32,674	W	NA
Bauxite[3] thousand metric tons	78,861	679	1	84,664	856	1
Beryl short tons	10,335	6,665	64	9,670	6,030	62
Bismuth thousand pounds	8,431	W	NA	8,675	W	NA
Chromite	9,387	--	--	10,468	--	--
Cobalt (content of ore and concentrate) short tons	26,445	--	--	34,245	--	--
Columbium-tantalum concentrate (gross weight) thousand pounds	46,908	--	--	67,236	--	--
Copper (content of ore and concentrate) thousand metric tons	7,690	1,038	13	7,909	1,091	14
Gold (content of ore and concentrate) thousand troy ounces	44,882	1,956	4	46,035	2,059	4
Iron ore (gross weight) thousand long tons	723,893	37,562	5	789,440	51,269	6
Lead (content of ore and concentrate) thousand metric tons	3,366	466	14	3,190	333	10
Manganese ore (35% or more Mn, gross weight)	24,093	--	--	25,341	--	--
Mercury thousand 76-pound flasks	181	25	14	174	19	11
Molybdenum (content of ore and concentrate) thousand pounds	140,295	33,593	24	208,665	103,664	50
Nickel (content of ore and concentrate)	723	--	--	820	15	2
Platinum-group metals[2] thousand troy ounces	6,524	6	([4])	7,053	15	([4])
Silver (content of ore and concentrate) do	392,268	43,415	11	398,554	44,440	11
Tin (content of ore and concentrate) metric tons	210,653	W	NA	207,842	W	NA
Titanium concentrates (gross weight):						
Ilmenite	2,967	W	NA	3,183	W	NA
Rutile	351	W	NA	391	W	NA
Tungsten ore and concentrate (contained tungsten) metric tons	39,430	980	2	44,939	1,203	3
Vanadium (content of ore and concentrate) short tons	30,924	2,171	7	34,292	1,617	5
Zinc (content of ore and concentrate) thousand metric tons	6,160	297	5	6,419	278	4
METALS, SMELTER BASIS						
Aluminum (primary only) do	13,945	3,353	24	15,521	4,099	26
Cadmium metric tons	16,725	1,052	6	17,687	1,686	10
Cobalt short tons	19,425	103	1	24,227	--	--
Copper smelter (primary and secondary)[5] thousand metric tons	8,092	987	12	8,258	1,060	13
Iron, pig	510,506	48,770	10	539,216	51,961	10
Lead, smelter (primary and secondary)[6] thousand metric tons	5,267	1,018	19	5,319	979	18
Magnesium (primary)	286	115	40	358	159	44
Nickel[7]	704	33	5	756	45	6
Selenium[8] kilograms	1,407,311	353,860	25	1,180,729	W	NA
Steel, raw	730,291	[9]84,615	12	778,928	[9]92,528	12
Tellurium[8] kilograms	93,616	W	NA	92,175	W	NA
Tin metric tons	211,756	[10]2,500	1	209,049	[10]4,000	2
Zinc (primary and secondary) thousand metric tons	6,201	305	5	6,448	331	5
NONMETALS						
Asbestos do	4,276	70	2	4,338	57	1
Barite	5,986	[11]754	13	6,313	[11]775	12
Boron minerals	2,446	1,303	53	2,541	1,367	54
Bromine thousand pounds	788,863	[11]370,000	47	855,730	[11]385,000	45
Cement, hydraulic	1,008,418	[12]71,347	7	1,058,721	[12]78,699	7
Clays:						
Bentonite[8]	5,708	[11]2,887	51	5,988	[11]3,154	53
Fuller's earth[8]	2,488	[11]1,912	77	2,526	[11]1,899	75
Kaolin[2]	21,656	[11]7,203	33	24,298	[11]7,953	33

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	1983			1984[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
NONMETALS —Continued						
Corundum short tons	20,096	--	--	19,627	--	--
Diamond thousand carats	55,819	--	--	63,830	--	--
Diatomite	1,668	619	37	1,664	627	38
Feldspar	4,082	710	17	4,011	710	18
Fluorspar	4,738	61	1	5,070	72	1
Graphite short tons	636,995	W	NA	631,842	W	NA
Gypsum	86,374	12,884	15	90,302	14,319	16
Iodine, crude thousand pounds	27,649	W	NA	27,255	W	NA
Lime	121,947	[11 12]14,902	12	124,796	[11 12]15,956	13
Magnesite	12,320	W	NA	11,953	W	NA
Mica (including scrap and ground) thousand pounds	528,934	280,000	53	575,375	322,000	56
Nitrogen, N content of ammonia	85,414	11,297	13	90,176	13,309	15
Peat	411,868	704	([4])	413,069	800	([4])
Perlite	1,441	[11]474	33	1,449	[11]498	34
Phosphate rock (gross weight) thousand metric tons	139,265	42,573	31	150,571	49,197	33
Potash (K_2O equivalent) do	27,426	1,429	5	28,638	1,564	5
Pumice[8]	12,404	[11]449	4	13,365	[11]502	4
Salt	175,563	[11 12]34,605	20	185,132	[11 12]39,255	21
Sodium compounds, natural and manufactured:						
Sodium carbonate	31,291	8,467	27	31,499	8,511	27
Sodium sulfate	4,410	855	19	4,364	872	20
Strontium[8] short tons	150,942	--	--	148,730	--	--
Sulfur, all forms thousand metric tons	50,315	9,290	18	51,884	10,652	21
Talc and pyrophyllite	7,800	1,066	14	7,967	1,170	15
Vermiculite[8]	493	282	57	550	315	57

[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 J. Fletcher Smoak[1]

CONTENTS

The value of abrasive materials consumed in the United States increased 37% in value over that of 1983 to $439 million; of which, 58% was manufactured abrasives, 36% was industrial diamond (natural and synthetic), and 6% was natural abrasives.

Production value of natural abrasives, which consist of crude tripoli, special silica stone, garnet, and emery, increased 4%. Production of crude tripoli, a finely disintegrated chert, increased 12% in quantity and 8% in value. Shipments of processed tripoli increased only 3% in quantity but increased 16% in value, with large increases occurring in both major end-use categories. Production of garnet, an abundant iron-aluminum silicate, decreased slightly in quantity and value after posting continued increases in quantity and value since 1980. There was a significant decrease in the quantity and

Table 1.—Salient U.S. abrasives statistics

	1980	1981	1982	1983	1984
Natural abrasives production by producers:					
Tripoli (crude) short tons	121,233	107,330	112,928	111,020	124,482
Value thousands	$676	$617	$653	$649	$699
Special silica stone[1] short tons	631	[2]2,501	[2]1,285	[2]1,101	[2]1,290
Value thousands	$1,933	[2]$1,096	[2]$553	[2]$482	[2]$602
Garnet[3] short tons	26,909	25,451	27,303	29,767	29,647
Value thousands	$1,908	$2,059	$2,321	$2,533	$2,487
Emery short tons	W	W	W	W	W
Value thousands	W	W	W	W	W
Manufactured abrasives[4] short tons	614,963	[5]586,915	418,224	[5]418,153	[5]531,264
Value thousands	$216,946	[5]$225,503	$167,471	[5]$167,430	[5]$203,231
Foreign trade (natural and artificial abrasives):					
Exports (value) do	$193,679	$189,719	$174,126	$192,794	$191,003
Reexports (value) do	$47,521	$27,758	$22,650	$24,111	$27,248
Imports for consumption (value) do	$268,842	$301,695	$245,048	$289,865	$381,694

W Withheld to avoid disclosing company proprietary data.

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

[2]The large increase in quantity and decrease in value was caused by changes in reporting procedures. In 1980, quantity and value were for finished products; 1981-84 data were for crude mined quantity and first marketable value. Finished product data are shown in table 6.

[3]Primary garnet; denotes first marketable product.

[4]Includes Canadian production of crude silicon carbide and fused aluminum oxide and shipments of metallic abrasives by producers.

[5]Excludes U.S. and Canadian production and value of aluminum-zirconium oxide.

value of refined garnet shipped compared with that of 1983, a record-high year; however, the overall trend continued to be upward. Production of crude special silica stone increased 17% in quantity and 25% in value, and shipments of finished special silica stone products increased 13% in quantity but only 4% in value. The disproportionate increase between shipment quantity and value was attributed to the lack of increase in shipments of finished oilstones and whetstones, which only accounted for 51% of the total quantity shipped but represented 94% of the total value. Several of the small oilstone-whetstone cutting operations went out of business or were inactive during the year. Production of emery, an impure aluminum oxide, reversed its downward trend with a reported 48% increase in quantity and a 53% increase in value of product mined and shipped.

The nonmetallic manufactured abrasives industry, which consisted of crude silicon carbide and fused aluminum oxide, experienced a 27% increase in shipments but reported only an 18% increase in value. The unit values of these shipments, except for high-purity fused aluminum oxide, dropped from those of 1983 because of strong price competition.

The metallic abrasives industry, which consisted of primary producers of steel shot and grit, chilled and annealed iron shot and grit, and cut wire shot manufacturers, reported an impressive 27% increase in both quantity and value shipped over that of 1983. This industry has been experiencing a continued recovery; however, the shipped unit values were reported at the same levels as those of 1983.

U.S. production of synthetic diamond grit and powder increased 10% in quantity to 76 million carats, establishing a new record high. Exports of grit and powder reached a new record high at 47 million carats, a 15% increase over that of 1983.

Total imports for consumption of abrasive materials increased 32% in value. Imports of industrial diamond increased 28% in value and 76% in quantity. The smaller increase in value and huge increase in quantity was attributed to a 92% increase in imports of synthetic grit, powder, and dust with a unit value decrease of 7% to $1.36 per carat and a 34% increase in imported stone with a corresponding value decrease of 20% to $8.03 per carat. Imports of synthetic grit, powder, and dust from Ireland increased 113% in quantity and accounted for the bulk of the increase in imports in this category. The average value of the synthetic grit, powder, and dust imported from Ireland decreased from $1.62 per carat in 1983 to $1.44 per carat. Total exports plus reexports of abrasive materials increased 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 53 operations canvassed, 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 13% in volume to 51.3 million carats but decreased 10% in value to $104.8 million. This was a record-high quantity. The increase in quantity was attributed to the record-high level exports of domestically produced synthetic diamond powder and dust. The diamond content in diamond wheels, exported and reexported, was 536,000 carats, a 15% increase; the declared value was $5.1 million, an increase of 4%. The value of imported diamond wheels increased 52% to $8.2 million.

Imports of abrasive materials increased 32% in value, and exports plus reexports increased slightly in value. Net imports were valued at $163.4 million.

Industrial diamond imports totaled 43.7 million carats of loose material valued at $113.6 million, an increase of 76% in quantity and 28% in value. The smaller increase in value with the corresponding large increase in quantity was attributed to two occurrences:

1. A huge increase in imports to 28.4 million carats of synthetic powder dust at only $1.36 per carat compared with 14.8 million carats at $1.47 per carat in 1983. Imports from Ireland increased 113% in this category and accounted for the bulk of the increase.

2. An increase in imports of stones of 2.2 million carats while the value decreased $1.95 per carat to $8.03.

Ireland, the largest U.S. source of industrial diamonds in terms of quantity, shipped to the United States a total of 25.6 million carats, mostly synthetic, valued at $40.0

million. Although the quantity increased 120%, the value only increased 91%, primarily because of an 11% decline in the unit price of synthetic powder and dust. Of the 25.6 million carats from Ireland, 21.8 million carats was synthetic powder and dust with an average value of $1.44 per carat. The share of imports of industrial diamond from Ireland was 59% of the total quantity and 35% of the 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 7.9 million carats valued at $49.8 million, an increase of 48% in quantity and 17% in value. The share of imports from the Republic of South Africa was 18% of the total quantity and 44% of the total value. Of the 7.9 million carats, 5.8 million carats was industrial stones with an average value of $7.84 per carat, 25% less than that of 1983.

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

(Thousands)

Kind	1983		1984	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust carats	41,071	$79,419	47,213	$72,484
Industrial diamond, natural or synthetic, other do	1,252	14,223	859	6,626
Emery, natural corundum, pumice in blocks pounds	9,389	866	3,783	947
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) do	23,486	14,393	24,588	15,329
Silicon carbide, crude or in grains do	10,611	6,768	11,365	8,086
Carbide abrasives, n.e.c. do	675	1,022	911	1,250
Other refined abrasives do	30,333	13,125	29,939	17,078
Grinding and polishing wheels and stones:				
Diamond carats	459	4,793	532	5,085
Polishing stones, whetstones, oilstones, hones, similar stone number	917	2,642	827	2,360
Wheels and stones, n.e.c pounds	3,514	19,459	3,465	20,171
Abrasive paper and cloth, coated with natural or artificial abrasive materials do	10,990	31,513	11,915	36,045
Grit and shot including wire pellets do	14,217	4,571	18,313	5,542
Total	XX	192,794	XX	191,003

XX Not applicable.

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

(Thousands)

Kind	1983		1984	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Industrial diamond, natural or synthetic, powder or dust carats	1,241	$3,080	779	$1,853
Industrial diamond, natural or synthetic, other do	1,933	19,842	2,442	23,815
Emery, natural corundum, pumice in blocks pounds	420	276	227	230
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) do	--	--	282	126
Silicon carbide, crude or in grains do	568	396	680	527
Carbide abrasives, n.e.c. do	--	--	10	71
Grinding and polishing wheels and stones:				
Diamond carats	8	117	4	56
Polishing stones, whetstones, oilstones, hones, similar stone number	1	10	--	--
Wheels and stones, n.e.c pounds	28	219	32	200
Abrasive paper and cloth, coated with natural or artificial abrasive materials do	68	171	XX	370
Total	XX	24,111	XX	27,248

XX Not applicable.

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

(Thousands)

Kind	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Emery, flint, rottenstone, tripoli, crude or crushed ___short tons__	4	$367	20	$421
Silicon carbide, crude ___do___	79	39,573	64	29,992
Aluminum oxide, crude ___do___	131	53,670	175	75,755
Other crude artificial abrasives ___do___	(1)	136	8	3,513
Abrasives, ground, grains, pulverized or refined:				
Rottenstone and tripoli ___do___	--	--	--	--
Silicon carbide ___do___	5	7,890	7	9,343
Aluminum oxide ___do___	12	9,848	21	17,140
Emery, corundum, flint, garnet, other, including artificial abrasives ___do___	3	3,712	3	5,475
Papers, cloths, other materials wholly or partly coated with natural or artificial abrasives	(2)	52,248	(2)	71,525
Hones, whetstones, oilstones, polishing stones ___number__	1,045	1,009	2,191	1,154
Abrasive wheels and millstones:				
Burrstones manufactured or bound up into millstones short tons__	(1)	21	(1)	49
Solid natural stone wheels ___number__	40	77	291	165
Diamond ___do___	148	5,416	229	8,207
Abrasive wheels bonded with resins ___pounds__	5,654	10,445	9,662	16,469
Other	(2)	8,635	(2)	12,313
Articles not specifically provided for:				
Emery or garnet	(2)	97	(2)	250
Natural corundum or artificial abrasive materials	(2)	3,321	(2)	8,886
Other	(2)	2,239	(2)	4,494
Grit and shot, including wire pellets ___pounds__	8,946	2,149	18,759	2,385
Diamond, natural and synthetic:				
Diamond dies ___number__	8	395	12	526
Crushing bort ___carats__	46	145	219	291
Natural industrial diamond stones ___do___	5,303	55,393	7,125	58,838
Miners' diamond ___do___	3761	5,134	31,157	7,690
Powder and dust, synthetic ___do___	14,792	21,714	28,381	38,684
Powder and dust, natural ___do___	3,975	6,231	6,828	8,129
Total	XX	289,865	XX	381,694

XX Not applicable.
[1]Less than 1/2 unit.
[2]Quantity not reported.
[3]Includes 2,000 carats of synthetic miners' diamond in 1983, and 43,000 carats in 1984.

TRIPOLI

Fined-grained, porous silica materials are grouped together under the category "tripoli" because they have similar properties and end uses. Production of crude tripoli (table 1) increased in quantity and value as producers increased mine output to rebuild crude inventories. Processed tripoli, sold or used, increased 3% in quantity and 16% in value; most of this increase in quantity was for abrasive material; however, the value increases 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. Advantages of its use in paint include its chemical inertness, for corrosion-resistant coatings; a low surface moisture, which allows it to be mixed into ambient-moisture-cured systems without predrying; good wettability and dispersion properties in a solvent base; a General Electric Co. brightness of 85% to 90% and low oil absorption, allowing high pigment loading without appreciable increases in viscosity; and a relatively high Mohs-scale hardness of 6.5 to 7, which provides resistance to abrasion.[2]

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, and both of 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 Engineering and Mining Journal, December 1984, 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		1980	1981	1982	1983	1984
Abrasives	short tons	39,352	34,494	35,798	38,073	40,812
Value	thousands	$2,253	$2,206	$2,477	$3,203	$3,738
Filler	short tons	59,909	56,932	55,314	65,138	65,941
Value	thousands	$4,025	$4,393	$4,557	$6,077	$6,989
Total[3]	short tons	99,261	91,426	91,111	103,211	106,753
Total value[3]	thousands	$6,277	$6,600	$7,034	$9,280	$10,727

[1]Includes amorphous silica and Pennsylvania rottenstone.
[2]Partly estimated.
[3]Data may not add to totals 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 Ohio and Wisconsin.

Four main grades of whetstone were produced, ranging from the high-quality Arkansas Stone, with porosity of 0.07% and characterized by a waxy luster, down to the 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.

The much-coveted Black Hard Arkansas Stone was relatively expensive at more than $30 for an 8- by 2- by 1-inch stone. Only about 5% of the blocks quarried was recovered as finished whetstone, and the producers continued to seek uses for the rejected material. Some was used in the production of silica-brick refractories, grinding media, lightweight aggregates, a wet abrasive blasting medium, and as a filler-extender.[3]

Arkansas finished stone production accounted for 60% of the total value and 40% of the total quantity of special silica stone products sold or used by U.S. producers.

Frontier Whetstone Cutting Co., Hot Springs, AR, and Natural Hones Inc., Malvern, AR, reported no production and have permanently ceased operations. American Trails Whetstone Co., Glenwood, AR, and Poor Boy Whetstones, Hot Springs, AR, were idle during the year. The previous management of Natural Hones started a new company, Arkansas Oilstone Co., Hot Springs, AR, and reported production.

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

Year	Quantity (short tons)	Value (thousands)
1980	631	$1,933
1981	523	[2]3,928
1982	713	5,360
1983	602	3,814
1984	683	3,975

[1]Includes grindstones, oilstones, and whetstones. Excludes grinding pebbles and tube-mill liners.
[2]Large increase in value because inclusion of nonquarrying finished stone producers was initiated and continued.

Table 7.—Producers of special silica stone products in 1984

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.
Wallis Whetstone Inc.:		
Malvern, AR (inactive)	Quarry	Crude novaculite.
Washita Mountain Whetstone Co.:		
Lake Hamilton, AR	Stone cutting and finishing	Whetstones and oilstones.

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. Four domestic producers continued to be active, two in New York and one each in 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 garnet was used mostly in sandblasting and in bonded abrasives. 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., near Rangeley in Oxford County, ME, produced almandine garnet and a garnet-containing utility grit, which was used largely in sandblasting and water filtration.

Production of garnet decreased slightly in quantity and value after posting continued increases every year since 1980. There was a significant decrease in the quantity and value of refined garnet shipped compared with that of 1983, a record-high year; however, the overall trend continued to be upward.

Construction of a new garnet processing plant has been completed in Geraldton, Western Australia. The plant will produce a range of grits for coated abrasives and powders for a wide variety of polishing applications in addition to the normal range of garnet for impact finishing and liquid filtration.[4]

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

Year	Quantity (short tons)	Value (thousands)
1980	26,550	$4,934
1981	25,519	5,204
1982	26,660	5,549
1983[r]	30,300	5,970
1984	27,672	5,677

[r]Revised.

CORUNDUM AND EMERY

Corundum.—There were no imports of abrasive-grade corundum during 1980-84. Demand was met by withdrawal from stocks. In recent years, the domestic supply has 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	1980	1981	1982	1983[p]	1984[e]
India	1,603	1,424	1,494	787	550
South Africa, Republic of	155	100	68	54	22
U.S.S.R.[e]	9,500	9,500	9,500	9,600	9,600
Uruguay[e]	206	240	[r]50	[r]55	55
Zimbabwe	20,592	13,450	9,606	[r] [e]9,600	9,400
Total	32,056	24,714	20,718	20,096	19,627

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 4, 1985.

Emery.—Two companies, De Luca Emery Mine Inc. and John Leardi Emery Mine, continued to operate emery mines, both near Peekskill in Westchester County, NY. The ore containing corundum, spinel, and magnetite, with some silicate accessory minerals, was processed by two companies—Washington Mills Abrasives Co., North Grafton, MA, and Emeri-Crete Inc., New Castle, NH. Domestic emery was used mostly as a nonslip additive for floors, pavements, and stair treads. Minor uses were as coated abrasives and tumbling or deburring media.

World production of emery was principally from Greece and Turkey. In 1983, production of emery in Greece was reported to be 7,724 short tons, and production in Turkey was reported to be 25,183 tons.

Prices quoted for emery by domestic suppliers in December 1984 ranged from $145 per ton for the lowest grade nonskid flooring material to $520 per ton for specialized industrial abrasive grade, in truckload quantities, f.o.b. plant.

INDUSTRIAL DIAMOND

Domestic production of synthetic industrial diamond was estimated to be at a record-high level of 76 million carats, a 10% increase, and the prime contributing factor to the record-high level of exports for both value and quantity of industrial diamond. Secondary production, salvage from used diamond tools and from wet and dry diamond-containing waste, was estimated to be 2.2 million carats. 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.

The U.S. Government industrial diamond stockpile inventory, as of December 31, was at the desired goal of 22.0 million carats of crushing bort; however, the 14.0 million carats of stone exceeded the goal for stone of 7.7 million carats. Available for disposal, from enabling legislation effective October 1, 1984, was 6.3 million carats of stone. The inventory of small diamond dies was 25,473 pieces; the goal was 60,000 pieces; however, there has been no purchase authorization issued.

The United States remained the largest consumer of natural industrial diamond stones but was totally dependent on foreign sources, importing approximately 8.3 million carats.

Exports plus reexports of industrial diamond dust and powder, including synthetic, was at a record-high level for quantity of 48.0 million carats valued at $74.3 million. Exports plus reexports of stone totaled 3.3 million carats valued at $30.4 million.

The Geological Survey of Wyoming reported that exploration is continuing in the Colorado-Wyoming State Line District and the Iron Mountain District of Wyoming. Of the more than 100 known kimberlite occurrences, 15 have yielded diamond. The Happy Jack area between the State Line and Iron Mountain Districts also has potential as a kimberlite source.

Exploration has continued in Upper Michigan, but commercial potential remains unknown. Several companies have been involved in exploratory operations and have established offices in Crystal Falls, MI.

De Beers Consolidated Mines Ltd. reported that the industrial side of its business had another good year in 1984. There was improvement in sales of natural grit, but sales of drilling stones continued to be affected by the depression in minerals exploration. Sales of synthetic grit and polycrystalline diamond products, which had passed the $100 million mark in 1983, rose by as much as 15%, and there was further growth in the profitability of the three diamond synthesis factories facilitated by new techniques developed at the Diamond Research Laboratory. The improvement in demand for industrial diamonds was particularly encouraging in view of the fact that the Argyle Diamond Mines Joint Venture (ADMJV) mine in Australia, which will be a big producer of industrial-quality diamond, was due to come into full production at yearend 1985. Plans for marketing its production were being developed, and De Beers has intensified research into new uses of natural diamond grit.[5]

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

(Thousand carats and thousand dollars)

Year	Quantity	Value
1982	19,127	85,837
1983	24,877	88,617
1984	43,710	113,632

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

(Thousand carats and thousand dollars)

	Natural industrial diamond stones (including glazers' and engravers' diamond, unset)				Miners' diamond[2]				Powder and dust, synthetic				Powder and dust, natural			
	1983		1984		1983		1984		1983		1984		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	3	79	2	61	--	--	--	--	--	--	1	3	--	--	--	--
Belgium-Luxembourg	124	1,248	159	2,571	33	54	6	86	28	46	227	170	296	314	576	383
Canada	6	25	54	36	50	148	([3])	7	30	44	23	21	67	23	214	84
China	4	102	([3])	7	--	--	1	4	32	59	5	18	10	5	--	--
Congo	210	4,620	194	3,918	--	--	--	--	--	--	--	--	9	14	32	108
Finland	--	--	--	--	--	--	--	--	231	214	118	110	--	--	--	--
France	2	12	([3])	19	1	68	--	--	([3])	3	--	--	--	--	3	2
Germany, Federal Republic of	1	25	38	1,298	59	287	13	88	634	909	398	1,069	30	149	38	74
Ghana	4	69	([3])	7	([3])	2	1	10	--	--	--	--	23	86	--	--
Greece	--	--	2	5	--	--	--	--	347	322	702	426	--	--	--	--
Hong Kong	8	120	2	5	--	--	--	--	7	27	--	--	--	--	([3])	1
Ireland	69	361	113	218	360	1,931	1,015	5,823	10,216	16,593	21,766	31,446	1,008	2,029	2,684	2,553
Israel	6	136	14	49	--	--	--	--	77	186	7	19	2	6	16	25
Japan	12	313	8	276	3	3	1	4	1,465	1,032	3,040	2,263	([3])	8	14	63
Mexico	([3])	4	--	--	7	50	5	24	29	56	43	19	([3])	2	6	6
Netherlands	35	887	41	526	([3])	24	20	20	([3])	([3])	4	19	5	8	86	45
South Africa, Republic of	3,672	38,459	5,849	45,877	15	527	([3])	24	500	994	433	977	1,126	2,423	1,601	2,888
Switzerland	13	1,294	6	17	1	143	([3])	60	177	167	345	285	603	591	692	827
U.S.S.R.	--	--	([3])	30	--	--	--	--	83	25	73	18	350	104	351	116
United Kingdom	521	1,800	534	1,591	([3])	19	13	83	810	587	743	1,251	369	317	292	390
Venezuela	7	352	30	1,262	--	--	([3])	58	--	--	--	--	--	--	--	--
Zaire	461	1,202	36	54	223	1,579	22	118	33	49	51	137	7	20	167	400
Other Africa, n.e.c	127	4,178	40	941	([3])	119	2	54	--	--	--	--	48	17	8	12
Other	17	107	3	71	8	179	57	1,227	94	400	404	434	22	118	48	153
Total[4]	5,303	55,393	7,125	58,838	761	5,134	1,157	7,690	14,792	21,714	28,381	38,684	3,975	6,231	6,828	8,129

[1]Excludes 45,600 carats of crushing bort from Japan, the Netherlands, the Republic of South Africa, and the United Kingdom in 1983, and 219,300 carats from France, Japan, and the United Kingdom in 1984.

[2]Includes 2,000 carats of synthetic miners' diamond in 1983, and 43,000 carats in 1984.

[3]Less than 1/2 unit.

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

WORLD REVIEW

Angola.—Production targets of 1.80 and 2.0 million carats of diamonds were set for 1982 and 1983, respectively. Actual production in 1982 only reached 1.2 million carats, and it was unlikely that the target was met for 1983. Smuggling and illicit mining were estimated to be depriving the Government of up to 50% of diamond income. There was also strong evidence that the insurgent force, Unita, was deriving substantial income from smuggling activities. The fall in diamond prices had also hit hard, with revenues cut by one-half from more than $200 million in 1980 to $105 million in 1982. Current investments by the state-controlled mining company to boost production included a $7 million cyclone washer to treat 900 cubic meters per day of the Cuango gravels and a new sorting house, including a heavy media plant for the Lucapa region.[6]

One person has been sentenced to death and 122 others received jail terms in Angola, following a trial involving charges of diamond and currency smuggling and espionage. The case marks an attempt by Angola's Government to curb diamond smuggling.[7]

Australia.—The Australian public was to be offered a 5% stake in the ADMJV project by the government of Western Australia. This was to be achieved by the recently created Western Australian Development Corp. with a $65 million public offering. The 5% interest of Northern Mining Corp. NL had previously been sold to the Western Australian government.[8]

The ADMJV experienced a decline in the overall grade of production from its alluvial mining project. This was in line with the expected depletion of higher grade alluvial materials. At the same time, the 1984 output of diamonds was greater than anticipated as a result of greater plant capacity, improved throughput rates, and ore grades being higher than expected.[9]

Demonstrated economic reserves for the ADMJV diamond mine have been reported at 233 million carats of gem and cheap-gem diamond and 281 million carats of industrial diamond.[10]

The ADMJV diamondiferous lamproite pipe contains sufficient reserves to support a mining operation at 3 million tons per year for at least 20 years. The deposit has a surface area of 45 hectares. The pipe's southern section has a higher average grade (carat per ton) than its northern end. Proven ore reserves of 61 million tons at a grade of 6.8 carats per ton in the southern section will provide for 20 years of operation. The pipe will be mined by conventional open pit benching techniques, with waste being transported to adjacent dumps.

The topography of the mine area was extremely rugged, and initial access, pit development, and haulage road layout have been complex. About 20 million tons of waste was being prestripped during mine development. This work was due to be completed by the end of the third quarter of 1985.

The 15-kilometer access road from Great Northern Highway to the project has been upgraded. The all-weather jet airport was finished in September. ADMJV planned to operate the project on a commute system, using Perth, 3,000 kilometers away, and Kununurra, 220 kilometers distant, as residential bases for the majority of the work force. Commuting was expected to minimize any adverse social and environmental impacts and would provide the basis for a long-term, stable operation. It was proposed that employees would rotate through a cycle of 14 days on-site and 7 days leave in Perth. About 70 senior staff and support personnel would live in Kununurra, the nearest town to Argyle, and would commute to the site daily by air.[11]

Freeport of Australia Pty. Inc., a subsidiary of Freeport-McMoRan Inc. of New York, was carrying out a bulk sampling program on alluvial gravels about 20 kilometers from the AK-1 pipe where ADMJV was operating.

Freeport of Australia and its local partner, Gem Exploration and Minerals Ltd., recovered 2,370 diamonds from 2,350 tons of material during 1983-84, or nearly 0.17 carat per ton, but two of the terraces examined show more encouraging results: 0.35 to 0.56 carat per ton. A second separation plant was recently brought in to increase bulk testing, and if operations proved to be financially viable, the project would be launched by the end of 1985.[12]

The Australian Diamond Exploration Joint Venture had encouraging results in its exploration for diamonds in the Northern Territory during 1984. Preliminary sampling was conducted over 22 of the 37 "first priority" geophysical targets, and diamonds were discovered in 15 of them. The exploration area has now been narrowed down to a zone next to the border with Queensland. Geologists describe the find as potential kimberlite pipes, similar geologically to the earlier discoveries at Ellendale, Western Australia, which are still awaiting development. The gems are of higher quality than those at Argyle. The exploration established the presence of a number of magnetic anomalies similar to those of other African and Australian kimberlite cluster areas. It was concluded that the abundant presence of microdiamonds indicated the diamond-bearing source rocks to be in the proximity and are believed to be covered by about 20 to 100 meters of overburden. The three equal joint venture members are Ashton Mining Ltd., AOG Minerals Ltd., and Aberfoyle Ltd.[13]

Botswana.—Botswana was the world's second largest producer of diamonds with output reported at almost 13 million carats. Substantial increases in production and grade were reported from all three mines, Orapa, Letlhakane, and Jwaneng, with Jwaneng reporting a 1.6-million-carat increase in output. The recovery grade was 60.95, 30.63, and 149.02 carats per 100 metric tons, respectively, at Orapa, Letlhakane, and Jwaneng.[14]

Canada.—Renewed interest has been prompted by the recent discovery of kimberlite boulders contained in glacial gravels from the vicinity of Hearst Township in Ontario.

At least two companies were actively engaged in diamond prospecting in northeastern Ontario. They were Monopros Ltd., a Canadian subsidiary of De Beers, and BP Resources (Canada) Ltd.[15]

Ghana.—Ghana Consolidated Diamonds Ltd., which in 1983 produced just 340,000 carats of diamonds, was expected to begin production from its $12 million Birrim River project in February 1985. Output was projected to reach 1 million carats per year over a 15-year period based on reserves of 20 million carats.[16]

Guinea.—Guinea's $85.5 million Société Mixte Aredor-Guinea diamond mine was officially opened. The mine was 173 kilometers east of Kissidougou, in the Baule Basin. Exploration completed at the end of September 1983 proved reserves to be just under 2.1 million carats contained in almost 6.5 million cubic meters of gravel. The throughput rate at the mine was 400,000 cubic meters of alluvial diamond-bearing gravel per year. Prospecting results have shown that the deposit contained over 90% gem-quality diamonds, with stone sizes averaging 0.53 carat. Should further exploration prove successful, throughput was to be increased to 1 million cubic meters per year.[17]

A major new diamond area was discovered in Guinea. The main foreign partner in the Aredor-Guinea diamond project, Bridge Oil Ltd. of Australia, reported that the deposit, outside the main project area, contained six known kimberlite pipes and potentially rich alluvial diamonds. Production should begin in April 1985.[18]

Namibia.—Ocean Diamond Mining (ODM) recently acquired the mining rights for an area in the Atlantic off the coast of Namibia. ODM planned to recover diamonds from the area with a ship called the *Calypso,* which was to use air-lift techniques to excavate diamondiferous gravels. The operation would be close to the beach-mining projects of the De Beers Group and Consolidated Diamond Mines (Pty.) Ltd. Production was projected to be about 2,000 to 3,000 carats per month.[19]

Sierra Leone.—The Sierra Leone Government paid $8.5 million to acquire British Petroleum Co. (Sierra Leone) Ltd.'s 49.5% stake in the country's National Diamond Mining Co., according to a recent official statement. The Government now has total control of the country's diamond mining industry, its main foreign exchange earner.[20]

South Africa, Republic of.—Intensive prospecting continued in the interior of the Republic of South Africa, and although several new kimberlites were located, none has yet proved to be of economic importance. Sampling of the group of kimberlites on the Venetia farm in the Transvaal continued. However, a preliminary appraisal of the property suggests that a commercial mining operation would not be viable under present economic circumstances.[21]

Mafikeng Diamonds Ltd. planned to complete construction of a recovery plant at the Molopo alluvial diggings, about 10 kilometers from Mafikeng. The plant had been used for the initial feasibility studies for the operation. Recovery of about 1,000 carats of largely gem stone-quality diamonds per month during the trial mining program, from what was believed to be a low-grade deposit, led to the decision to convert to commercial operations. In addition to the major operation, diamonds were also recovered on a relatively small scale at alluvial diggings in the Taung district.[22]

U.S.S.R.—University scientists at Kharkov claim to have discovered a method of locating diamond-bearing rocks from the amounts of specific trace elements accumulating in overlying trees and shrubs. By using this new method in conjunction with traditional geological ones, it was reportedly found possible to delineate the deposit outlines. Successful testing of the method was carried out at established deposits in the Yakut area of the U.S.S.R.[23]

In 1983, the new Anabar diamond placer mine in Yakutia was reported to have been commissioned. This diamond placer on the Ebelyakh River was discovered in the mid-1960's, but development was delayed because of its remote location at the Arctic Circle.[24]

A major diamond mining complex on the bank of the Lena River reopened in 1984. The complex was temporarily closed for modernization and the installation of new purification filters. Industries are being encouraged by the Soviet Government to install closed-cycle water supply systems and purification facilities to prevent pollution of the arctic seas. Other installations planned along the same lines include the construction of a station for the biological purification of communal waste in the diamond mining area of Mirnyy and a mineralized sewage collector at the Mir diamond field.[25]

Zaire.—The average sale price received by Société Zairoise de Commercialisation de Minerais in 1983 rose to $8.63 from $7.59 per carat in 1982. Marketing contracts concluded with British Diamond Distributors Ltd. in March 1983 guaranteeing a minimum price of $8.55 per carat. The principal producer, Société Minière de Bakwanga (MIBA), also benefited in terms of both earnings and financial position from the devaluation of the zaire (national unit of currency), which took place on September 12, 1983.

MIBA inaugurated an important new production plant; a large 100,000-cubic-meter-per-month bucket dredge is now in operation and will be capable of producing 1.0 million carats per year. It should enable low-cost mining in areas that are uneconomical to mine by traditional methods. In a bid to control small-scale diamond mining, the Government, in November 1983, cleared all prospectors from MIBA's main operating centers, which cover about 5,000 square kilometers, but has legalized small miners elsewhere in MIBA's vast concession areas. It also intended to close the purchasing offices at Mbujimayi to individual miners. The Government policy, however, risks causing tension in a region where a host of prospectors depend for their living solely on the proceeds of illicit diamond mining.[26]

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

(Thousand carats)

Country	1980			1981			1982			1983[p]			1984[e]		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total	Gem[2]	Industrial	Total	Gem[2]	Industrial	Total
Angola	1,110	370	1,480	1,050	350	1,400	915	310	1,225	1,003	31	1,034	970	30	1,000
Australia	--	48	48	21	184	205	251	306	557	2,770	3,385	6,155	2,560	3,130	[3]5,690
Botswana	765	4,336	5,101	744	4,217	4,961	1,165	6,604	7,769	4,829	5,902	10,731	5,810	7,104	[3]12,914
Brazil[4]	253	414	667	163	926	1,089	80	450	530	200	800	1,000	220	880	1,100
Central African Republic	227	115	342	209	103	312	186	91	277	230	65	295	[3]270	[3]80	[3]350
China[e]	[r]180	[r]720	[r]900	[r]190	[r]760	[r]950	[r]200	[r]800	[r]1,000	[r]200	[r]800	[r]1,000	200	800	1,000
Ghana	126	1,132	1,258	85	751	836	68	616	684	34	306	340	35	315	350
Guinea[e]	12	26	38	12	26	38	13	27	40	[r]23	[r]17	[r]40	[3]34	[3]14	[3]48
Guyana	4	6	10	4	6	10	[e]5	[e]6	[e]11	5	7	12	5	5	10
India	12	2	14	14	2	16	11	2	13	12	2	14	12	2	14
Indonesia[e]	3	12	15	3	12	15	3	12	15	5	22	27	5	22	27
Lesotho	50	4	54	49	4	53	39	3	42	--	--	--	--	--	--
Liberia	123	175	298	132	204	336	170	263	433	132	198	330	[3]108	[3]132	[3]240
Namibia	1,482	78	1,560	1,186	62	1,248	963	51	1,014	915	48	963	884	46	[3]930
Sierra Leone	317	275	592	208	97	305	203	87	290	242	103	345	240	105	345
South Africa, Republic of:															
Finsch Mine	465	2,442	2,907	1,002	3,463	4,465	847	3,003	3,850	1,765	3,278	5,043	1,714	3,184	[3]4,898
Premier Mine	407	1,632	2,039	510	1,530	2,040	615	1,845	2,460	800	1,844	2,644	765	1,785	[3]2,550
Other De Beers properties[5]	1,550	1,489	3,039	1,603	1,069	2,672	1,359	906	2,265	1,400	569	1,969	1,452	593	[3]2,045
Other	390	145	535	314	35	349	521	58	579	589	66	655	585	65	650
Total	2,812	5,708	8,520	3,429	6,097	9,526	3,342	5,812	9,154	4,554	5,757	10,311	4,516	5,627	10,143
Tanzania	137	137	274	110	107	217	[e]100	[e]120	[e]220	183	78	261	182	78	260
U.S.S.R.[e]	2,250	8,600	10,850	2,100	8,500	10,600	2,100	8,500	10,600	3,700	7,000	10,700	4,300	6,400	10,700
Venezuela	238	483	721	102	388	490	[e]99	[e]394	[e]493	45	234	279	75	175	250
Zaire	345	9,890	10,235	450	8,550	9,000	[e]450	[e]8,550	[e]9,000	3,355	8,627	11,982	5,169	13,290	[3]18,459
World total	[r]10,446	[r]32,531	[r]42,977	[r]10,261	[r]31,346	[r]41,607	10,363	33,004	43,367	22,437	33,382	55,819	25,595	38,235	63,830

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

[1]Table includes data available through July 8, 1985. 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 (1980-84), the Central African Republic (1980-84), Guinea (1984), Liberia (1980-81, 1984), Sierra Leone (1980-81), and Venezuela (1980-81), 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]Series changed from estimated data to reported data to conform with official Brazilian Government published data.

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

TECHNOLOGY

Researchers were working with diamond crystallization in an effort to gain an understanding of the origin of natural diamond. A striking phenomenon was observed in experiments conducted at atmospheric pressure: When a piece of metal foil was placed on a diamond and heated in a hydrogen atmosphere, the foil progressively sunk into the diamond to form a smooth-walled hollow corresponding to the foil shape. The simplicity of obtaining various intricate hollows in diamond was so evident that it forced the researchers toward application of the newly discovered phenomenon.

The mechanism of the surprising phenomenon turned out to be rather simple. A piece of iron or nickel foil dissolved the diamond carbon at the contact. The dissolved carbon diffused through the foil, reacted with hydrogen on the foil's upper surface, and was removed as methane. By dissolving the diamond carbon on its lower surface and passing it through to the gas on its upper surface, the foil sank uniformly into the diamond. A more detailed analysis showed that sinking was due to fortuitous coincidence of the following factors:

1. At high temperature, carbon readily dissolves in certain metals.

2. Owing to small atom size, carbon can fairly quickly diffuse in a metal.

3. The carbon dissolved in a metal is chemically much more active than diamond and can react with such gases that neither diamond nor even black carbon react with, for example, hydrogen.

This "thermo-chemical working" has been applied to several applications, some of which are etched images on diamond, sharpening of diamond microsurgical knives, production of small diamond gears, boring square holes in diamond, wire-sawing diamond, and sawing and grinding polycrystalline diamond shapes.[27]

Improvements in the synthesis of "perfect" diamond and cubic boron nitride monocrystals necessitate control of the impurity content in the reaction zone of a high-pressure assembly. Available data on the elemental composition of lithographic stone and pyrophyllite, which are widely employed as pressure-transmitting media, indicate that these materials could be the source of impurities such as calcium, silicon, oxygen, magnesium, aluminum, and iron, which are often found in synthetic diamonds. Researchers examined the diffusion of capsule material (in this case, lithographic stone) into the reaction zone, which contained graphite samples 10 millimeters in diameter by 10.6 millimeters high.[28]

A new form of synthetic polycrystalline diamond was developed that can replace natural diamond and competitive synthetic-diamond products in surface-set drills and dressing tools and single-crystal natural and synthetic diamond in saw blades and grinding wheels. Particles produced in the piece-per-carat size for surface-set drills and dressing tools are priced in the $8-to-$10-per-carat range and can replace natural and carbonado diamond selling at considerably higher prices. Particles produced in the mesh-size range for saw-blade applications are priced at $3 to $5 per carat and can be used at much lower concentrations to replace single-crystal natural and synthetic diamond.[29]

When a Michigan engine manufacturer began using polycrystalline diamond inserts to mill cam housings made from die-cast SAE 305, low-silicon aluminum for 4-cylinder, overhead cam engines, tool life increased 9,000% over the previously used carbide tooling.

Engineers at this plant reported that, when using conventional carbide inserts to face-mill engine housings, cutter changes were required at least once during each shift. The carbide tooling could finish 700 to 1,500 parts before failure. But the polycrystalline diamond inserts were holding tolerances for 3 months, finishing more than 90,000 parts. When no longer able to generate finish tolerances, the diamond inserts are transferred to a roughing station where they machine another 150,000 parts.[30]

Core-drilling tests were made on southwestern Pennsylvania coalfields to test the newly developed all-polycrystalline-diamond triangles (PDT), no substrate base, against natural, single-crystal mined diamond. Penetration rates averaged 10 inches per minute for polycrystalline diamond compacts (PDC) bits and only 6 inches per minute for mined-diamond bits. There was a startling improvement in bit life when PDT bits replaced mined-diamond bits. PDT bit life averaged over 2,500 feet of hole compared with only 1,200 feet of hole for the mined-diamond bits.

PDT's are set in a metal matrix by the drill-bit manufacturer using procedures similar to those used to set mined-diamond stone.

Improved performance of bits made with the triangles is a result of polycrystalline microstructure of the diamond. The triangles do not have the inherently weak planes of mined diamond. Tiny diamond crystals in the triangles are strongly bonded to each other. Owing to these diamond-to-diamond bonds, the triangles resist fracture in all directions. Catastrophic failure owing to fracture under impact during drilling, a problem with mined-diamond bits, is therefore highly unlikely with PDT bits. Individual crystals fracture during drilling. This slow, even microfracturing exposes fresh, sharp diamond cutting edges. As a result, the polycrystalline diamond has far less tendency to polish or wear smooth than does single-crystal mined diamond.[31]

A plant producing particleboard door cases switched from carbide tools to PDC because tool edge life was only 4,822 linear feet for the carbide tool compared with almost 1.4 million linear feet with the PDC tool. This represented an edge-life improvement of 287 times and a cost savings of almost 18%.[32]

The Diamond Research Laboratory in Johannesburg, the Republic of South Africa, recently announced the development of an advanced family of thermally stable PDC. The key to the new material's distinctive properties was a synthesis process, which resulted in a special binder phase being retained as an integral part of the finished product. Consequently, the product was a dense, nonporous, fully intergrown polycrystalline diamond with substantially higher resistance to shock loading than other available types of thermally stable PDC where the binder phase had been removed.

From the application point of view, the unique properties, which include thermal stability up to 1,200° C, meant that the material was ideally suited to arduous operating conditions.

Like standard PDC, the new product was fully dense and intergrown, but, unlike the standard product, it was inherently stable since the residual matrix remained passive and no reaction occurred with the diamond. In standard PDC, the effect of high temperature causes extensive graphitization of the diamond catalyzed by the presence of the binder phase. The conversion of diamond to graphite led to catastrophic failure of the product. With standard PDC, thermal stability could be improved by removing the metallic binder phase using an acid-leaching technique. But although the partial removal of the active binder phase reduced substantially the catalytic conversion of diamond to graphite, the skeletal structure enabled oxygen to permeate freely through the open pores, which at high temperatures caused extensive graphitization from within.[33]

Abstracts relative to diamond materials and machines, including patents, were published monthly from January to June in the Industrial Diamond Review. Each 1984 monthly report contained 17 to 23 pages of abstracts and patent information.

MANUFACTURED ABRASIVES

Manufactured abrasives operations experienced a substantial turnaround in quantities and values shipped. These industries had suffered through 2 very lean years. Shipment levels in 1984, while encouraging, were still significantly below the 1981 levels. Price competition was strong; therefore, percentage increase in values are generally well below the percentage increase in quantities shipped, because of the lower unit values.

Five firms produced crude fused alumina in the United States and Canada at nine plants. Production was at only 53% of furnace capacity. Reported production of white, high-purity material increased 25% to 19,900 tons but was only 55% of the normal level. Production of regular material increased 29% in quantity and 26% in value to 156,800 tons and $53.7 million. Almost all of the combined output of white and regular material was for abrasive applications. Two companies reported shipping an appreciable quantity of regular material for refractory manufacture. Reported year-end stocks totaled 11,100 tons.

Electrominerals Div. of The Carborundum Co., which was consolidated in 1983 with the Processed Mineral Sector of Sohio Chemical and Industrial Products Co., along with QIT-Fer et Titane Inc., was reorganized as the Sohio Electro Minerals Co.

The Exolon Co., Tonawanda, NY, and ESK Corp., Hennepin, IL, merged on April 27, 1984, and formed The Exolon-ESK Co. ESK was owned by the West German company Wacker Chemie AG, which also owned Elektroschmelzwerk Kempten AG in the Federal Republic of Germany. The existing silicon carbide and fused aluminum oxide operations would remain the same, and the sales and executive offices were to be located in Tonawanda.

The Industrial Abrasives Div. of 3M Co. started manufacturing Cubitron, a gel-derived spinel containing 93% alumina and 7% magnesia, on a production basis in new facilities in Cottage Grove, MN. The high-purity material does not contain fracture lines.[34] Many grades of the material were produced for use on metal grinding belts, wood planing belts, and fiber-backed discs.[35]

One firm produced fused alumina-zirconia abrasive in plants in both Canada and the United States. All production was used for abrasive applications. Output increased in both tonnage and value.

Five firms in the United States and Canada produced silicon carbide in six plants. The companies produced crude material for abrasives, refractories, and other nonabrasive uses. Total production was only 62% of furnace capacity. Output during the year increased 26% to 137,000 tons and value increased 10%. Abrasive use increased 28% and accounted for 37% of the output. Metallurgical applications increased 68% and accounted for 52% of the output. Refractory applications decreased 46% and accounted for 11% of the output. One manufacturer stated that its breakdown between refractory and metallurgical applications in 1983 was reported incorrectly; however, it was unable to correct the error and could only state that the refractory application should have been lowered. The large decrease for refractory application for 1984 was, therefore, misleading, since the previous data are incorrect, but there was some reduction in refractory usage. Yearend stocks totaled 15,880 tons as of December 31.

Silicon Metal Products Ltd. continued recovery of fine-grained silicon carbide from granite sludge at its plant in Elberton, GA. The proprietary beneficiation process was developed by the company.

A new company, Northern Recovery Systems Inc., was formed for the purpose of recovering fine-grained silicon carbide from granite sludges. The company acquired the Vermont Minerals Inc. plant in Barre, VT. Commercial operation was scheduled to begin on May 1, 1985. The product will be over 90% silicon carbide, all finer than 200 U.S. mesh. The higher grade materials will be primarily sold to the refractories industry and the lower grade material will be sold to the metallurgical industry. Plant capacity was initially set at 2,500 tons per year, and feedstock material was assured for 5 years. Additional sources of feedstock material were being developed.

In the yearend 1984 stockpile report to Congress by the General Services Administration, the inventory of crude fused aluminum oxide abrasive grain was 51,000 tons. Stocks of crude silicon carbide were 80,550 tons; the goal was 29,000 tons.

Metallic abrasives were produced by 11 firms in 12 plants in the United States. Steel shot and grit comprised 91% of the total quantity of metallic abrasives sold or used; the balance included chilled iron shot and grit and annealed iron shot and grit. The following four States, in decreasing order of quantity, supplied 100% of the total sold or used: Pennsylvania, Michigan, Ohio, and Virginia. The total sold or used increased 26% in quantity and 27% in value.

Shipments of chilled and annealed iron shot and grit, produced by two companies, one in Indiana and one in Ohio, increased 9% in both quantity and value. Cut wire shot production, primarily stainless steel, production was reported by two firms, one in Michigan and one in New York.

TECHNOLOGY

A U.S. company developed a new water-jet cutting tool called the Paser for "Particle Stream Erosion." The system used a combination of high-pressure water and commercially available abrasive materials such as garnet or silica to cut through glass, metals, and other heavy or dense materials with no heat and reported leaving a clean, finished surface. Problems normally associated with heat buildup were eliminated; there was no danger of flying particles, and the unit produced no airborne dust when cutting materials such as fiberglass. Omnidirectional cutting permitted contouring and beveling. The cutting tool was designed to be integrated into computer-controlled systems.[36]

A firm in the United Kingdom also developed an abrasive water-jet cutting system. The cutter was reported to have the capability of drilling or slicing through hard materials such as rock, steel, glass, and reinforced concrete, as well as soft composites, plastic, and rubber. No sparks, heat, dust, or shocks were generated, so the technique could be used in explosive or flammable atmospheres as well as in areas where dust was a problem. The system operated at a moderate pressure and used abrasive entrained in the jet. Typical cutting speeds were 6 centimeters per minute on 3.81-centimeter mild steel plate, 12.7 centimeters per minute on 0.64-centimeter stainless steel plate, and 58.4 to 102 centimeters per hour on 30.5-centimeter-thick high-strength concrete.[37]

A domestic manufacturer developed two new silicon carbide products that were targets for structural application, such as high-performance ceramic components for heat engines. One of the ceramics was a patented silicon-carbide composite that possessed a toughness index over 50% greater than that of standard silicon carbide materials. The other was a patent-pending, silicon-carbide-based structural ceramic that could be electrical-discharge machined, which allowed the manufacture of precision components without diamond grinding.[38]

The Bureau of Mines produced high-purity ultrafine alpha-silicon carbide using the Bureau's patented turbomilling process. These powders with Brunauer-Emmett-Teller (BET) surface areas from 30 to 35 square meters per gram were produced in an all-polymer turbomill. These high-purity powders hot pressed to greater than 99% of their optimal density and exhibited properties commensurate with those of commercially available alpha-silicon carbide.[39]

Silicon carbide ceramics containing up to 24.6 volume percent of dispersed titanium carbide particles yielded fully dense composites by hot pressing. The microstructure consisted of fine titanium carbide particles in a fine-grained silicon carbide matrix. Addition of titanium carbide particles increased the critical fracture toughness of silicon carbide and yielded high flexure strength, both properties increased with increasing volume fraction of titanium carbide. The strengths at elevated temperatures were also improved by the titanium carbide additions. Observations of the fracture path indicated that the improved toughness and strength were a result of crack deflection by the titanium carbide particles.[40]

Silicon-nitrate and silicon carbide materials were developed by the Japanese Engineering Research Association for high-performance applications. The hot isostatically pressed ceramic materials were able to endure a tensile test of over 30 kilograms per square millimeter after 1,000 hours at temperatures above 1,200° C and a resistance to collapse under a continuously applied load of 10 kilograms. The indexes of reliability of the finished products were 32.9 for the silicon-nitrate and 20.3 for the silicon-carbide figures, which are comparable to the 20 to 25 range typical of cast metal products. With reliability on par with metals, these materials could find future use in such applications as turbine blades where high temperature strength is a prerequisite.[41]

Cubic boron nitride was produced by subjecting a starting mixture of hexagonal boron nitride, a conversion initiator, and an additive of crystalline hydrate to a pressure of 40 to 70 kilobars and to a temperature of 1,100° C to 1,200° C. The initiator was either alkaline, alkaline-earth metal, and/or a nitride of the metal, and the hydrate additive was a salt containing either sulfur, a halogen, and/or nitrogen. Compared with known methods, this procedure resulted in a 10% to 30% increase in conversion of hexagonal boron nitride to cubic boron nitride and a doubling of the number of grains above 100 micrometers in size.[42]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Harben, P. Tripoli and Novaculite—The Little Known Relations. Ind. Miner. (London), No. 184, Jan. 1983, p. 28.

[3]Work cited in footnote 2.

[4]Industrial Minerals (London). No. 196, Jan. 1984, p. 9.

[5]De Beers Consolidated Mines Ltd., Annual Report—1984. Extracts from Julian Ogilvie Thompsons Statement for 1984. Min. J. (London), v. 304, No. 7810, Apr. 26, 1985, pp. 296-297.

[6]O'D. Maisonpierre, R. Mining Annual Review—1984. Angola. Min. J. (London), June 1984, p. 386.

[7]Industrial Minerals (London). No. 208, Jan. 1985, p. 70.

[8]———. No. 204, Sept. 1984, p. 15.

[9]———. No. 210, Mar. 1985, p. 9.

[10]Bureau of Mineral Resources, Geology, and Geophysics, Australia. Table—Australian and World Identified Resources of Major Minerals and Fuels. Dec. 31, 1983.

[11]South African Mining, Coal, Gold, and Base Minerals. Argyle. V. 1, R 3.75, Jan. 1985, pp. 5-10.

[12]Mining Journal (London). V. 303, No. 7777, Sept. 7, 1984, p. 166.

[13]———. V. 303, No. 7792, Dec. 21, 1984. p. 433.

[14]De Beers Consolidated Mines Ltd. Annual Report—1984, p. 21.

[15]Mining Journal (London). V. 304, No. 7797, June 25, 1985, p. 59.

[16]Industrial Minerals (London). No. 207, Dec. 1984, p. 66.

[17]———. No. 200, May 1984, pp. 16-17.

[18]———. No. 206, Nov. 1984, p. 92.

[19]Page 119 of work cited in footnote 8.

[20]Mining Magazine. World Highlights. V. 151, No. 6, Dec. 1984, p. 563.

[21]Mining Journal (London). Mining Annual Review—1984. June 1984, p. 377.

[22]U.S. Embassy, Pretoria, Republic of South Africa. State Dep. Airgram A-11, Mar. 23, 1984, pp. 4-5.

[23]Page 187 of work cited in footnote 17.

[24]Levine, R. M. Mining Annual Review—1984. Eastern Europe—Soviet Union. Min. J. (London), June 1984, p. 477.

[25]Work cited in footnote 23.

[26]Mining Journal (London). V. 303, No. 7768, July 6, 1984, p. 2.

[27]Grigorieu, A. P., and V. V. Kovalsky. Working of Diamond With Metal. Inst. Geol. Yakutian Branch, Siberian Dep. of the U.S.S.R., Acad. Sci. Indiaqua 39, 1984/3, pp. 47-54.

[28]Davydov, V. A. Sverkhtverdye Materialy 1982, pp. 3-7. Abstracted Ind. Diamond Rev., v. 44, No. 500, Jan. 1985, p. 47.

[29]Cutting Tool Engineering. Product Review. V. 36, No. 3, Jan. 1984, p. 16.

[30]Mitchell, J. G. Switching to Diamond Tooling Optimizes Machinery Uptime for Engine Manufacturer. Cutting Tool Eng., v. 36, No. 3, June 1984, p. 36.

[31]Silter, D. K. Deliver at Least Double the Footage of Ordinary Bits. The Northern Miner, v. 70, No. 10. Sect. B, May 17, 1984, p. B5.

[32]General Electric Co., Specialty Materials Dep. (Wor-

thington, OH). Tools Made With Compact Blanks Stayed Sharp. Case History 114, Mar. 1985, p. 1.

[33]Mining Journal (London). Methods and Machines. V. 303, No. 7768, July 6, 1985, p. 8.

[34]Sheppard, L. M. Better Ceramics Through Chemistry. Mater. Eng., v. 99, No. 6, June 1984, pp. 45-52.

[35]Ceramic Industry. V. 123, No. 7, Dec. 1984, p. 12.

[36]Glass Industry. New Products. V. 65, No. 10, Oct. 1984, p. 8.

[37]World Mining Equipment. Technology Update. V. 8, No. 6, June 1984, p. 6.

[38]Materials Engineering. V. 99, No. 5, May 1984, p. 12.

[39]Wittmer, D. E. Use of Bureau of Mines Turbomill To Produce High Purity Nonoxide Ceramic Powders. BuMines IC 8854, 1984, 12 pp.

[40]Wei, G. C., and P. F. Becher. U.S. Dep. Energy, Oak Ridge National Lab. TN, DOE CONF-840440-1, 1984, 21 pp.; NTIS PB84-907144.

[41]Page 79 of work cited in footnote 9.

[42]Lysanov, V. S. Institut Sverktverdykh Materialov Akademii Nauk Ulkrainskoi U.S.S.R. Aug. 26, 1980. Abstracted Ind. Diamond Rev., v. 498, May 1983, p. 273.

Table 13.—Crude artificial abrasives manufacturers in 1984

Company	Location	Product
The Exolon-ESK Co	Hennedin, 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 (high-purity).
Do	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular) and silicon carbide.
Norton Co	Huntsville, AL	Fused aluminum oxide (high-purity).
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.
Satellite Alloy Corp	Springfield, PA	Silicon carbide.
Sohio Electro Minerals Co	Niagara Falls, NY	Fused aluminum oxide (high-purity).
Do	Vancouver, WA (inactive)	Silicon carbide.
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 1984

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 iron.
Metal Tec 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	Mishawaka, IN (inactive)	Steel.
Do	Bedford, VA	Do.

[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	1980	1981	1982	1983	1984
Silicon carbide[1]	170	156	112	109	137
Value	$64,346	$68,839	$54,507	$52,016	$57,125
Aluminum oxide (abrasive grade)[1]	193	203	132	137	177
Value	$63,881	$73,712	$45,975	$50,565	$63,818
Aluminum-zirconium oxide	19	W	8	W	W
Value	$8,438	W	$4,600	W	W
Metallic abrasives[2]	233	228	166	172	217
Value	$80,281	$82,952	$62,389	$64,849	$82,288
Total	615	[3]587	418	[3]418	[3]531
Total value	$216,946	[3]$225,503	$167,471	[3]$167,430	[3]$203,231

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.

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

Use	1983			1984		
	Quantity (short tons)	Value (thousands)	Yearend stocks (short tons)	Quantity (short tons)	Value (thousands)	Yearend stocks (short tons)
SILICON CARBIDE						
Abrasives	39,896	$20,680	3,953	50,946	$22,217	6,704
Metallurgical	42,300	17,875	5,571	71,140	28,718	6,140
Refractories and other	26,903	13,461	2,612	14,509	6,190	3,036
Total	109,099	52,016	12,136	136,595	57,125	15,880
ALUMINUM OXIDE						
Regular: Abrasives plus refractories[1]	121,167	42,587	10,490	156,814	53,740	9,175
High purity	15,940	7,978	1,937	19,856	10,078	1,950
Total	137,107	50,565	12,427	176,670	63,818	11,125

[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)	
1983:					
Chilled iron shot and grit	W	W	W	W	W
Annealed iron shot and grit	W	W	W	W	W
Steel shot and grit	154,856	$44,825	153,637	$57,770	272,000
Other[3]	16,648	6,507	18,310	7,079	36,000
Total	171,504	51,332	171,947	64,849	XX
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

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] and Pamela A. Stephenson[3]

World production of primary aluminum increased to a record-high level in 1984. The largest increases were in Australia, where new facilities came on-stream, and in the United States, where idled capacity was reactivated early in the year. Domestic producers increased their rate of production from about 78% of capacity at the beginning of the year to 87% by the end of May, but cut back to the 78% operating rate by yearend because of oversupply and consequent falling prices. Foreign sources of aluminum gained a larger share of the U.S. market, and net imports to the United States rose to a record-high level.

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 10 companies to which monthly survey requests were sent, 90% responded, representing 95% of the total primary aluminum production shown in tables 1, 5, and 12. Production data for the nonrespondent were estimated based on total primary aluminum monthly and annual production data from various sources.

Legislation and Government Programs.—On June 5, 1984, the Supreme Court upheld the contracts between the Bonneville Power Administration (BPA) and the Direct Service Industries, representing the aluminum producers and other industries of the Pacific Northwest. The decision, which overruled the Federal Court of Appeals in San Francisco, declared that BPA has the authority under Public Law 96-501, the Pacific Northwest Power Planning and Conservation Act of 1980, to make available and give preference to the industries in the allocation of surplus or "nonfirm" power. The public utilities claimed first rights to surplus power and had won their claim in the appeals court.

Table 1.—Salient aluminum statistics

(Thousand metric tons and thousand dollars unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Primary production	4,654	4,489	3,274	3,353	4,099
Value	$7,346,410	$7,520,841	$5,485,121	$5,754,298	$7,319,844
Price: Producer list, ingot, average cents per pound	71.6	76.0	76.0	77.8	81.0
Secondary recovery	1,260	1,394	1,466	1,564	[1]1,760
Exports (crude and semicrude)	1,346	787	748	776	734
Imports for consumption (crude and semicrude)	647	848	878	1,091	1,477
Aluminum industry shipments[2]	[r]5,515	[r]5,644	5,090	5,833	[p]6,519
Consumption, apparent	4,595	4,614	4,370	[r]5,035	5,279
World: Production	[r]15,383	[r]15,083	13,455	[p]13,945	[e]15,521

[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.

DOMESTIC PRODUCTION

Primary.—Production of primary aluminum was 4,099,045 metric tons in 1984. At the beginning of the year, the operating rate of the primary smelters was 78.4% with 1.08 million tons of the 5.0 million tons of reported annual capacity shut down. In February, U.S. annual smelter capacity was reduced to about 4.9 million tons because of the permanent closure of Reynolds Metals Co.'s 103,000-ton-per-year plant at San Patricio, TX, which had stopped metal production in May 1981.

As the economic recovery that began in mid-1983 continued into early 1984, producers continued to start up potlines, and by the end of May, the operating rate was up to 87.4%, with about 617,000 tons of annual capacity not operating. The status of the primary industry was as follows: 3 smelters permanently shut down, 3 temporarily shut down, 5 operating at reduced capacity, and 22 operating at full capacity.

However, metal prices began to decline in January as U.S. and world inventories increased. By June, U.S. producers began to reduce production in an effort to offset this trend. By yearend, the operating rate was down to 78.2% of annual production capacity, and the status of the industry was 3 smelters permanently closed, 4 temporarily closed, 14 operating at reduced capacity, and 12 operating at full capacity.

Through May, production capacity was started as follows: Kaiser Aluminum & Chemical Corp., 25,000 tons per year at Spokane, WA, and 37,200 tons per year at Ravenswood, WV; Reynolds, 80,000 tons per year at Listerhill, AL; ARCO Aluminum Co., 54,000 tons per year at Sebree, KY, and 44,000 tons per year at Columbia Falls, MT; Alumax Inc. (Eastalco Aluminum Co.), 40,000 tons per year at Frederick, MD; and Ormet Corp., 81,000 tons per year at Hannibal, OH. Facilities partially shut down from June through December were smelters of Aluminum Co. of America (Alcoa) at Evansville, IN, Badin, NC, Alcoa, TN, Rockdale, TX, and Vancouver, WA; Kaiser at Spokane, WA, and Ravenswood, WV; Reynolds at Listerhill, AL, Jones Mill, AR, and Troutdale, OR; Alumax at Mount Holly, SC, Frederick, MD, and Ferndale, WA; Consolidated Aluminum Corp. at New Johnsonville, TN; and ARCO at Columbia Falls, MT. Martin Marietta Corp. closed its The Dalles, OR, smelter in December.

In January, Alcan Aluminium Ltd., of Canada, and Atlantic Richfield Co. (ARCO) announced an agreement for Alcan to purchase from ARCO the 163,000-ton-per-year Sebree, KY, aluminum smelter; the new 181,000-ton-per-year Logan County, KY, rolling mill; a rolling mill in Terre Haute, IN; the packaging products mill and rolling mill in Louisville, KY; and its 25% interest in the Aughinish, Ireland, alumina refinery. The U.S. Department of Justice, in accordance with U.S. antitrust laws, approved the purchase in October but limited Alcan's ownership and management of the Logan County mill to 40%, with ARCO retaining a 60% share. ARCO's 163,000-ton-per-year Columbia Falls, MT, smelter reportedly remained available for sale.

In October, Martin Marietta announced the sale of a portion of its aluminum interests to Comalco Pty. Ltd., Australia, and to ARCO. Comalco agreed to purchase the 108,000-ton-per-year Goldendale, WA, primary aluminum smelter; a 109,000-ton-per-year rolling mill and a 204,000-ton-per-year recycling plant at Lewisport, KY; an alumina unloading port at Portland, OR; and other assets. ARCO reportedly agreed to purchase a 270,000-ton-per-year petroleum coke plant at Wilmington, CA, which Martin Marietta operated as a joint venture with Champlin Petroleum Co. In December, Martin Marietta entered into a joint venture with Nippon Kokan K.K. of Japan to form the International Light Metals Corp. to produce and market aluminum- and titanium-base alloy forgings and extrusions for the aerospace markets. The new company, held 60% by Martin Marietta and 40% by Nippon Kokan, was to operate the Torrence, CA, forging and extrusion plant formerly owned by Martin Marietta. At the end of 1984, The Dalles, OR, 81,600-ton-per-year primary smelter and the St. Croix, Virgin Islands, alumina refinery were still up for sale. On December 1, Martin Marietta announced the complete and immediate shutdown of The Dalles smelter since efforts to sell the plant were unsuccessful.

Norandal U.S.A. Inc., Noranda Aluminum Co.'s fabricating subsidiary, entered into an agreement to purchase Revere Copper and Brass Inc.'s Scottsboro, AL, aluminum sheet mill. Revere had been operating the mill under chapter 11 of the bankruptcy laws. Sale of the mill was reportedly part of the reorganization plan scheduled for submission to the bankruptcy court overseeing Revere's reorganization.

Kaiser resumed operations at its Halethorpe, MD, extrusions plant after workers ratified a 5-year labor contract. The plant was closed in late 1984 because of a failure between the union local and the company to reach a wage and cost concession agreement.

Alusuisse Metals Inc., Fairlawn, NJ, the U.S. trading and imports subsidiary of Swiss Aluminium Ltd. (Alusuisse), was incorporated into Consolidated Aluminum Corp., St. Louis, a wholly owned Alusuisse company.

Alumax announced plans to build a $150 million can sheet rolling mill in Texas. The plant was expected to be operational in mid-1986 with about 70,000 tons per year of sheet capacity. Most of the can sheet reportedly will be sold to Continental Can Corp. plants in San Jose, CA, and Portland, OR, under a long-term contract. To provide some of the material for the rolling mill, Alumax will build a 7,000-ton-per-year beverage container recycling plant in Texas. Continental Can will supply scrap feed for the recycling plant. Alumax sold its Howmet Aluminum Architectural Products Div. to Butler Manufacturing Co., Kansas City, MO, in May. Howmet Aluminum Architectural Products was originally part of Howmet Aluminum Corp., a subsidiary of Pechiney, which was sold to Alumax in 1983.

Alcoa planned to modernize its Warrick, IN, aluminum rolling mill facilities to produce wider and higher quality can sheet. The program, which began early in 1984, was expected to take 2 to 3 years. Two hot-rolling mills and one of four cold-rolling mills will be made wider. The modernization plan also included construction of an electromagnetic costing complex and quality control equipment. Construction was to begin in January 1985 on a three-stand, continuous, high-speed, cold-rolling mill for 80-inch-wide rigid container and other alloy sheet at the Alcoa, TN, mill facilities. The new rolls will have the capability to produce 80-inch-wide sheet 0.010-inch thick with a tolerance of plus or minus 0.0001 inch in coils of 96-inch diameter. The rolling mill was to be built by SMS Schloemann-Siemag AG of the Federal Republic of Germany. In addition to the new mill, other plant improvements at Alcoa, TN, include a new delacquering furnace for scrap beverage cans and the widening of an existing hot-rolling mill.

In July 1984, Kaiser completed a $200 million modernization of its Trentwood, WA, hot-rolling mill to reduce ingots into 1/8-inch coils. In late fall, work to upgrade a cold-rolling mill to produce wider sheet at a faster speed was started. When modernization of the mill is completed, the line will be able to finish coils from 40,000-pound ingots. Kaiser reopened its Halethorpe, MD, heavy-press extrusion plant in late spring after reaching a 5-year agreement with the local unit of the United Steelworkers of America (USWA). The plant was closed at the end of 1983 after workers turned down the company's offer of reduced wage and benefit concessions. However, on June 1, 1984, Kaiser closed its Bay Minette, AL, cable and wire manufacturing plant when the local union of the USWA refused to accept cuts in wages and other benefits. The plant remained closed for about 4 months and was reopened after an agreement was reached. After closing the Dolton, IL, extrusion plant in January, after failing to obtain wage and benefit concessions from its workers, Kaiser sold the plant in October to a former manager of Kaiser's extrusion division. The new company formed as a result of the sale was Dolton Extrusion Co.

Reynolds reopened its Malvern, AR, aluminum cable plant in January after reaching wage and benefit modifications with local members of the USWA. The plant, idled in September 1982, produces electrical cable products including overhead conductor and 600-volt cable.

The BPA proposed a revision to the formula under which investor-owned utilities in the Pacific Northwest obtain low-cost power from BPA in exchange for high-cost power produced by the utilities. The formula used by the utilities included many items believed unrelated to the cost of producing power. A revision of the formula to exclude these items would reduce the power costs to the aluminum smelters but could increase the cost to residential and nonindustrial consumers. The reduced costs to the smelters would benefit the aluminum industry in computing the 1983-85 "floor rate" for BPA power required by July 1, 1985, under the provisions of the 1980 Northwest Power Act. In August 1984, BPA offered Pacific Northwest aluminum producers an incentive rate reduction of 5 mills per kilowatt hour (kW•h) for a period of 6 months effective September 1. The discount was offered to stop the trend of Pacific Northwest aluminum production cutbacks during mid-1984. The offer reduced power costs to 22.7 mills/kW•h; however, producers were to maintain production at the September 1 levels, and use approximately 2,640 megawatts of power on a take or pay basis. In November, BPA dropped its controversial "customer charge," which required a minimum charge to aluminum smelters whether operating or not, from its proposed rate structure that was to take effect in July 1985. At the same time, BPA lowered the proposed July 1, 1985, rate of 25.2 mills/kW•h to an estimated 22 mills/kW•h.

Secondary.—Total consumption in 1984 of used beverage can scrap (UBC) by primary producers and secondary smelters increased about 4% compared with that of 1983. Primary producers increased UBC consumption by about 8%. Recycled UBC was equivalent to 50.7% of the aluminum can shipments, using an average of 25.9 cans to the pound.[4]

Reynolds began construction of a 45,000-ton-per-year secondary aluminum smelter near Sheffield, AL. The new smelter was being built adjacent to another Reynolds subsidiary smelter, the 109,000-ton-per-year Alabama Reclamation Co. plant, the largest secondary aluminum plant in the United States. A new Reynolds subsidiary, Southern Reclamation Co., will operate the new $10 million plant, expected to begin operation in 1985. The plant will have three automated rotary furnaces and be able to melt all forms of aluminum scrap. Both secondary ingot and molten metal will be produced at the plant. The addition of the new plant reportedly will raise Reynolds' secondary capacity to 282,000 tons per year.

Alumet Smelting Corp., Newark, NJ, was formed as a new fully integrated secondary smelter. The facility, adjacent to a scrapyard that will provide most of the aluminum scrap, has the capacity to produce about 1,400 tons of secondary ingot per year.

In March, Torrance Iron and Metal Co., Long Beach, CA, purchased the Fontana, CA, secondary smelting plant of the U.S. Reduction Co., a subsidiary of American Can Co., Greenwich, CT. In June, the remaining four smelters of U.S. Reduction were purchased by several executives of the secondary industry. A new organization formed by the shareholders retained the name of the 80-year-old U.S. Reduction. The new company included smelters in East Chicago, IL, Marietta, PA, Russellville, AL, and Toledo, OH. Also part of the new company are U.S. By Products Corp., Kansas City, a producer of aluminum granules from scrap for explosives, and Amcan Trading, Leasing and Master Alloys, Russellville, a producer of specialty alloys from primary metal. The Toledo smelter, closed since 1982, was reopened by the new owners in September. The company's secondary capacity is about 91,000 tons per year.

In October, Batchelder-Beilin Inc., Chicago, a secondary smelter, filed for reorganization under chapter 11 of the Bankruptcy Code owing to excessive liabilities. Operations had been curtailed at the facility during the previous month.

CONSUMPTION

Apparent consumption of aluminum increased by about 5% in 1984 compared with that of 1983. Net shipments of aluminum ingot and mill products to domestic manufacturers of end products increased to 6.5 million tons in 1984 from 5.8 million tons in 1983. Transportation led the gains in end-use categories with a significant 26% increase over 1983 shipments, reflecting a rise in U.S. car and truck production over that of 1983. Domestic-make car sales of nearly 8 million in 1984 were the best since 1979. Shipments of aluminum for electrical uses registered the second largest percentage increase over that of 1983.

Although the containers and packaging industry remained the largest consumer of aluminum with 26% of total end-use shipments, the 1984 increase in consumption was only slightly more than 3%. The limited growth indicated that the aluminum beverage can market was near saturation. Also, competition from plastic and lightweight steel alloy cans and from imported aluminum can stock was reportedly increasing. Aluminum can shipments, 97% of which was for beverages, accounted for 1.8 million tons of metal and represented 64% of all domestic metal can shipments during the year.

Table 2.—U.S. consumption of and recovery from purchased new and old aluminum scrap,[1] by class

(Metric tons)

Class	Consumption	Calculated recovery	
		Aluminum	Metallic
1983			
Secondary smelters	821,346	657,739	710,730
Primary producers	773,950	650,278	697,010
Fabricators	192,519	165,017	176,587
Foundries	86,626	72,259	77,726
Chemical producers	37,569	17,092	17,659
Total	1,912,010	1,562,385	1,679,712
Estimated full industry coverage	2,019,000	1,648,000	1,773,000
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

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

Table 3.—U.S. stocks, receipts, and consumption of purchased new and old aluminum scrap[1] and sweated pig in 1984

(Metric tons)

Class of consumer and type of scrap	Stocks, Jan. 1[r]	Net receipts[2]	Consumption	Stocks, Dec. 31
Secondary smelters:				
New scrap:				
Solids and clippings	14,920	235,810	237,995	12,735
Borings and turnings	10,451	138,295	139,463	9,283
Foil	W	W	W	W
Dross and skimmings	8,257	64,588	65,000	7,845
Other[3]	508	16,653	16,875	286
Total	34,136	455,346	459,333	30,149
Old scrap:				
Castings, sheet, clippings	8,618	168,130	168,031	8,717
Aluminum-copper radiators	2,241	18,441	19,207	1,475
Aluminum cans	1,080	[4]81,158	[4]79,932	2,306
Other	126	5,632	5,721	37
Total	12,065	273,361	272,891	12,535
Sweated pig	7,043	60,726	60,683	7,086
Total secondary smelters	53,244	789,433	792,907	49,770
Primary producers, foundries, fabricators, chemical plants:				
New scrap:				
Solids and clippings	25,001	431,232	437,641	18,592
Borings and turnings	361	28,305	28,474	192
Foil	W	W	W	W
Dross and skimmings	722	32,244	32,279	687
Other[3]	4,935	46,184	44,004	7,115
Total	31,019	537,965	542,398	26,586
Old scrap:				
Castings, sheet, clippings	964	63,071	62,994	1,041
Aluminum-copper radiators	71	1,239	1,299	11
Aluminum cans	13,990	[4]474,814	[4]462,848	25,956
Other	2,195	24,877	24,330	2,742
Total	17,220	564,001	551,471	29,750
Sweated pig	597	11,904	11,882	619
Total primary producers, etc	48,836	1,113,870	1,105,751	56,955

See footnotes at end of table.

Table 3.—U.S. stocks, receipts, and consumption of purchased new and old aluminum scrap[1] and sweated pig in 1984 —Continued

(Metric tons)

Class of consumer and type of scrap	Stocks, Jan. 1[r]	Net receipts[2]	Consumption	Stocks, Dec. 31
All scrap consumed:				
New scrap:				
Solids and clippings	39,921	667,042	675,636	31,327
Borings and turnings	10,812	166,600	167,937	9,475
Foil	2,565	10,498	10,746	2,317
Dross and skimmings	8,979	96,832	97,279	8,532
Other	2,878	52,339	50,133	5,084
Total new scrap	65,155	993,311	1,001,731	56,735
Old scrap:				
Castings, sheet, clippings	9,582	231,201	231,025	9,758
Aluminum-copper radiators	2,312	19,680	20,506	1,486
Aluminum cans	15,070	555,972	542,780	28,262
Other	2,321	30,509	30,051	2,779
Total old scrap	29,285	837,362	824,362	42,285
Sweated pig	7,640	72,630	72,565	7,705
Total of all scrap consumed	102,080	1,903,303	1,898,658	106,725

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Includes imported scrap. According to reporting companies, 6.52% of total receipts of aluminum-base scrap, or 124,001 metric tons, was received on toll arrangements.
[2]Includes inventory adjustment.
[3]Includes data on foil.
[4]Used beverage cans toll treated for primary producers are included in secondary smelter tabulation.

Table 4.—Production and shipments of secondary aluminum alloys by independent smelters in the United States

(Metric tons)

	1983		1984	
	Production	Net shipments[1]	Production	Net shipments[1]
Die-cast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	94,153	94,114	110,904	111,549
380 and variations	355,469	359,867	286,458	285,374
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	33,298	33,259	30,188	30,487
No. 12 and variations	W	W	W	W
No. 319 and variations	44,296	44,752	53,647	53,184
F-132 alloy and variations	9,492	9,732	13,535	13,296
Al-Mg alloys	553	618	548	632
Al-Zn alloys	4,865	4,748	4,095	4,309
Al-Si alloys (0.6% to 2.0% Cu)	5,451	5,489	4,293	4,337
Al-Cu alloys (1.5% Si, maximum)	2,936	3,124	2,573	2,512
Al-Si-Cu-Ni alloys	4,718	4,835	2,406	2,250
Other	2,211	2,260	481	495
Wrought alloys: Extrusion billets	107,949	110,757	107,292	105,684
Destructive and other uses: Steel deoxidation:				
Grades 1, 2, 3, and 4	25,825	25,287	23,778	23,084
Miscellaneous:				
Pure (97.0% Al)	405	437	168	169
Aluminum-base hardeners	1,586	1,483	1,557	1,566
Other[2]	14,489	14,639	6,799	6,788
Total	707,696	715,401	648,722	645,716
Less consumption of materials other than scrap:				
Primary aluminum	40,528	--	41,443	--
Primary silicon	38,023	--	35,093	--
Other	3,090	--	2,316	--
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot[3]	626,055	XX	569,870	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 5.—U.S. apparent aluminum supply and consumption

(Thousand metric tons)

	1980	1981	1982	1983	1984
Primary production	4,654	4,489	3,274	3,353	4,099
Change in stocks:[1] Aluminum industry	+23	-694	+184	r+547	-388
Imports	647	848	878	1,091	1,477
Secondary recovery:[2]					
New scrap	960	1,031	884	953	935
Old scrap	617	758	782	820	825
Total supply	6,901	6,432	6,002	r6,764	6,948
Less total exports	1,346	787	748	776	734
Apparent aluminum supply available for domestic manufacturing	5,555	5,645	5,254	r5,988	6,214
Apparent consumption[3]	4,595	4,614	4,370	r5,035	5,279

rRevised.

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

Industry	1982		1983		1984p	
	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	1,618	28.5	1,777	27.8	1,832	26.1
Transportation	840	14.8	1,061	16.6	1,333	19.0
Building and construction	1,052	18.5	1,302	20.3	1,296	18.5
Electrical	525	9.2	589	9.2	677	9.7
Consumer durables	373	6.6	478	7.5	502	7.2
Machinery and equipment	320	5.6	353	5.5	375	5.3
Other markets	243	4.3	267	4.2	287	4.1
Statistical adjustment	+119	2.1	+6	.1	+217	3.1
Total to domestic users	5,090	89.6	5,833	91.2	6,519	93.0
Exports	587	10.4	563	8.8	488	7.0
Grand total	5,677	100.0	6,396	100.0	7,007	100.0

pPreliminary.

Source: The Aluminum Association Inc.

Table 7.—U.S. net shipments[1] of aluminum wrought and cast products, by producers

(Metric tons)

	1982	1983	1984p
Wrought products:			
Sheet, plate, foil	2,748,896	3,252,877	3,283,558
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing	r870,858	1,052,996	1,185,179
Rolled and continuous-cast rod and bar; wire	391,199	424,582	456,174
Forgings (including impacts)	47,269	52,711	66,517
Powder, flake, paste	36,275	35,717	44,074
Total	r4,094,497	4,818,883	5,035,502
Castings:			
Sand	80,929	89,823	118,189
Permanent mold	108,487	113,460	149,442
Die	480,022	570,884	529,798
Other	58,723	52,256	32,857
Total	728,161	826,423	830,286
Grand total	r4,822,658	5,645,306	5,865,788

pPreliminary. rRevised.

[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 8.—Distribution of wrought products in the United States

(Percent)

	1982	1983	1984[p]
Sheet, plate, foil:			
Nonheat-treatable	[r]55.9	56.7	54.1
Heat-treatable	3.1	3.1	3.6
Foil	[r]8.1	7.8	7.6
Rolled and continuous-cast rod and bar; wire:			
Rod, bar, wire	2.7	2.3	2.4
Cable and insulated wire	[r]6.9	6.5	6.6
Extruded products:			
Rod and bar	1.0	1.4	1.2
Pipe and tubing	1.1	1.3	1.5
Shapes	[r]17.9	18.0	19.7
Tubing:			
Drawn	.7	.6	.6
Welded	.5	.5	.5
Powder, flake, paste	.9	.7	.9
Forgings (including impacts)	[r]1.2	1.1	1.3
Total	100.0	100.0	100.0

[p]Preliminary. [r]Revised.

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, increased from about 2.27 million tons at the end of 1983 to 2.65 million tons at the end of 1984.

PRICES

The producer list price for 99.5%-pure aluminum ingots was 81 cents per pound throughout the year. During the year, most domestic producers instituted a transaction price more comparable with the market or spot price. The average annual market price for aluminum ingot, usually 99.7% pure, as published by Metals Week (McGraw Hill), was 61.1 cents per pound. Prices for 99.7%-pure aluminum ingot were generally 0.5 cent per pound above that for 99.5% ingot. At the beginning of the year, the average weekly spot price was 76 cents, and in the latter half of January, the price reached 77.4 cents, the highest level of the year. By monthend, it began a decline to a low of 47 cents by mid-October. The price revived in mid-November to 57.5 cents, then declined again to close the year at a weekly average of 50.2 cents per pound. The New York Commodity Exchange (COMEX) and London Metal Exchange (LME) prices followed the same general trend as the spot price. COMEX prices were 3 to 4 cents lower than spot prices for metal with a short delivery date and 2 to 3 cents higher for metal with longer delivery dates. The LME cash price began the year about 5 cents lower than the U.S. market price, but by yearend, the price closed to less than 3 cents lower than the spot price. In November, Metals Week began publishing an average weekly transaction price. Published U.S. transaction prices were about 0.5 cent below the market price. The following table summarizes aluminum prices at selected dates during the year, in cents per pound:

Price	Jan. 16	Apr. 16	July 9	Oct. 15	Nov. 19	Dec. 31
COMEX 1[1]	--	64.71	55.20	44.38	54.40	47.21
COMEX 2[1]	77.45	65.48	56.35	45.22	55.11	47.92
COMEX 3[1]	81.34	70.31	62.08	49.97	59.25	51.82
LME (cash)	71.22	62.12	54.16	44.60	54.12	47.64
U.S. market	76.00-77.25	67.75-68.75	57.75-58.75	47.50-48.50	57.00-58.00	49.75-50.75
U.S. transaction	--	--	--	--	57.23	49.72

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

During 1984, two changes in world pricing policies were implemented by major foreign producers. Pechiney of France began the Pechiney Independent Price (PIP) index. The index is calculated quarterly and based on Pechiney's sales of 99.5% ingot to independent customers during the quarter. The index is the ratio of the quarter's average price per ton to the 1975 selling price, the base year with an index of 100.[5] In October, the published Alcan World Price was withdrawn by Alcan Aluminium. This price had provided the benchmark for worldwide aluminum export sales for many years.

Secondary alloyed ingot prices, as quoted in the American Metal Market, followed a pricing trend similar to that of primary aluminum. Secondary alloy 380 began the year at a price of 79 to 81 cents per pound, declining steadily after a March high of 81 to 82 cents to a low of 62 to 63 cents in October. The yearend price for alloy 380 was 65 to 67 cents. Alloys 360 and 413 began the year at 82 to 84 cents and finished the year at 68 to 70 cents. Old sheet and cast aluminum scrap ranged from a high of about 51.5 cents per pound in March to a low of 30.5 cents per pound in mid-October.

FOREIGN TRADE

Exports of crude aluminum from the United States fell sharply from the 1983 level, largely reflecting reduced shipments of ingot to China and Japan. Exports of aluminum in most other forms, including scrap, increased. Imports of aluminum in all forms increased and totaled more than twice the quantity exported. Increases in receipts of crude metal from Bahrain, Brazil, Canada, the United Arab Emirates, and other countries far more than offset a loss of all receipts from Ghana, where a smelter owned by U.S. companies was shut down throughout the year. Venezuela, Japan, and Canada, in descending order, provided much of the increase in imports of semifabricated products, and Canada provided most of the scrap.

U.S. tariff rates in effect during 1984 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	0.3 cent per pound.
Wrought (bars, plates, sheets, strip).	618.25	3% ad valorem.
Waste and scrap	618.10	2% ad valorem.

Table 9.—U.S. exports of aluminum, by class

Class	1983		1984	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	360,704	$534,048	259,598	$396,798
Scrap	237,827	249,156	258,404	275,686
Plates, sheets, bars, etc.	162,294	388,679	198,399	496,841
Castings and forgings	9,518	55,346	11,590	69,845
Semifabricated forms, n.e.c	5,374	32,578	5,822	34,259
Total	775,717	1,259,807	733,813	1,273,429
Manufactures:				
Foil and leaf	17,523	31,742	21,369	33,320
Powders and flakes	1,937	7,058	3,219	11,951
Wire and cable	18,766	45,999	4,824	14,535
Total	38,226	84,799	29,412	59,806
Grand total	813,943	1,344,606	763,225	1,333,235

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

Country	1983						1984					
	Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	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)
Australia	1,281	$1,717	1,191	$5,225	1	$7	1,517	$2,494	1,537	$6,642	339	$445
Belgium-Luxembourg	125	163	1,444	4,572	707	850	10	25	495	2,441	1,632	1,610
Brazil	84	595	445	1,912	56	66	278	1,404	1,090	5,589	270	549
Canada	13,629	25,612	98,883	244,491	25,693	25,457	17,356	34,324	130,978	335,468	21,630	23,794
China	55,950	86,560	18	135	--	--	21,366	28,726	47	294	--	--
Dominican Republic	985	1,671	252	515	6	14	1,086	2,039	281	732	10	18
France	139	493	834	6,346	346	316	59	225	369	3,177	445	432
Germany, Federal Republic of	117	804	2,825	10,755	2,394	2,054	99	760	1,894	10,296	5,881	5,894
Hong Kong	65	117	766	2,422	72	112	3,370	4,703	375	1,932	231	322
India	39	175	55	308	246	254	1,519	2,898	64	282	73	88
Indonesia	50	79	351	979	53	60	1,000	1,269	74	459	--	--
Ireland	1	17	1,967	4,182	--	--	1	6	196	554	--	--
Israel	65	255	2,777	9,390	10	1	115	492	2,553	13,135	28	73
Italy	28	377	4,366	15,348	602	630	40	272	4,967	17,703	2,823	2,820
Japan	253,272	355,117	3,718	15,871	186,888	200,112	139,717	209,866	3,517	14,561	170,596	184,264
Korea, Republic of	4,789	8,125	1,763	6,160	1,171	938	21,166	28,784	976	4,369	1,168	1,400
Malaysia	1,052	1,774	23	126	--	--	1,169	1,667	139	381	34	21
Mexico	5,901	11,816	8,008	18,204	12,574	11,806	15,845	25,222	21,865	50,487	32,056	35,638
Netherlands	36	142	2,735	11,557	149	153	7,851	10,033	1,705	7,893	3,780	3,512
Saudi Arabia	35	216	1,691	5,175	--	--	19	127	1,732	5,787	19	44
South Africa, Republic of	--	--	338	1,071	2,787	2,975	9	125	211	957	16	159
Spain	1	9	697	2,690	559	271	19	27	755	3,723	631	569
Sweden	25	129	7,127	21,676	18	2	22	173	3,407	10,735	23	35
Taiwan	16,417	25,189	1,349	9,688	2,400	1,558	14,519	19,367	975	8,980	16,193	13,287
Thailand	2,514	4,079	676	2,219	1	8	7,269	12,122	354	1,324	2	2
United Kingdom	255	649	21,418	39,441	92	179	113	702	21,774	49,296	208	274
Venezuela	6	36	5,055	11,303	--	--	66	274	8,782	22,771	2	3
Other	r3,843	r8,132	r6,414	r24,842	r1,002	r1,333	3,998	8,672	4,699	20,977	314	433
Total	360,704	534,048	177,186	476,603	237,827	249,156	259,598	396,798	215,811	600,945	258,404	275,686

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

Table 11.—U.S. imports for consumption of aluminum, by class

Class	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	742,691	$1,021,273	881,956	$1,292,724
Circles and disks	8,677	18,154	13,219	31,672
Plates, sheets, etc., n.e.c	236,053	487,003	393,738	893,013
Rods and bars	13,844	26,467	46,531	90,337
Pipes, tubes, etc	1,438	5,695	4,074	12,609
Scrap	88,472	87,468	137,675	145,748
Total	1,091,175	1,646,060	1,477,193	2,466,103
Manufactures:				
Foil	13,262	47,078	24,496	90,629
Leaf	(1)	99	(1)	108
Flakes and powders	3,762	6,406	4,673	8,601
Wire	1,523	3,549	3,017	6,633
Total	18,547	57,132	32,186	105,971
Grand total	1,109,722	1,703,192	1,509,379	2,572,074

[1]1983—aluminum leaf not over 30.25 square inches in area, 803,734 leaves, and aluminum leaf over 30.25 square inches in area, 88,227,795 square inches; and 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.

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

Country	1983						1984					
	Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Metals and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	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)
Argentina	1,914	$2,640	4,778	$7,272	--	--	8,859	$13,226	4,936	$10,357	--	--
Australia	--	--	14,267	28,481	--	--	2,329	3,749	25,921	59,152	--	--
Bahrain	--	--	--	--	--	--	39,141	30,587	288	461	--	--
Belgium-Luxembourg	759	972	18,448	31,692	1,422	$1,766	948	1,389	29,781	56,210	1,731	$2,058
Brazil	11,785	17,519	743	1,271	--	--	44,523	68,973	15,379	28,166	--	--
Canada	554,015	748,465	40,908	88,175	67,063	66,886	603,069	906,200	68,454	156,787	91,947	99,809
Egypt	2,690	3,745	--	--	--	--	6,053	9,786	1,518	2,647	--	--
France	3,363	4,642	13,438	30,554	186	200	8,210	12,258	28,897	74,403	74	95
Germany, Federal Republic of	8,835	15,038	10,555	24,592	541	717	12,335	25,277	15,841	43,054	398	406
Ghana	39,748	66,564	--	--	--	--	--	--	--	--	--	--
Hungary	--	--	3,094	4,405	--	--	--	--	6,988	13,773	--	--
Israel	378	469	1,940	6,494	391	220	1,280	1,762	1,503	6,424	165	240
Italy	11,334	15,544	5,176	9,228	238	280	1,715	2,184	11,519	25,358	895	1,247
Japan	166	404	105,722	218,207	48	31	356	1,368	134,385	315,666	66	81
Korea, Republic of	--	--	34	56	--	--	7,734	7,679	76	184	--	--
Mexico	499	319	279	453	4,174	3,843	814	589	2,623	3,895	4,367	4,742
Netherlands	740	794	4,578	19,116	638	432	1,564	2,109	6,124	22,200	1,612	2,256
Norway	97	204	11,071	17,303	424	542	389	641	14,225	30,092	--	--
Romania	5,006	8,259	30	53	--	--	701	1,065	9,340	18,184	--	--
South Africa, Republic of	10,598	14,860	--	--	--	--	19,662	30,056	767	1,376	35	43
Spain	1,687	2,575	301	611	93	73	18,933	27,317	4,073	8,640	--	--
Switzerland	867	1,147	1,679	3,510	--	--	1,466	1,942	6,134	14,795	145	173
U.S.S.R	127	259	--	--	--	--	5,937	7,211	--	--	4,243	4,703
United Arab Emirates	9,401	13,342	54	71	--	--	34,160	51,807	--	--	5,033	367
United Kingdom	24,451	28,328	2,019	6,678	8,240	8,152	13,132	20,530	5,765	16,982	12,444	16,470
Venezuela	49,095	67,683	6,712	11,136	2,598	2,783	37,540	46,468	36,049	57,817	11,615	10,585
Yugoslavia	4,025	5,973	8,302	14,255	10	26	3,100	5,172	10,404	22,707	--	--
Other	r1,111	r1,528	r5,884	r13,706	r2,406	r1,517	8,006	13,379	16,572	38,301	2,905	2,473
Total	742,691	1,021,273	260,012	537,319	88,472	87,468	881,956	1,292,724	457,562	1,027,631	137,675	145,748

r Revised.

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

WORLD REVIEW

World production of primary aluminum increased 11% in 1984 to 15.5 million tons. World aluminum consumption did not keep pace with production, and stocks of primary aluminum held by members of the International Primary Aluminum Institute, which represented the bulk of inventories held outside of the centrally planned economy countries, increased by about 570,000 tons to 2.6 million tons at yearend.

World primary aluminum production capacity increased 3% during 1984. Significant plant expansions were completed in Australia and Indonesia. A new primary aluminum smelter began production in Brazil.

Australia.—Alcan Australia Ltd. postponed the startup of the third potline at its Kurri Kurri, New South Wales, primary smelter reportedly because of poor market conditions. The 50,000-ton-per-year potline had been scheduled to come on-stream before yearend 1984. The total capacity of the two operating potlines at Kurri Kurri was 90,000 tons.

Tomago Aluminium Co. Pty. Ltd. started operation of its second 115,000-ton-per-year potline at its Tomago, New South Wales, primary smelter. Partners in the smelter included Pechiney Australia Pty. Ltd., 35%; Gove Alumina Ltd., 35%; Australian Mutual Provident Society, 15%; VAW Australia Pty. Ltd., 12%; and Hunter Douglas Ltd., 3%.

Alcoa of Australia Ltd. and the Victoria State government announced the resumption of work on the $1.5 billion aluminum smelter at Portland, Victoria. Alcoa deferred completion of the 300,000-ton-per-year smelter in 1982 because of depressed world aluminum prices. The first 150,000-ton-per-year potline was scheduled to come on-stream in 1986. Alcoa of Australia reportedly held a 45% interest in the project and the Victoria State government held a 25% share. Additional partners were being sought for the remaining 30% interest.

Boyne Smelters Ltd. started production at its second 103,000-ton-per-year potline at its Gladstone, Queensland, primary smelter in 1984.

Bahrain.—A modernization program was underway at Aluminium Bahrain's (ALBA) primary smelter at Knuff. The modernization plan would increase capacity from 170,000 to 200,000 tons per year over a 6-year period, but reportedly that level may be reached by yearend 1986. ALBA's shareholders include the Bahrain Government, 58%; the Saudi Arabian Government, 20%; Kaiser Aluminum Bahrain, 17%; and Breton Investments, 5%.

Brazil.—The Alumínio do Maranhão S.A. alumina-aluminum complex jointly owned by Alcoa Alumínio do Brasil S.A. (60%) and Shell do Brasil S.A. (40%), a subsidiary of Billiton Metais S.A., started production at its 500,000-ton-per-year alumina plant and its 100,000-ton-per-year aluminum smelter at São Luis, Maranhão. Plans were announced to increase the first potline's capacity to 110,000 tons per year and to add a new 135,000-ton-per-year potline to the smelter by late 1986. Billiton's share in the smelter would decrease from its current 40% holding to 28% by 1986, but it would keep its 40% holding in the alumina refinery.

Canada.—Alcan Aluminium announced plans to build a 248,000-ton-per-year smelter at Laterriere, Quebec, as part of a longer-term program to rebuild obsolete capacity in Quebec. The $1 billion smelter would be built in three phases, each consisting of 82,700 tons of capacity. Startup was scheduled for mid-1988.

Alumax announced it would exercise its option to acquire a 25% stake in the joint Pechiney (50%) and Société Générale de Financement (25%) $1.2 billion smelter project at Bécancour, Quebec. The first 115,000-ton-per-year potline was scheduled to come on-stream at the end of 1986 with the second coming on-stream by mid-1987. A third line could be added later.

In September 1984, following 9 months of negotiations, Alcan signed a 3-year agreement covering approximately 7,000 smelter employees in Quebec. The agreement provided for wage increases in most cases of 12.5% over the 3-year life of the contract.

Colombia.—The Governments of Jamaica and Colombia signed a preliminary agreement for the construction of a joint-venture primary aluminum smelter with a capacity of 140,000 tons per year. The smelter would be built in Colombia at an estimated cost of $500 million and was scheduled to come on-stream in 1990.

Germany, Federal Republic of.—Vereinigte Aluminium Werke AG permanently closed 15,000 tons per year of capacity at its

35,000-ton-per-year smelter at Lippenwerke, Luenan, reportedly because of high power costs.

Ghana.—After many months of negotiations, the Volta Aluminium Co. (VALCO) and the Government of Ghana reached agreement on power rates to be charged to VALCO's smelter at Tema. VALCO is owned 90% by Kaiser and 10% by Reynolds. Under the agreement, the base power rate reportedly would be raised 5 mills/kW•h to about 17 mills/kW•h. The rate would vary according to a formula related to the average LME price for the previous 6 months and adjusted to take account of the quantity of power consumed by VALCO. There would be a floor price of 10 mills/kW•h. The VALCO plant has five potlines; however, the agreement entitled the plant to enough power to operate only four lines but provided that any excess power in Ghana would be offered to VALCO first. Because of a power shortage owing to a prolonged drought, the 200,000-ton-per-year smelter has been shut down since June 1983 and remained closed throughout 1984.

Iceland.—The Government of Iceland and Alusuisse reached agreement on power costs for the Icelandic Aluminium Co. Ltd.'s (ISAL) 86,000-ton-per-year primary smelter at Straumsvik, Hafnarfjordur. Electricity prices would be indexed to a weighted average of aluminum prices, with a floor price of 12.5 mills/kW•h and a ceiling price of 18 mills/kW•h. The formula was to be maintained for 20 years, after which it could be negotiated for another 10 years. Also included in the agreement was an option for Alusuisse to increase capacity by 40,000 tons per year and to seek a foreign partner for ISAL.

India.—The fourth potline at Bharat Aluminium Co.'s primary smelter at Korba, Madhya Pradesh, came on-stream with a capacity of 25,000 tons per year. The potline was completed in 1979, but its startup was postponed because of power shortages.

Indonesia.—P.T. Indonesia Asahan Aluminum completed the last phase of construction at its primary smelter at Kuala Tanjung, North Sumatra, bringing the smelter's capacity to 225,000 tons per year. Nippon Asahan Aluminum Co., a Japanese consortium of 12 companies including Japan's 5 primary aluminum producers, owns 75% of Indonesia Asahan. The smelter is the largest in Asia and the largest source of aluminum supply to Japan.

Italy.—The Italian state-owned aluminum company, Ente Participazione Finanziamento Industria Manifattura, announced plans to close its 35,000-ton-per-year primary smelter at Bolzano by 1985.

Japan.—The Ministry of International Trade and Industry announced plans to restructure Japan's aluminum smelting and semifabricating industry. Under the plan, installed capacity, now at 712,000 tons per year, would be cut to 350,000 tons by the end of March 1988. Production in 1984 was 287,000 tons. The planned cut would include abolishment of Nippon Light Metal Co. Ltd.'s 72,000-ton-per-year Tomakomai smelter, Sumitomo Aluminium Smelting Co. Ltd.'s 99,000-ton-per-year Toyo smelter, Mitsui Aluminium Co. Ltd.'s 99,000-ton-per-year Sakata plant, Showa Light Metal Co. Ltd.'s 17,000-ton-per-year smelter at Kitakata, and other cuts to be determined at the end of March 1988.

Mexico.—Aluminio S.A. de C.V. announced plans to add a third potline to its Vera Cruz smelter, raising capacity to 66,000 tons per year by 1986. Alcoa has a 44% interest in the 45,000-ton-per-year smelter.

Norway.—Alusuisse and Norsk Hydro A/S announced plans to increase the capacity to 100,000 tons per year from 66,000 tons at its primary smelter at Husnes. Norsk Hydro would also increase its interest in the smelter from 25% to 50%. The expansion reportedly would depend on strengthening demand in the worldwide aluminum market.

Sweden.—Gränges Aluminium AB announced plans to rebuild its oldest potline at its 82,000-ton-per-year primary smelter at Sundsvall, with a net increase in capacity of 9,000 tons per year. The 13,000-ton-per-year potline would be closed at the end of 1985 while the modernization was underway, with the rebuilt 20,000-ton-per-year potline scheduled to come on-stream in 1987.

U.S.S.R.—A 500,000-ton-per-year primary smelter reportedly was under construction at Sayansk, Siberia.

Venezuela.—Aluminio del Caroní S.A. announced plans to add a new 84,000-ton-per-year potline at its primary smelter at Ciudad Guayana, which would increase the smelter's capacity to 204,000 tons per year. Completion was scheduled for 1987.

Table 13.—Aluminum: World production,[1] by country

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Argentina	133	134	138	133	134
Australia	303	379	381	478	[2]758
Austria	94	95	94	94	[2]96
Bahrain	126	141	171	[e]170	177
Brazil	261	256	299	401	[2]412
Cameroon	43	37	85	78	80
Canada	1,068	1,116	1,065	1,091	1,200
China[e]	360	360	[r]380	380	380
Czechoslovakia	38	33	34	36	34
Egypt	120	134	141	140	166
France	432	436	390	361	[2]342
German Democratic Republic[e]	60	60	58	[r]57	58
Germany, Federal Republic of	731	729	723	743	750
Ghana	188	190	174	42	--
Greece	146	[e]147	[r e]147	136	[2]136
Hungary	73	74	74	74	[2]74
Iceland	73	75	62	77	[2]82
India	185	213	217	204	270
Indonesia	--	--	31	139	180
Iran	16	12	45	46	46
Italy	271	[r]274	233	196	[2]230
Japan[3]	1,091	771	351	256	[2]287
Korea, North[e]	10	10	10	10	10
Korea, Republic of	18	18	15	13	18
Mexico	43	43	41	40	40
Netherlands	259	262	251	235	248
New Zealand	155	154	167	220	[2]243
Norway	653	634	636	715	[2]761
Poland[4]	95	66	43	44	46
Romania[5]	241	[r]251	208	223	244
South Africa, Republic of	87	87	107	164	165
Spain	386	397	367	358	[2]381
Suriname[6]	[r]55	[r]41	60	29	30
Sweden	82	83	79	82	[2]83
Switzerland	86	82	75	76	[2]79
Taiwan	64	31	10	--	--
Turkey	34	40	37	32	35
U.S.S.R.[e]	1,760	1,800	1,875	2,000	2,100
United Arab Emirates: Dubai	25	[e]106	149	151	150
United Kingdom	374	339	241	252	286
United States	4,654	4,489	3,274	3,353	[2]4,099
Venezuela	328	314	274	[r e]332	310
Yugoslavia	161	173	246	284	[2]302
Total[7]	[r]15,383	[r]15,083	13,455	13,945	15,521

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

[1]Output of primary unalloyed ingot unless otherwise specified. Table includes data available through May 28, 1985.

[2]Reported figure.

[3]Includes high-purity aluminum containing 99.95% or more as follows, in metric tons: 1980—4,256; 1981—6,222; 1982—4,345; 1983—2,679; and 1984—4,358.

[4]Includes secondary unalloyed ingot.

[5]Includes primary alloyed ingot.

[6]Data represent exports.

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

Table 14.—Aluminum: World capacity, by continent and country[1]

(Thousand metric tons)

Continent and country	1982	1983	1984
North America:			
Canada	1,234	1,234	1,234
Mexico	45	45	45
United States	4,988	r4,996	4,893
South America:			
Argentina	140	140	140
Brazil	404	419	519
Suriname	60	60	60
Venezuela	r400	r400	400
Europe:			
Austria	92	92	92
Czechoslovakia	60	60	60
France	394	378	333
German Democratic Republic	85	85	85
Germany, Federal Republic of	r756	r772	777
Greece	145	145	145
Hungary	76	76	76
Iceland	86	86	86
Italy	276	276	276
Netherlands	266	266	266
Norway	799	r794	794
Poland	55	55	110
Romania	250	250	250
Spain	398	r389	389
Sweden	82	82	82
Switzerland	86	86	86
U.S.S.R	2,310	2,320	2,490
United Kingdom	r287	r287	287
Yugoslavia	317	357	357
Africa:			
Cameroon	80	80	80
Egypt	133	166	166
Ghana	200	200	200
South Africa, Republic of	132	172	172
Asia:			
Bahrain	170	170	170
China	382	382	382
India	r358	r363	363
Indonesia	75	150	225
Iran	50	50	50
Japan	712	712	712
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	r479	r594	812
New Zealand	244	244	244
Total	r17,403	r17,730	18,205

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.

TECHNOLOGY

An investigation to develop a process to electrolytically remove magnesium from aluminum scrap showed that aluminum can be recovered with a magnesium content as low as 0.005 weight percent, with current densities of 1.66 amperes per square centimeter. The magnesium is removed in a three-part concentration cell consisting of a bottom layer of molten aluminum-magnesium alloy, a layer of molten alkaline metal chloride electrolyte, and a top layer of molten magnesium. The recovered aluminum can be used to produce aluminum casting alloys, and the magnesium is suitable for desulfurizing iron and steel melts or alloying aluminum. The process reduces the environmental problems caused by the current chlorination process for removal of magnesium.[6]

Developments of and research on new

aluminum alloys have accelerated during the past several years to meet the demands of advanced technology in the aerospace industry and other fields and to compete with other lightweight materials such as titanium and composites. Several articles on aluminum-lithium alloy development and production were published in 1984. An aluminum-base alloy containing up to 3% lithium can increase tensile strength yet reduce weight by up to 15%, compared with aluminum-copper and aluminum-zinc alloys.[7] Commercial production of this type of alloy in 1985 was expected by both domestic and foreign aluminum companies. An investigation to optimize alloy chemistry to produce an aluminum alloy with good resistance, good formability, and high strength for use in automobile structural and body components indicated that increased copper content and lower silicon and magnesium contents were desirable.[8] The effect of a paint-bake cycle on the age-hardening of these alloys was also evaluated to determine optimum composition.

Developments in powder metallurgy (PM) alloys using rapid solidification processes produced aluminum materials with higher strengths and fatigue-crack resistance compared with that of cast ingot alloys.[9] Studies on development of alloys with high-strength, high-temperature applications using PM processes were in progress.[10] A forging with a minimum tensile strength of 103,000 pounds per square inch at temperatures of up to 290° C was the objective.

A new aluminum alloy that has most of the characteristics of metals such as strength, machinability, and electrical conductivity, but dissolves in water, was developed.[11] The aluminum-base alloy was reported to contain tin and other metals that activate the alloy and release hydrogen when immersed in water. The activated material has been tested as a source of fuel, and motor vehicles running on hydrogen were demonstrated.

Aluminum silicon carbide composites were being developed for use in aerospace, ship, and missile applications.[12] Silicon carbide whiskers and particulates, combined with aluminum, produced alloys with high strength that can be extruded, rolled, and forged.

Thirty papers on new developments, measurement control, and other investigations on aluminum reduction technology were published.[13] Several papers addressed improved cathode designs. One study recommended a new method of relining cells that eliminates costly prerodding of cathode blocks.[14] The study also suggested that the use of a cathode collector bar made of two relatively tall and narrow sections would reduce the cathode voltage drop in the bar-cathode block area, compared with conventional 5- to 6-inch square bars with similar cross-sectional areas but less contact surface area.

A study of anode design factors on prebaked anodes indicated that thermal stresses affecting the carbon anodes, the steel stubs, and the cast iron sealant are critical. Using these criteria, the optimum stub hole diameters that provide minimum contact resistance and low mechanical stress on the carbon block can be estimated.[15] Investigation of the properties and behavior of green anodes indicated that better information obtained in preparing the anodes can be useful in the production of baked anode blocks with less deficiencies.[16]

Improvements in control of the bath ratio of sodium fluoride to aluminum fluoride lowered the ratio from 1.34 to 1.24.[17] Ratio conformance rose during a 5-year period with a corresponding increase of current efficiency from 85.3% to 89.6%. Ratio control was improved by increasing bath sampling, changing the method and handling of samples, and improving operation and control of the day-to-day pot operations. A new wet method for determination of bath ratio was described.[18]

A low-cost titanium boride (TiB_2) material that has good thermal shock and impact resistance, good adhesion to the carbon cathode blocks, and ease of fabrication was developed.[19] The coating material consists principally of TiB_2 material, phenolic resin, a resin precursor, carbonaceous filler and additives, and a curing agent. The mixture is applied to carbon blocks and cured at 100° C. The coating was evaluated with several types of carbon in laboratory and commercial cells.

Several investigations are in progress on using a direct carbothermic process to process aluminum-bearing minerals. Satisfactory results of a pilot plant study using leucitic minerals were reported.[20] The product was an aluminum-silicon alloy that required further refining.

A review of developments in the electrolysis of molten salts describes additional aluminum electrolysis studies.[21]

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

[2]Physical scientist, Division of Nonferrous Metals.

[3]Mineral data assistant, Division of Nonferrous Metals.

[4]National Association of Recycling Industries Inc. Annual Aluminum Can Recycling Survey, 1984.

[5]Metal Bulletin Monthly (London). The PIP Explained. No. 162, June 1984, pp. 101-107.

[6]Tiwari, B. L., and R. A. Sharma. Electrolytic Removal of Magnesium From Scrap Aluminum. J. Met., v. 36, No. 7, July 1984, pp. 41-43.

[7]Kraus, J. R. Aluminum-Lithium Flies High. Am. Met. Mark., v. 92, No. 114, June 12, 1984, p. 8.

Naser, D. M. Aluminum—Lithium Alloy Development. Light Met. Age, v. 42, Nos. 11-12, Dec. 1984, pp. 15-16.

[8]Bull, M. J., P. E. Fortin, and D. M. Moore. On Optimized Aluminum Alloy (X6111) for Auto Structural Applications. Light Met. Age, v. 42, Nos. 11-12, Dec. 1984, pp. 28-29.

[9]Light Metals Age. Alcoa's Research Yields High-Strength Powder Alloys Precision Spin Forgings. V. 42, Nos. 11-12, Dec. 1984, pp. 10-11.

[10]Metal Progress. Trends in Nonferrous Metal Technology. Progress Report Aluminum. V. 125, No. 1, Jan. 1984, pp. 73-77.

[11]Chemical & Engineering News. Aluminum Alloy Decomposes in Water. V. 62, No. 10, Mar. 5, 1984, p. 28.

[12]Metal Progress. Trends in Nonferrous Metal Technology. Advanced Composites Update. V. 125, No. 1, Jan. 1984, p. 90.

[13]McGeer, J. P. (ed). Light Metals 1984. (Proc. AIME Annu. Meeting, Los Angeles, CA, Feb. 27-Mar. 1, 1984). Metall. Soc. AIME, Warrendale, PA, 1984, 1,749 pp.

[14]Vodla, J. J. A New Approach to Aluminum Cathode Design and Relining. Paper in Light Metals 1984, ed. by J. P. McGeer. Metall. Soc. AIME, Warrendale, PA, 1984, pp. 483-490.

[15]Brooks, D. G., and V. L. Bullough. Anode Design Factors for Prebake Reduction Cells. J. Met., v. 36, No. 5, May 1984, pp. 32-36.

[16]Wilkening, S. Properties and Behavior of Green Anodes. J. Met., v. 36, No. 5, May 1984, pp. 26-31.

[17]Jeltsch, R. C. Bath Ratio Control at the Mead Works. Paper in Light Metals 1984, ed. by J. P. McGeer. Metall. Soc. AIME, Warrendale, PA, 1984, pp. 493-499.

[18]Nagy, K., R. Byrgo, and D. Fremstad. Routine Analysis of Bath Ratio: A New Method. Paper in Light Metals 1984, ed. by J. P. McGeer. Metall. Soc. AIME, Warrendale, PA, 1984, pp. 501-512.

[19]Boxall, L. G., A. V. Cooke, and H. W. Hayden. Use of TiB_2 Cathode Materials—Application and Benefits in Conventional VSS Cells. Paper in Light Metals 1984, ed. by J. P. McGeer. Metall. Soc. AIME, Warrendale, PA, 1984, pp. 573-588.

[20]Landi, M. F., D. A. Roit, S. Montesi, and L. Piros. The Production of Raw AL/Si Alloys From Italian Leucitic Minerals by a Direct Carbothermic Process. Experiments and Results on a Pilot Plant. Paper in Light Metals 1984, ed. by J. P. McGeer. Metall. Soc. AIME, Warrendale, PA, 1984, pp. 601-618.

[21]Duby, P. Developments in Electrometallurgy—1984. J. Met., v. 37, No. 4, Apr. 1985, pp. 63-66.

Antimony

By Patricia A. Plunkert[1]

Production of primary antimony products increased significantly compared with that of 1983 despite the closure during 1984 of the only antimony ore producer. Increased demand resulted mainly from the improved market for antimony trioxide in flame-retardant applications. In December, the General Services Administration (GSA) resumed its sale of antimony metal from the National Defense Stockpile.

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 smelter production shown in table 1 and the primary antimony production by class shown in table 3.

Table 1.—Salient antimony statistics

(Short tons of antimony content unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production:					
Primary:					
Mine (recoverable antimony)	343	646	503	838	557
Smelter[1]	16,062	17,844	12,282	r14,557	16,979
Secondary	19,893	19,856	16,596	14,204	14,806
Exports of metal, alloys, waste and scrap	453	324	830	304	511
Exports of antimony oxide	762	375	277	365	480
Imports for consumption	17,996	17,970	13,387	12,885	23,089
Reported industrial consumption, primary antimony[1]	11,239	11,592	9,414	r10,418	12,447
Stocks: Primary antimony, all classes Dec. 31	8,411	9,158	5,973	3,935	6,916
Price: Average, cents per pound[2]	150.8	135.5	107.2	91.3	151.2
World: Mine production	r69,997	r63,475	60,933	p55,526	e58,857

eEstimated. pPreliminary. rRevised.

[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 March 8, the Environmental Protection Agency (EPA) issued final regulations under the Clean Water Act for specified nonferrous metals manufacturing operations that limit the discharge of pollutants into navigable waters and into publicly owned treatment works. Various daily and monthly average maximum effluent limits for antimony within the primary aluminum smelting and secondary lead subcategories were specified.[2]

On June 27, EPA proposed effluent limitations guidelines and standards under the Clean Water Act for particular nonferrous metals manufacturing plants not covered previously. The primary antimony subcategory, 1 of 24 subcategories covered by this regulation, set proposed limits on effluent discharges from both new and existing primary antimony plants that used a hydrometallurgical processing method. Daily and monthly average maximums on the antimony, arsenic, lead, and mercury content of effluents emanating from these plants were proposed.[3]

Various proposals to extend Public Law 96-510, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), beyond its scheduled termination date of September 30, 1985, were pending in both Houses of the U.S. Congress throughout much of 1984. In April 1981, the Superfund taxes on antimony were set at $4.45 per short ton of metal and $3.75 per ton of trioxide.

The Department of Defense Authorization Act of 1985, (Public Law 98-525), signed by the President on October 19, 1984, authorized the disposal of 3,200 tons of antimony metal from the National Defense Stockpile, effective October 1, 1984. On November 14, GSA announced that the sale would be limited to approximately 1,000 tons of Grade-B antimony metal at a maximum rate of 150 tons per month during fiscal year 1985. Grade-B metal contained a minimum of 99.5% antimony and a maximum of 0.1% arsenic. This metal is to be used only for domestic consumption. On December 6, 1984, GSA issued its initial invitation to bid on this material. Sales from this offering, the only sale of antimony metal from the stockpile during calendar year 1984, amounted to 69 tons.

GSA reported that yearend Government stocks of antimony metal in the National Defense Stockpile totaled 38,771 tons of stockpile-grade material. The stockpile goal remained at 36,000 tons.

DOMESTIC PRODUCTION

MINE PRODUCTION

United States Antimony Corp.'s (USAC) mining operation at Thompson Falls, MT, was closed during 1984, and domestic mine production decreased significantly. Sunshine Mining Co. continued to produce 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.

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
1980	343	382
1981	646	590
1982	503	365
1983	838	878
1984	557	711

SMELTER PRODUCTION

Primary.—Production of primary antimony products increased compared with that of 1983 owing to an increase in demand, especially in the demand for antimony trioxide for flame-retardant applications.

A total of 10 plants produced primary antimony products in 1984: Amspec Chemical Corp., Gloucester City, NJ; Anzon America Inc., Laredo, TX; 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	
1980	507	15,461	64	30	16,062
1981	790	16,425	83	546	17,844
1982	539	11,564	179	W	12,282
1983	1,121	13,153	r283	W	r14,557
1984	1,113	15,719	147	W	16,979

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

Table 4.—Byproduct antimonial lead produced at primary lead refineries in the United States

Year	Gross weight (short tons)	Antimony content: From domestic ores[1] (short tons)	From foreign ores[2] (short tons)	From scrap (short tons)	Total: Quantity (short tons)	Total: Percent of gross weight
1980	971	18	12	--	30	3.1
1981	3,922	361	185	9	555	14.2
1982	W	W	W	W	W	W
1983	W	W	W	W	W	W
1984	W	W	W	W	W	W

W Withheld to avoid disclosing company proprietary data.
[1]Includes primary residues and a small quantity of antimony ore.
[2]Includes foreign base bullion and small quantities of foreign antimony ore.

Secondary.—Old scrap, predominantly 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 5.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons of antimony content unless otherwise specified)

	1983	1984
KIND OF SCRAP		
New scrap: Lead- and tin-base	1,447	1,317
Old scrap: Lead- and tin-base	12,757	13,489
Total	14,204	14,806
FORM OF RECOVERY		
In antimonial lead	12,664	13,177
In other lead- and tin-base alloys	1,540	1,629
Total	14,204	14,806
Value (millions)	$56.8	$59.2

CONSUMPTION AND USES

Reported domestic consumption of primary antimony increased compared with that of 1983 and reached its highest level since 1978. Antimony metal alloyed with lead was used in starting-lighting-ignition (SLI) batteries, industrial chemical pumps and pipes, tank linings, roofing sheets, and cable sheaths. In these alloys, antimony increases strength and inhibits chemical corrosion. In 1984, the Battery Council International reported an 8% increase in the total shipments of replacement and original equipment automotive SLI batteries in the United States.

Antimony compounds were used in plastics both as stabilizers and as flame retardants. The use of antimony trioxide as a flame retardant increased significantly compared with that of 1983 owing primarily to increased demand in the transportation and construction industries. 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.

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

(Short tons of antimony content)

Year	Class of material consumed					
	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	Total
1980	1,648	9,469	28	64	30	11,239
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	r283	W	r10,418
1984	1,525	10,747	28	147	W	12,447

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

Table 7.—Reported industrial consumption of primary antimony in the United States, by product

(Short tons of antimony content)

Product	1980	1981	1982	1983	1984
Metal products:					
Ammunition	362	409	294	175	W
Antimonial lead	748	1,257	793	r926	845
Bearing metal and bearings	223	206	143	143	169
Cable covering	31	24	25	31	W
Castings	10	11	9	9	11
Collapsible tubes and foil	18	9	1	W	W
Sheet and pipe	29	36	26	43	80
Solder	134	105	124	154	228
Type metal	21	19	11	10	31
Other	74	69	67	71	337
Total	1,650	2,145	1,493	r1,562	1,701
Nonmetal products:					
Ammunition primers	20	25	20	16	21
Ceramics and glass	1,303	782	1,358	1,252	1,292
Fireworks	4	4	6	4	7
Pigments	499	341	330	198	178
Plastics	1,636	1,551	1,050	r993	1,108
Rubber products	325	232	221	70	21
Other	107	111	103	119	160
Total	3,894	3,046	3,088	r2,652	2,787
Flame-retardant:					
Adhesives	461	585	179	184	343
Paper	173	131	103	133	159
Pigments	56	40	25	14	8
Plastics	3,874	4,509	3,312	4,441	5,858
Rubber	189	174	104	220	342
Textiles	942	962	1,110	1,212	1,249
Total	5,695	6,401	4,833	6,204	7,959
Grand total	11,239	11,592	9,414	r10,418	12,447

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

Table 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons of antimony content)

Stocks	1980	1981	1982	1983	1984
Antimonial lead[1]	4	117	W	W	W
Metal	680	916	556	805	603
Ore and concentrate	2,743	2,529	532	446	1,304
Oxide	3,855	4,707	4,711	2,614	4,926
Residues and slags	1,116	864	150	51	69
Sulfide	13	25	24	19	14
Total	8,411	9,158	5,973	3,935	6,916

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 $1.25 to $1.35 per pound at the beginning of the year. The price increased throughout the first 10 months of the year with the exception of June and July when a slight decrease in price occurred. The high price for the year of $1.70 to $1.77 per pound of antimony metal was reached in mid-November. The price then decreased steadily and by yearend was listed at $1.35 to $1.40 per pound.

Asarco's published price for high-tint antimony trioxide in lots of 40,000 pounds was $1.16 per pound at the beginning of the year. The price was increased several times during the year and reached a high of $1.80 per pound in August. The price remained at this level until the first part of November when it was reduced to $1.65 per pound, and it remained at this level through the end of the year. Other domestic producers adjusted their prices during the year to remain competitive with Asarco's price and the generally lower priced imported material.

Metal Bulletin (London) published European price quotations for antimony ore and concentrates. The previously published price quotation for antimony sulfide ore concentrates, 50% to 55% antimony content, was discontinued in 1984. At yearend, the remaining quotations were clean sulfide concentrates, 60% antimony content, $27.75 to $29.00 per metric ton unit (equivalent to $25.25 to $26.35 per short ton unit), and lump sulfide ore, 60% antimony content, $28.75 to $31.00 per metric ton unit (equivalent to $26.15 to $28.20 per short ton unit).

Table 9.—Antimony price ranges in 1984, by type

Type	Price per pound
Domestic metal[1]	$2.00
Foreign metal[2]	$1.20- 1.77
Antimony trioxide[3]	1.16- 1.80

[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 metal, alloy, waste and scrap, and antimony trioxide increased significantly. In addition to exports of antimony trioxide, the United States also exported 3,561 tons (gross weight) of other antimony compounds with a value of $10 million. The Federal Republic of Germany and Japan were the recipients of more than 50% of these compounds.

Total imports of antimony materials increased approximately 80% from those of 1983. China and the Republic of South Africa supplied over 60% of the material imported into the United States during 1984. Imports from China increased approximately fivefold compared with those of 1983.

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

Country	Antimony oxide				Antimony metal, alloys, waste and scrap			
	1983		1984		1983		1984	
	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)
Australia	49	$168	80	$348	1	$3	41	$129
Canada	82	182	98	248	50	79	20	33
Denmark	--	--	--	--	25	60	--	--
Dominican Republic	--	--	--	--	13	39	9	14
Germany, Federal Republic of	93	181	57	123	1	2	2	3
Israel	--	--	18	16	3	18	--	--
Italy	68	247	83	316	(1)	6	19	25
Japan	23	71	69	157	--	--	21	45
Korea, Republic of	--	--	3	12	40	28	19	15
Mexico	59	170	28	92	11	22	24	67
Netherlands	18	51	21	62	11	17	60	168

See footnotes at end of table.

Table 10.—U.S. exports of antimony, by class and country —Continued

Country	Antimony oxide				Antimony metal, alloys, waste and scrap			
	1983		1984		1983		1984	
	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)
Singapore	19	$36	36	$112	--	--	--	--
Taiwan	--	--	--	--	--	--	223	$127
Thailand	--	--	--	--	47	$103	--	--
Trinidad	--	--	--	--	19	38	5	11
United Kingdom	--	--	53	113	48	492	5	19
Venezuela	(1)	1	16	55	--	--	28	150
Other	30	87	14	40	33	132	36	111
Total[2]	440	1,194	578	1,693	304	1,039	511	915

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

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

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
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	.4 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

Class and country	1983		1984	
	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)
Antimony metal:				
Belgium-Luxembourg	74	$126	257	$282
Bolivia	194	286	357	552
Canada	2	204	5	235
Chile	--	--	79	198
China	639	1,043	2,641	6,208
Germany, Federal Republic of	(1)	22	1	64
Japan	(1)	3	(1)	12
Mexico	257	178	467	365
Peru	65	74	33	42
Spain	--	--	17	28
U.S.S.R	20	33	19	34
United Kingdom	31	18	22	17
Total	1,282	1,987	3,898	8,037
Antimony oxide:				
Belgium-Luxembourg	308	608	591	1,513
Bolivia	2,690	3,683	1,206	1,981
Brazil	132	227	--	--
Canada	25	4	101	10
Chile	220	275	61	76
China	1,222	2,107	5,983	13,612
France	1,652	3,602	1,721	4,615
Germany, Federal Republic of	102	636	123	609
Hong Kong	20	36	174	384
Italy	88	152	59	117
Japan	(1)	9	3	60
Netherlands	42	100	20	42
South Africa, Republic of	3,816	991	7,463	2,207
Taiwan	--	--	20	36
U.S.S.R	--	--	44	66

See footnotes at end of table.

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

Class and country	1983 Gross weight (short tons)	1983 Value (thousands)	1984 Gross weight (short tons)	1984 Value (thousands)
Antimony oxide —Continued				
United Kingdom	287	$888	315	$1,020
Total	10,604	13,318	17,884	26,348
Antimony sulfide:[2]				
Austria	--	--	2	15
Belgium-Luxembourg	19	46	11	30
Canada	25	3	--	--
China	--	--	37	47
France	3	5	--	--
Germany, Federal Republic of	--	--	2	20
South Africa, Republic of	--	--	20	45
United Kingdom	([1])	4	--	--
Total	47	58	72	157

[1]Less than 1/2 unit.
[2]Includes needle or liquated.

Table 13.—U.S. imports for consumption of antimony ore and concentrate, by country

Country	1983 Gross weight (short tons)	1983 Antimony content (short tons)	1983 Value (thousands)	1984 Gross weight (short tons)	1984 Antimony content (short tons)	1984 Value (thousands)
Bolivia	1,815	1,196	$1,158	1,923	1,253	$2,016
Canada	5	3	4	18	9	11
Chile	33	22	20	319	188	279
China	--	--	--	270	158	249
Honduras	--	--	--	192	96	119
Hong Kong	--	--	--	61	25	56
Mexico	2,678	632	400	3,976	970	1,288
Peru	--	--	--	139	84	160
South Africa, Republic of	846	444	146	1,075	596	1,079
Thailand	923	471	598	1,918	920	1,541
United Kingdom	5	2	9	--	--	--
Total	6,305	2,770	2,335	9,891	4,299	6,798

Table 14.—U.S. imports for consumption of antimony

Year	Antimony ore and concentrate: Gross weight (short tons)	Antimony ore and concentrate: Antimony content (short tons)	Antimony ore and concentrate: Value (thousands)	Antimony sulfide[1]: Gross weight (short tons)	Antimony sulfide[1]: Antimony content[e] (short tons)	Antimony sulfide[1]: Value (thousands)
1982	5,607	2,769	$4,289	88	59	$188
1983	6,305	2,770	2,335	47	32	58
1984	9,891	4,299	6,798	72	48	157

Year	Antimony metal[2]: Gross weight (short tons)	Antimony metal[2]: Value (thousands)	Antimony oxide: Gross weight (short tons)	Antimony oxide: Antimony content[e] (short tons)	Antimony oxide: Value (thousands)
1982	1,900	$3,893	10,433	8,659	$18,045
1983	1,282	1,987	10,604	8,801	13,318
1984	3,898	8,037	17,884	14,844	26,348

[e]Estimated.
[1]Includes needle of liquated.
[2]Does not include alloy containing 83% or more antimony.

WORLD REVIEW

Bolivia.—Empresa Minera Unificada S.A. announced plans to suspend production at its Caracota Mine for at least 3 months for reserve development work. The company planned to deepen the main shaft at this mine, which had a rated capacity of 5,500 tons of ore per year.[4]

Empresa Minera Hermanos Bernal S.A. announced that it intended to expand production capacity at its antimony smelter in Tupiza. Plans called for the installation of four additional rotary furnaces as well as a new cupel furnace to fume antimony metal to oxide. The new equipment will reportedly give the company the capability of producing high-grade antimony products rather than its traditional crude oxide production. After completion of the planned expansion, antimony oxide production capacity was expected to reach 4,400 tons per year.[5]

Canada.—Durham Resources Inc. announced that dewatering was completed and shaft sinking begun at its Lake George antimony mine in New Brunswick. The mine, which was closed in May 1981 when the main ore zone was depleted, was expected to reopen in the third quarter of 1985. On-site exploration outlined a second ore body with reserves estimated at 850,000 tons grading 4.15% antimony. Durham planned to deepen an existing shaft to intersect the new ore body. Planned production was expected to be 400 to 425 tons of ore per day.

On April 30, 1984, Equity Silver Mines Ltd., in British Columbia, announced that its leaching plant, which produced sodium antimonate as a byproduct of the processing of a complex silver-gold-copper ore, would be closed indefinitely in order to reduce costs. The closure was reportedly made feasible because mining operations had progressed to the Main Zone ore body, which contains lower levels of impurities than previously mined ore, and because of increased acceptability of unleached concentrates by smelters.[6]

Guatemala.—Minas de Guatemala announced plans to restart production by early 1985 at its Annabella and Los Lirios antimony-tungsten mines and milling operation, which have been shut down since mid-1981. The mines and mill were expected to produce 110 tons per month of antimony concentrates containing 55% to 60% antimony, 20% sulfur, 1.5% arsenic, and 1% lead.[7]

Honduras.—Cía. Minera Norcro announced the opening of an open pit antimony mine near Santa Rita. Most of the output was an antimony oxide ore reportedly containing 45% to 53% antimony and less than 0.5% combined lead and arsenic. Some lumpy sulfide ore grading 30% antimony was also produced. The initial production rate was 120 tons of ore per month, while the planned capacity of the mine was reported to be 330 tons per month.[8]

Japan.—Antimony trioxide production, mainly from imported material, reached 10,691 tons, an increase of 28% compared with 1983 production levels. Antimony metal production decreased from 301 tons in 1983 to 279 tons in 1984.[9]

Nissan Chemical Industries Ltd. announced plans to begin production of an antimony pentaoxide-based flame retardant at its Sodegaura factory. The company would reportedly become the first company in Japan to commercialize the product.[10]

South Africa, Republic of.—Consolidated Murchison Ltd. announced a project to deepen the Monarch East shaft at its Gravelotte Mine. The project, which would reportedly allow access to additional antimony ore reserves, was expected to be completed by 1988.

Table 15.—Antimony: World mine production (content of ore unless otherwise specified), by country[1]

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Australia[2]	[r]1,520	[r]1,241	1,263	582	550
Austria	730	665	735	726	720
Bolivia	17,047	16,866	15,408	10,969	10,700
Brazil	51	297	(3)	(3)	--
Burma	485	[e]110	--	--	--
Canada[e 4]	2,600	[r]1,840	--	--	560
China[e]	11,000	11,000	[r]13,200	[r]16,500	16,500
Czechoslovakia[e]	[5]639	[r]550	[r]550	550	550
France	--	344	340	122	--
Guatemala	613	563	[e]550	(3)	--
Honduras	25	[e]22	(3)	(3)	350
Italy	786	767	374	(3)	440
Malaysia (Sarawak)	[r]144	211	153	148	110
Mexico[6]	2,399	1,984	1,725	2,777	2,200
Morocco	606	556	998	500	550
Pakistan	11	[r]22	22	14	20
Peru (recoverable)	379	755	814	786	770
South Africa, Republic of (content of concentrates)	[r]14,404	[r]10,814	[7]10,070	[7]6,947	9,900
Spain	689	712	506	539	550
Thailand	3,214	1,322	734	1,315	1,400
Turkey	1,068	924	1,189	926	900
U.S.S.R.[e]	9,300	9,500	9,900	10,000	10,300
United States[8]	343	646	503	838	[5]557
Yugoslavia	1,852	1,604	1,672	1,047	990
Zimbabwe	92	160	227	[r e]240	240
Total	[r]69,997	[r]63,475	60,933	55,526	58,857

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 21, 1985.
[2]Antimony content of antimony ore and concentrates, lead concentrates, and lead and zinc middlings.
[3]Revised to zero.
[4]Partly estimated on the basis of reported value of total production.
[5]Reported figure.
[6]Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced.
[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.

TECHNOLOGY

The Bureau of Mines investigated the behavior and interaction of antimony, arsenic, bismuth, selenium, and tellurium in a copper matte-iron silicate slag system. A previous study, conducted by the Bureau,[11] focused on the behavior of these five minor elements when all were present simultaneously in the matte-slag system, whereas the more recent study reported the individual behavior of these elements in the same matte-slag system. The investigation revealed that the distribution coefficient for antimony (the percent antimony in matte versus the percent antimony in slag) varied only with the matte grade (percent copper in the matte) and was not significantly altered by either slag additives or the other minor elements studied.[12]

The Argus Chemical Div. of Witco Chemical Corp. announced the development of two reportedly low-cost antimony stabilizers for polyvinylchloride pipe and conduit applications in which color is not of prime importance. The products, designated Mark 9104 and Mark 9105 stabilizers, sold for $1.20 and $1.00 per pound, respectively, in truckload quantities.[13]

An advanced solid-state sensor array made of indium antimonide, which reportedly provided significantly improved sensitivity to infrared energy, was unveiled by researchers at General Electric Co. A new charge-injection-device cell design was said to minimize the distance that a charge was forced to travel for transfer from the collection capacitor to its adjoining injection capacitor. This device was developed with Naval Research Laboratory funding primarily for military surveillance applications.[14]

A review of various thin-film photocathodes employing antimony was published.[15]

[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. 49, No. 47, Mar. 8, 1984, pp. 8742-8831.

[3]———. U.S. Environmental Protection Agency. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 49, No. 125, June 27, 1984, pp. 26352-26483.

[4]Mining Journal (London). Caracota Mine Suspension. V. 302, No. 7767, June 29, 1984, p. 441.

[5]Metal Bulletin (London). Bernal Expands Antimony Smelter. No. 6860, Feb. 7, 1984, p. 13.

[6]Mining Journal (London). Equity To Reduce Costs. V. 302, No. 7745, Jan. 27, 1984, p. 62.

[7]Metals Week. Guatemalan Mines, Mill Set For Restart. Nov. 12, 1984, p. 2.

[8]Industrial Minerals (London). Antimony Mine Start Up. No. 203, Aug. 1984, pp. 11, 13.

[9]Japan Metal Journal. V. 15, No. 10, Mar. 11, 1985, p. 5.

[10]Japan Chemical Week. Nissan Chemical To Produce New Flame Retardant. V. 25, No. 1241, Jan. 19, 1984, p. 9.

[11]Johnson, E. A., P. E. Sanker, L. L. Oden, and J. B. See. Copper Losses and the Distribution of Impurity Elements Between Matte and Silica-Saturated Iron Silicate Slags at 1,250° C. BuMines RI 8655, 1982, 18 pp.

[12]Johnson, E. A., L. L. Oden, P. E. Sanker, and R. L. Fulton. Minor-Element Interactions in Copper Matte Smelting. BuMines RI 8874, 1984, 9 pp.

[13]Modern Plastics. Low-Cost Heat Stabilizers For Rigid PVC. V. 61, No. 10, Oct. 1984, p. 86.

[14]Photonics Spectra. Super-Sensitive Sensor. V. 19, Issue 3, Mar. 1985, p. 38.

[15]———. Thin-Film Photoconductors. V. 19, Issue 2, Feb. 1985, pp. 89-93.

Asbestos

By R. A. Clifton[1]

U.S. apparent consumption of asbestos failed to decline in 1984 for the first time since 1978. U.S. apparent consumption rose 4% over that in 1983 but was just 28% below the alltime high of 1973. Shipments from domestic mines, all chrysotile, decreased 18%, and imports for consumption increased 7%.

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

	1980	1981	1982	1983	1984
United States:					
Production (sales) metric tons	80,079	75,618	63,515	69,906	57,422
Value thousands	$30,599	$30,685	$24,917	$27,866	$24,238
Exports and reexports (unmanufactured) metric tons	48,671	64,419	58,771	54,634	39,919
Value thousands	$21,067	$21,508	$19,713	$19,683	$18,346
Exports and reexports of asbestos products (value) do	$141,653	$145,130	$127,867	$129,582	$163,347
Imports for consumption (unmanufactured) metric tons	327,296	337,618	241,737	196,387	209,963
Value thousands	$91,809	$103,893	$64,925	$57,956	$64,749
Consumption metric tons	358,700	348,800	246,500	217,000	226,000
World: Production do	r4,699,306	r4,348,387	4,115,413	p4,275,604	e4,338,297

eEstimated. pPreliminary. rRevised.

Legislation and Government Programs.—The Emergency Temporary Standard (ETS) for exposure to asbestos published by the Occupational Safety and Health Administration (OSHA) in November 1983 was terminated by the Fifth Circuit Court of Appeals. On March 7, 1984, the court issued a ruling that invalidated the ETS because the record did not indicate that the risk was as serious as OSHA had defined it.

By yearend, the Environmental Protection Agency (EPA) proposal of July 27, 1983, to ban asbestos in some products immediately and in all products eventually, had not been published.

By notice in the Federal Register of April 10, 1984, OSHA published its proposal to revise the standard for occupational exposure to asbestos. In addition, OSHA's 1975 proposal was formally withdrawn and replaced by this action. The regulatory text of the proposal (1) specifies two alternative permissible exposure limits (PEL), 0.2 fiber per cubic centimeter and 0.5 fiber per cubic centimeter, (2) requires an employee information and training program, and (3) requires warning signs to be displayed at each location where a revised PEL may be exceeded. OSHA plans to adopt a new PEL that reflects evidence that will be produced in the record concerning health risk and technical and economic feasibility and that may be higher or lower than the limits proposed. Hearings on the proposal were held during 1984.

A trade newsletter stated that recent findings of a study of the 44 nonfuel materials in the National Defense Stockpile indicated that 8 need immediate quality assessment because of their critical role in national defense.[2] One of these is chrysotile asbestos.

Environmental Impact.—As part of a review requested by OSHA, the U.S. Department of the Interior strongly suggested that the American Society for Testing and Materials' asbestos definition be adopted as the federal definition.[3] The compromise definition, which was expected to be useful to both the environmental and minerals communities, is as follows:

Asbestos.—A term applied to six naturally occurring minerals exploited commercially for their desirable physical properties, which are in part derived from their asbestiform habit. The six minerals are the serpentine mineral chrysotile and the amphibole minerals grunerite asbestos (also referred to as amosite), riebeckite asbestos (also referred to as crocidolite), anthophyllite asbestos, tremolite asbestos, and actinolite asbestos. Individual mineral particles, however processed and regardless of their mineral name, are not demonstrated to be asbestos if the length-to-width ratio is less than 20 to 1.

Figures compiled by the Rand Institute on 3,400 completed asbestos disease litigation cases showed that the total cost of the average case was $95,000, of which only $35,000 was paid to the plaintiff. A solution being tried was to set up a separate fund to settle the asbestos claims outside of the courtroom. The fund, called the Asbestos Claims Facility, would be run by a newly created, nonprofit organization.[4] The defendants would provide the funding, although the specific contributions of the various industrial companies and insurance companies involved had not been decided by yearend.

The necessity of removing asbestos from millions of buildings where it had been installed, mainly as insulation, was examined.[5] The study indicated that the National Academy of Sciences under contract to EPA concluded that the typical amount of asbestos dust in the home, including homes containing no asbestos construction materials, is about 400 fibers per cubic meter. Studies in the United Kingdom had shown that, in buildings containing damaged asbestos-based materials, the density of fibers was no higher. The lifetime public risk from asbestos-linked cancer was stated in the report to be about 9 per million—nearly 900 times smaller than the risk of death by accidents in the home.

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

(Metric tons)

	Stockpile goals	Total inventories 1982	1983	1984
Amosite	15,422	38,587	38,591	30,855
Chrysotile	2,722	9,034	9,753	9,754
Crocidolite	--	754	754	33
Total	18,144	48,375	49,098	40,642

DOMESTIC PRODUCTION

Mines in the United States shipped about 18% less asbestos than in 1983, and the value decreased 13%. Only two States produced asbestos; California was the leader, followed by Vermont.

Calaveras Asbestos Corp. was California's and the Nation's leading producer, from its Copperopolis Mine. The other California producer, the Santa Rita Mine on the Joaquin Ridge near Coalinga, in San Benito County, was owned and operated by Union Carbide Corp. through its newly named Calidria Corp. This mine was the second largest U.S. producer. The third U.S. producer was the Vermont Asbestos Group's Lowell Mine in Orleans County, VT.

Employment in U.S. asbestos mines and mills remained at somewhat less than 400 persons.

The Vermont Asbestos Group's mine was struck in October 1983, and the miners were out until February 1, 1984.

The Alaska asbestos project was again reviewed.[6] The Slate Creek chrysotile asbestos deposits are known to contain indicated reserves of about 60 million metric tons with an average fiber content of more than 5%. The fiber is strong and fast filtering and is considered to be ideal for use in asbestos-cement products. The Cache deposit, the largest of the Slate Creek deposits, would be the first scheduled for development. Because of domestic environmental problems, development of these Alaskan deposits remained on hold during 1984 despite the potential of supplying the Pacific Rim with excellent quality asbestos.

Table 3.—Asbestos producers in 1984

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

CONSUMPTION AND USES

Total U.S. asbestos consumption increased 4%; of this, 97% was chrysotile and 3% was crocidolite. Small amounts of amosite were reported used. Spinning grades 1, 2, and 3 represented 1% of the total chrysotile imported. Grade 7 remained the most used, 70%, followed by grades 4 at 11%, 5 at 10%, and 6 at 8%.

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

(Thousand metric tons)

End use	Chrysotile							Crocidolite	Amosite	Total asbestos
	Grades 1 and 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Total			
1983 total	0.4	2.2	17.0	13.9	17.4	159.3	210.2	6.2	0.6	217.0
1984:										
Asbestos-cement pipe	--	--	22.4	7.4	1.5	--	31.3	5.7	--	37.0
Asbestos-cement sheet	--	--	.3	1.2	8.0	2.6	12.1	--	--	12.1
Coatings and compounds	--	--	--	--	--	21.6	21.6	--	--	21.6
Flooring products	--	--	--	--	--	46.4	46.4	--	--	46.4
Friction products	--	--	1.0	7.3	6.2	33.9	48.4	--	--	48.4
Insulation:										
Thermal	--	--	.1	--	--	.4	.5	--	.1	.6
Electrical	--	--	--	1.5	.5	.2	2.2	--	--	2.2
Packing and gaskets	--	--	.4	.5	.7	11.6	13.2	--	--	13.2
Paper	--	--	--	.1	--	1.6	1.7	--	--	1.7
Plastics	--	--	--	.5	--	.6	1.1	--	--	1.1
Proofing products	--	--	--	3.0	--	4.1	7.1	--	--	7.1
Textiles	--	1.5	--	--	--	--	1.5	--	--	1.5
Other	.1	.5	.9	.2	.5	30.6	32.8	--	.3	33.1
Total	.1	2.0	25.1	21.7	17.4	153.6	219.9	5.7	.4	226.0

PRICES

Depressed markets and high producer inventories of the last few years have caused final negotiated asbestos prices to be lower than listed prices. A realistic set of unit values can be calculated using import data. These averaged data represented most of the domestic market. The unit value of exported asbestos, $460 per ton, represented a 28% increase.

Table 5.—Customs unit values of imported asbestos

(Dollars per metric ton)

	1980	1981	1982	1983	1984
Canada:					
Chrysotile:					
Cement	251	272	234	257	284
Crude	158	--	380	199	1,084
Spinning	843	927	917	932	699
Other	296	373	334	384	431
South Africa, Republic of:					
Amosite	1,611	728	771	840	869
Crocidolite	686	676	646	629	705

FOREIGN TRADE

There was a 27% increase in the total value of asbestos fibers and asbestos products exported from the United States; of this, the fiber portion remained at 13%. Exports of brake linings and disk brake pads increased 47% in value and accounted for 63% of the value of all asbestos products exported in 1984. Canada remained the largest recipient of U.S. exports accounting for 62% of the value, followed by Japan, 7%; Mexico, 6%; Saudi Arabia, 3%; and Venezuela, 3%.

Canada provided 93% of the asbestos fiber imported into the United States, and the Republic of South Africa provided 7%. Several countries provided minor amounts. Chrysotile continued to dominate the imported types with 97% of the total. The value of imported asbestos fiber increased 12%.

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

(Thousand dollars)

Country	1983 Unmanufactured fibers	1983 Manufactured products	1983 Total[1]	1984 Unmanufactured fibers	1984 Manufactured products	1984 Total
Australia	19	2,107	2,126	55	2,457	2,512
Brazil	221	1,432	1,653	215	3,683	3,898
Canada	1,539	73,739	75,278	889	112,012	112,901
Germany, Federal Republic of	985	2,367	3,352	1,023	2,540	3,563
Japan	3,787	8,036	11,823	3,279	9,062	12,341
Korea, Republic of	550	781	1,331	479	1,259	1,738
Kuwait	--	1,380	1,380	31	857	888
Mexico	4,649	3,565	8,214	6,997	4,649	11,646
Saudi Arabia	13	10,339	10,352	4	4,904	4,908
Thailand	2,599	189	2,788	1,916	179	2,095
Turkey	497	913	1,410	13	350	363
United Kingdom	204	2,116	2,320	192	619	811
Venezuela	329	1,773	2,102	571	3,975	4,546
Other	4,005	19,846	23,851	2,557	16,144	18,701
Total[1]	19,398	128,584	147,981	18,221	162,690	180,911

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

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

Products	1982 Quantity	1982 Value (thousands)	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
EXPORTS						
Unmanufactured:						
Crudes, fibers, stucco metric tons	42,342	$14,752	40,476	$14,879	26,381	$14,106
Sand and refuse do	16,183	4,791	13,760	4,519	13,398	4,115
Total do	58,525	19,543	54,236	19,398	39,779	18,221
Manufactured:						
Asbestos fibers do	2,538	8,119	1,537	5,198	958	5,067
Brake linings and disk brake pads do	NA	42,852	NA	70,456	NA	103,303
Clutch facings and linings number	NA	16,879	NA	20,285	NA	23,206
Gaskets metric tons	358	3,020	337	2,196	275	1,815
Insulation do	NA	6,799	NA	3,270	NA	5,720
Packing and seals do	1,311	15,309	1,015	10,174	1,150	9,063
Shingles and clapboard do	4,011	3,235	3,082	1,935	2,098	1,615
Other articles of asbestos do	17,639	13,444	4,953	5,593	1,759	2,595
Other articles, n.s.p.f do	NA	17,047	NA	9,477	NA	10,306
Total	XX	126,704	XX	128,584	XX	162,690
REEXPORTS						
Unmanufactured:						
Crudes and fibers do	246	170	333	271	140	125
Sand and refuse do	XX	XX	65	14	--	--
Total do	246	170	398	285	140	125
Manufactured:						
Asbestos fibers do	66	203	3	7	1	5
Brake linings and disk brake pads do	NA	539	NA	318	NA	47
Clutch facings and linings number	NA	309	NA	167	NA	194
Gaskets metric tons	r(1)	1	(1)	117	46	136
Insulation do	--	--	NA	10	(1)	10
Packing and seals do	5	22	1	10	(1)	1
Other articles of asbestos do	27	80	59	203	NA	264
Other articles, n.s.p.f do	NA	9	NA	166	--	--
Total	XX	1,163	XX	998	XX	657

r Revised. NA Not available. XX Not applicable.
1 Less than 1/2 unit.

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)
1982	229,079	$56,714	11,390	$7,199	1,268	$1,012	241,737	$64,925
1983:								
Amosite	--	--	609	512	--	--	609	512
Chrysotile:								
Crude	4	1	313	220	89	138	406	359
Spinning fibers	1,840	1,714	190	123	161	225	2,191	2,062
All other	182,459	48,018	4,465	2,998	80	120	187,004	51,136
Crocidolite (blue)	--	--	6,177	3,887	--	--	6,177	3,887
Total	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

WORLD REVIEW

World production of asbestos increased slightly for the second consecutive year. Canadian asbestos exports accounted for 65% of total world exports. Of total world asbestos deliveries, about 38% was made to North America including 30% to the United States, 22% to Asia, 20% to Europe, 11% to Central and South America, 8% to Africa and the Middle East, and 1% to Oceania.

As of mid-1983, producer inventories in Canada and most of the market economy countries were at a record high, even though all producers had adjusted production downward. It was estimated that 200,000 tons of asbestos fiber was stockpiled in Canada alone. The major reduction in mine production continued to give rise to shortened work periods, layoffs, and, in many instances, prolonged shutdowns of mining and processing operations. Furthermore, prices of most fiber grades had not increased during the last 3 years.[7]

World chrysotile production capacity was apparently increasing while demand was decreasing. Many countries were competing with Canada for a share of the export markets. In addition to the established producers such as Australia, Italy, the Republic of South Africa, the U.S.S.R., and Zimbabwe, Brazil, Colombia, and Greece had recently entered the world market.

Developing countries of Africa, Asia, Latin America, and the Middle East essentially constitute the only markets offering potential for growth, given their needs for asbestos products in construction and irrigation. Most of these countries are faced with a scarcity of hard currencies along with the shrinking of financing resources.

Australia.—Woodsreef Mines Ltd. announced plans to reopen its mine at Barraba early in 1985 if financing can be arranged. Using their wet process for fiber recovery, the company proposes to process the 25 million tons of dry process tailings left from previous mining for an expected 12-year operational life. An additional 12 million tons of unmined ore is amenable to the wet process. The company claims that the wet process almost doubles the yield of fiber obtained from ore compared to dry processing, and yields comparable to initial dry plant yields can be recovered from the tailings.

The wet process virtually eliminates all environmental problems and produces a well-opened fiber suitable for use in asbestos-cement without further treatment. The main product line will be a grade 5R equivalent, although limited quantities of grade 6D equivalent may be available. The fiber will probably be marketed in a pelletized form. Successful end-use trials on a commercial scale have already been conducted in asbestos-cement plants in Australia, Malaysia, Thailand, and the United States.

Brazil.—S.A. Mineração de Amianto (SAMA) holds about 96% of Brazil's asbestos reserves at Minacu, Goiás. In 1983, SAMA produced 150,000 tons of asbestos fiber and exported 14,000 tons. Measured, indicated, and inferred reserves total 5 million tons, with an average ore grade of 6.76%.

Canada.—Asbestos, which ranked third among all minerals in value of production in Quebec Province during 1984, continued to suffer reductions in production. In 1983, 745 million tons was produced with a value of C$321 million compared with 695 million tons in 1984 valued at C$301 million.[8] In volume, asbestos shipments dropped by 45% from those of 1979, and producers now have production capacity that far exceeds demand.

Brinco Mining Ltd. has increased the expected life of its Cassiar asbestos operations in British Columbia severalfold following the completion of a deep drill hole, which was collared 750 feet southeast of the 15-million-ton McDame deposit. This deep hole at least doubled the previously established reserves for the McDame deposit as a conservative estimate. Although the grade of the deposit is similar to the main Cassiar ore body, the unit value of the ore was expected to be higher because of the quality of the asbestos fiber.[9]

In another action, Brinco announced the sale of its 60.13% equity interest in Abitibi Asbestos Mining Co. in Maizerete Township, Quebec, to Dydar Resources Ltd., a private firm.

The Société Nationale de l'Amiante (SNA), an asbestos firm owned by the Quebec government, was active in two major areas with its asbestos properties. Asbestos Corp. Ltd. temporarily suspended operations at its Thetford plant effective December 1, 1984, because of a high inventory, 40,000 tons, caused by poor sales in 1984 and because of predicted weak markets in 1984.[10] A merger of their two operating mines in the Eastern Townships was under study.

China.—A delegation from China, while visiting in Canada, gave some information about their asbestos industry. Their production was not definitely known because there were many small local mines and records were poor. Mines were in 16 or 17 Provinces, and about 30 were owned by local communes, not by the state. The larger mines employed a total of 2,000 to 3,000 workers. According to the State Bureau of Building Materials, production was about 140,000 tons in 1982. Reserves are large, about 50 million tons. Product utilization has not been very wide.

Cyprus.—Production of asbestos in Cyprus came exclusively from one mine located in the serpentinite deposit of the Troodos Massif. The mine, at Amiandos, was owned and operated by Cyprus Asbestos Mines Ltd. Production was halved over a 3-year period to approximately 17,000 tons in 1983, inline with decreasing sales, which amounted to about 15,000 tons. Most of that production was exported.

Cyprus Asbestos produced two grades of asbestos, 3S and HSH, but because of declining quality, it is now developing two new grades in their place. During the summer of 1984, a pilot plant was set up to produce grades 4T and equivalent 4Z together with a small quantity of grade 7. The company planned to commence commercial production of its new grades in 1985 aiming at markets in the Middle and Far East. The majority of the company's production was destined for export with only about 1,000 tons per year supplied to the domestic market for the manufacture of asbestos cement pipes.[11]

United Kingdom.—The Health and Safety Executive of the United Kingdom put new control limits on asbestos exposure in 1984. The control limit for crocidolite remained at 0.2 fiber per cubic centimeter, and the limit for amosite was lowered from 0.5 to 0.2 fiber per cubic centimeter. The chrysotile control limit was halved to 0.5 fiber per cubic centimeter.

Yugoslavia.—A new asbestos tile and paper factory started trial operations in Stragari.[12] The factory was to export over one-half of its overall output to hard currency markets. Annual production of the factory was to be as follows: asbestos concentrate, 40,000 tons; asbestos paper, 22 million square meters; and asbestos tile, 9,000 tons.

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

(Metric tons)

Country[2]	1980	1981	1982	1983^p	1984^e
Argentina	1,261	1,280	1,218	1,240	1,250
Australia	92,418	r45,494	18,587	e20,000	10,000
Brazil	169,173	138,420	145,998	158,885	160,000
Bulgaria	700	400	600	700	600
Canada (shipments)	1,323,053	1,122,000	834,000	858,000	922,000
China^e	131,700	106,000	110,000	r160,000	160,000
Colombia^e	NA	5,400	5,400	5,400	9,000
Cyprus	34,535	24,440	18,952	17,288	16,000
Egypt	316	325	424	245	325
Greece	--	--	e100,000	e100,000	110,000
India	31,253	24,515	26,761	24,873	25,000
Indonesia^e	--	5,000	25,000	25,000	25,000
Italy	157,794	137,086	116,410	139,054	140,000
Japan	3,897	3,950	4,135	e4,000	4,000
Korea, Republic of	9,854	14,084	15,933	12,506	15,000
Mozambique	800	800	800	800	800
Philippines	6	--	--	--	--
South Africa, Republic of	277,734	235,943	211,860	221,111	170,000
Swaziland (exports)	32,833	35,264	26,413	31,275	30,000
Taiwan	683	2,317	2,392	7,819	2,500
Turkey	18,162	3,860	958	e4,000	4,000
U.S.S.R.^e	2,070,000	2,105,000	2,180,000	2,250,000	2,300,000
United States (sold or used by producers)	80,079	75,618	63,515	69,906	357,422
Yugoslavia	12,106	13,591	11,657	10,502	10,400
Zimbabwe	250,949	247,600	194,400	153,000	165,000
Total	r4,699,306	r4,348,387	4,115,413	4,275,604	4,338,297

^e Estimated. ^p Preliminary. ^r Revised. NA Not available.
[1]Table includes data available through Apr. 23, 1985.
[2]In addition to the countries listed, Afghanistan, Czechoslovakia, North Korea, and Romania also produced asbestos, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.
[3]Reported figure.

TECHNOLOGY

Higher methanol-to-gasoline yields were made possible with an asbestos-based catalyst as a result of research being carried out at Concordia University in Montreal, Canada. By crystallizing zeolite ZSM-5, a catalyst, on asbestos fibers, a mixed catalyst was made that selectively converts methanol to products with higher olefin-to-paraffin ratios than does ZSM-5 alone. In tests, olefin production was raised from 10% to 15%, using ZSM-5 alone, to almost 60%, while paraffin generation was cut from 45% to less than 5%. The concentration of aromatic liquids produced was about the same, 40%, with both catalysts. The catalyst is made by soaking asbestos fibers in dilute sulfuric acid, which partially leaches out magnesium and other metal impurities. The fibers are then hydrothermally reacted with sodium aluminate and tetrapropyl ammonium hydroxide to form submicrometer-size, spherical nodules of ZSM-5 on the fibers.[13]

A safe and inexpensive method of removing preformed asbestos insulation from ship pipes, fittings, and boilers was developed and successfully tested by Southwest Research Institute. The process uses a 1-to-5 solution of ethylene glycol and water to reduce the friability of the asbestos as well as the consequent fiber level in the air. Workers saturate the asbestos with the solution, allow it to soak into the insulation for 2 to 3 days, and then remove the insulation. Tests showed asbestos fiber concentrations to be well within permissible levels.[14]

Preparatory work was reportedly done by some paint companies to use attapulgite in place of asbestos. Although asbestos was still used in paints for a number of purposes, attapulgite was already getting considerable use as a replacement for asbestos in texture paint.[15]

Research on substitutes for asbestos has recently intensified.[16] Approaches were novel materials such as pulped polyolefins and a synthetic glass made from slate-mining wastes; new combinations of existing asbestos substitutes aimed at boosting their performance; and modifications of the chemical and physical nature of asbestos fibers to make them less injurious to living tissue.

Over the years, about 30 materials were advanced as substitutes for asbestos. These include glass fiber, cotton, ceramic fibers, carbon fibers, phenolic and aramid fibers, clay, mica, and diatomaceous earth. Many had already found their way into the market, either alone or combined in different proportions to achieve desired properties. Not one of these materials or groups of materials, however, is entirely satisfactory for all of the many asbestos outlets that include cement, brake linings, wallboard, and fireproof fabrics. Moreover, many of the substitutes have limitations, such as inadequate heat resistance, low strength, chemical instability, and cost.

Pulped polyolefin, introduced 3 years ago under the tradename Pulpex, was being investigated as an asbestos substitute in such applications as reinforcement for cement, felts for flooring tiles, and filters in the beverage industry. Chemically, Pulpex consists of tiny fibers of high-density polyethylene or polypropylene. Physically, it has a fleecy, white appearance that in bulk form and under a microscope strongly resembles asbestos fibers. Although the product has been used in cement piping in Europe, it has been more difficult to market in the United States because of a tremendous reluctance to change from asbestos despite its well-known health hazards. The area where pulped polyolefins already had marked success was in replacing the asbestos in felt that underlies vinyl floor tiles. However, they are about 10 times more costly than the cheaper grades of asbestos.

Far more experimental than the Pulpex work is a project under way at the University of California at Los Angeles. The program, sponsored by the Bureau of Mines, seeks to turn the wastes from marble and slate processing into a glassy fiber that shows promise for replacing asbestos in cement.

The search for asbestos replacements also involves the combination of well-known substitute materials in novel blends. Nowhere is this practice more common than in friction materials, including linings for brakes and clutches. In this application, there is no single drop-in substitute for asbestos.

Although complete replacement of asbestos is the goal of most research on substitutes, some attempts are being made to modify asbestos itself to make it less harmful. One such program is in progress in Canada at SNA. The process involves treating asbestos fibers with dry vapors of phosphorus compounds in an inert atmosphere.

Among the compounds used are phosphorus oxychloride and phosphorus pentachloride. The asbestos treated in this fashion has 0.5% to 5% by weight of phosphate groups chemically bound to the fibers. According to the company, such fibers do far less damage to living tissue than do ordinary asbestos fibers, although it is not known why.

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[1]Physical scientist, Division of Industrial Minerals.

[2]Energy and Minerals Resources. Minerals Newswire. V. 12, No. 18, May 7, 1984, p. 143.

[3]Ross, M., R. A. Kuntze, and R. A. Clifton. A Definition for Asbestos. Definitions for Asbestos and Other Health-Related Silicates, ed. by Benjamin Levadie. American Society for Testing and Materials, ASTM STP 834, 1984, pp. 139-147.

[4]Chemical Week. An Out of Court Fund for Asbestos Claims. V. 134, No. 17, Apr. 25, 1984, pp. 18-19.

[5]The Economist (London). Is the Anti-Asbestos Lobby Moving Too Quickly, Too Late? V. 292, No. 7359, Sept. 15, 1984, p. 65.

[6]Mullins, W. J., and J. F. McQuat. The Alaska Asbestos Project (Part 1)—Project Review. Ind. Miner. (London), No. 199, Apr. 1984, p. 40.

[7]Dupere, J. Asbestos Industry at the Crossroads: Current Position and Outlook. Min. Eng., v. 36, No. 7, 1984, pp. 727-730.

[8]The Northern Miner. Quebec Increases Value of Annual Mineral Output. V. 70, No. 42, Dec. 27, 1984, p. 20.

[9]———. Brinco Hole Doubles McDame Reserves. V. 70, No. 27, Sept. 13, 1984, p. 1.

[10]Industrial Minerals (London). Asbestos Corp. Shutdown. No. 207, Dec. 1984, p. 9.

[11]Griffiths, J. The Industrial Minerals of Cyprus. Ind. Miner. (London), No. 207, Dec. 1984, pp. 21-35.

[12]Industrial Minerals (London). Company News and Mineral Notes. No. 205, Oct. 1984, p. 70.

[13]Chemical Engineering. Chementator. V. 91, No. 9, Apr. 30, 1984, p. 17.

[14]Chemical Week. A New Process To Remove Asbestos. V. 134, No. 14, Apr. 14, 1984, p. 34.

[15]American Paint and Coatings Journal. Miscellaneous Materials. V. 69, No. 2, July 30, 1984, p. 22.

[16]Chemical Week. The Urgent Search for Asbestos Substitutes. V. 135, No. 2, July 11, 1984, pp. 54-55.

Barite

By Sarkis G. Ampian[1]

Domestic production of barite, after declining in 1982 and 1983, increased 3% to 775,000 short tons valued at $25 million. Production from Nevada, the leading producer, decreased 7% to 615,000 tons. Production from Georgia and Missouri, the second and third leading States, respectively, increased. Imports for consumption of crude barite rose 24% to 1.73 million tons, and ground barite imports rose over thirtyfold from 1,326 tons to 45,024 tons valued at $3.2 million. Imports of barite for the third consecutive year led domestic production. Ground barite imports, except for the drilling boom years of the late 1970's and early 1980's, had been 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 extender uses accounted for the remaining 7%.

Demand for barite increased after declining for 2 straight years owing to an increase in drilling activity and improvement in the overall economy. However, the increase in drilling activity was in land rigs drilling shallower wells that use less barite. U.S. mine production also rose for the first time in 2 years because of lower rail rates, which increased the competitiveness of domestic ores in the marketplace. Barite grinding capacity, escalated in earlier years to meet demand, remained in a position to meet present or future demand.

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)

	1980	1981	1982	1983	1984
United States:					
Barite, primary:					
Sold or used by producers	2,245	2,849	1,845	754	775
Value	$65,957	$102,439	$69,522	$29,203	$25,445
Exports	97	62	49	23	1
Value	$13,794	$9,947	$6,510	$3,514	$574
Imports for consumption (crude)	1,850	1,932	2,320	1,396	1,731
Consumption (apparent)[1]	3,998	4,719	4,116	2,127	2,505
Crushed and ground (sold or used by processors)[2]	3,649	4,716	4,088	2,745	2,883
Value	$365,632	$406,255	$322,700	$194,380	$220,806
Barium chemicals (sold or used by processors)	40	34	25	22	26
Value	$22,441	$20,670	$18,720	$16,860	$17,105
World: Production	[r]8,262	[r]9,055	8,025	[p]5,986	[e]6,313

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

DOMESTIC PRODUCTION

The term "primary barite" denoted the first marketable product and includes crude run-of-mine barite, flotation concentrates, and material concentrated by other beneficiation processes such as washing, jigging, or magnetic separation. Run-of-mine barite, the lowest cost primary barite, sold or used by producers represented 64% of total production compared with 38% in 1983; flotation concentrate was 8% of total 1984 production; and the balance was other beneficiated material.

Reported primary production increased 3%. Nevada and Georgia continued to be the leading States for barite output. Other producing States, in descending order, were Missouri, Montana, Tennessee, Illinois, and Washington. Illinois produced barite as a coproduct of fluorspar mining and milling; in all other States, barite was the primary product.

The leading domestic barite producers were Dresser Minerals Div., Dresser Industries Inc., IMCO Services Div., Halliburton Co., NL Baroid/NL Industries Inc., all with mines in Missouri and Nevada; and Milchem Inc., with mines in Nevada. Other important producers in Nevada were All Minerals Corp., A. W. Arnold and Associates Inc., Eisenman Chemical Co. (a subsidiary of Newpark Resources Inc.), FMC Corp., and Old Soldier Mining Co. DeSoto Mining Co. in Missouri and C-E Minerals, a division of Combustion Engineering Inc., in Washington also produced barite.

The domestic barite industry experienced an upturn during the year primarily due to increased drilling activity and an improved domestic economy. Production data reveal that increases in mine output could be attributed directly to transportation economics resulting from lower rail rates. Nevertheless, the continuing oil glut and lower energy consumption rates detracted from any major turnaround in oil- and gas-well-drilling activity. Prior to the downturn, which started at midyear 1982, the industry had enjoyed a twofold increase in mine and grinding plant capacities from the latter half of the 1970's to the first half of 1982. The downturn left many barite producers with excess inventories and long-term contracts to purchase foreign ores and was followed by cutbacks in domestic mine production and grinding plant activities that still persist. This slowdown was exacerbated by the world barite oversupply and lower ocean freight rates, in part owing to lower bunker fuel prices and excess bottoms. These factors, coupled with high domestic mining costs, high rail rates, and a strong U.S. dollar, combined to make foreign barite more attractive than domestic ore. The major producers were increasingly making use of unit trains and guaranteed tonnage contracts, in collaboration with the carriers, to lower rail rates from Nevada to both the U.S. gulf coast and midcontinent areas to remain competitive in the marketplace. The competitiveness of the domestic industry, both for producers and grinders alike, was further threatened by the imports of ground barite into an already depressed marketplace and by pending barter agreements, which could further soften foreign barite prices.

Most mining and grinding operations continued to be either suspended or on minimal production schedules. Many of the additions to mining, milling, and/or grinding capacity were largely to reduce operation costs to remain competitive in a soft market situation. Many on-going and planned projects, including exploration programs, for the most part have been indefinitely deferred.

Hughes Drilling Fluids added a second 54-inch Raymond mill and additional storage capacity to its Houston grinding plant. Circle A Mining Co. constructed a jig plant north of Wells, NV, and started production at midyear. Eisenman Chemical, a subsidiary of Newpark Resources Inc., reopened its Lakes Mountain jig plant in Nevada for a 3-month period. Newpark Resources also announced that it intended to develop a new supply base at Harbor Island, near Corpus Christi, TX, to supply fluids to the offshore petroleum exploration industry in the Gulf of Mexico.

New Riverside Ochre Co. modified its Cartersville, GA, beneficiation plant by installing a new ball mill to increase the capacity of its flotation circuits. The concentrates are used chiefly to produce barium chemicals.

In mergers, acquisitions, and closures, Dowell (a subsidiary of Dow Chemical Co.) merged into Dowell Schlumberger. Previously, Dowell serviced the domestic drilling industry, and Dowell Schlumberger, an equal partnership between Dow and the French company Schlumberger Ltd., catered to the rest of the world. Schlumberger will manage the new venture. Newpark Resources, in another move, purchased the assets of Sherwell Supply Co., a division of Sherwin Williams Co., a drilling fluids distribution company with facilities at numerous Oklahoma locations. A. W. Arnold closed plants in Oklahoma and south Louisiana.

The Port of Houston, the second largest barite entry port, installed a new $4.1 million shiploading system, including a traveling shiploader, a dust suppression system, and a new conveyor belt scheme, to increase efficiency and improve turnaround time for ships calling at the port.

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)
1983:									
Georgia	2	--	--	W	W	W	W	W	W
Illinois	1	--	--	W	W	W	W	W	W
Missouri	2	--	--	--	--	W	W	W	W
Montana	1	2	$150	--	--	8	$600	10	$750
Nevada	11	276	7,140	W	W	387	14,596	663	21,736
Tennessee	1	W	W	--	--	--	--	W	W
Washington	1	W	W	--	--	--	--	W	W
Total	19	283	7,594	[2]101	[2]$7,336	472	21,609	[3]754	29,203
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	[3]25,445

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes some flotation concentrates in 1983.
[2]Not included in primary barite total.
[3]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Consumption of crushed and ground barite increased about 5% from 2.7 million tons in 1983 to 2.9 million tons. This upturn reverses the 2 consecutive years of decline from the record high of 1981, when 4.7 million tons of crushed and ground barite were used. This increase reflected a slight increase in barite required for all well drilling, which accounted for over 93% of total sales. The oil- and gas-well-drilling industry completed over 82,000 wells and drilled over 348 million feet of hole.[2] The figures indicated an increase in the number of wells and feet drilled of 7% each.

Total well footage drilled exceeded 10 million feet in six States: Texas, 124.4 million feet; Oklahoma, 45.9 million feet; Louisiana, 35.4 million feet; Kansas, 22.1 million feet; Ohio, 17.2 million feet; and Wyoming, 10.7 million feet. Generally, the deeper a hole is drilled, the more barite is used per foot of drilling. Among the six leading States, Wyoming had the highest well depth, over 7,100 feet, and Kansas, the lowest, had an average depth of about 3,000 feet. The U.S. average declined nearly 200 feet to about 4,200 feet. The main reason that barite consumption increased was because of the 7% increase in the number of wells drilled. This increase, however, was offset by the decline of barite per foot of drilling, which decreased to 15.5 pounds per foot of drilling compared with 16.3 pounds per foot in 1983. The increase in uprating rigs was in land rigs that drill shallower wells, which require less barite. Another barometer of drilling activity, the Hughes Tool Co. rig count, showed that the average number of operating domestic rigs increased by nearly 9% to 2,428 rigs.[3] The increase in rigs reverses a 2-year downward trend that saw the number of rigs tumble from the record high of 1981, 3,969 rigs, to 2,232 rigs in 1982. The estimated rig count during the year ranged from a low of about 2,100 to a high of 2,800.

The total value of barium chemicals sold or used in 1984 increased slightly to $17.1 million. This was the first yearly increase noted since the 1979 record year. Previously, the total value had declined 35%.

Table 3.—Crushed and ground barite[1] sold or used by processors in the United States, by State

State	1983			1984		
	Number of plants	Quantity (thousand short tons)	Value (thousands)	Number of plants	Quantity (thousand short tons)	Value (thousands)
Louisiana	11	1,056	$77,680	13	1,315	$109,413
Missouri	3	11	1,135	2	W	W
Nevada	11	635	26,019	9	478	15,691
Oklahoma	6	82	7,249	5	91	6,737
Texas	13	750	58,643	14	783	63,186
Utah	4	55	3,842	4	55	3,976
Other[2]	12	157	19,811	11	161	21,803
Total[3]	60	2,745	194,380	58	2,883	220,806

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

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[2]	1983		1984	
	Quantity	Value	Quantity	Value
Barium chemicals	40	3,703	116	9,605
Filler or extender[3]	57	12,030	72	14,178
Well drilling	2,648	178,647	2,695	197,023
Total	2,745	194,380	2,883	220,806

[1]Includes imports.
[2]Uses reported by processors of ground and crushed barite, except for barium chemicals.
[3]Includes glass, paint, rubber, other filler, and other uses.

Table 5.—U.S. barium chemicals[1] produced and sold or used by processors

Barium chemical	1983				1984			
	Plants[2]	Production (short tons)	Sold or used by processors: Quantity (short tons)	Sold or used by processors: Value (thousands)	Plants[2]	Production (short tons)	Sold or used by processors: Quantity (short tons)	Sold or used by processors: Value (thousands)
Barium carbonate	3	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	r23,240	r21,680	r$16,860	2	27,364	26,249	$17,105
Total	4	23,240	21,680	16,860	3	27,364	26,249	17,105

rRevised. 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			
1964	931	19.91	4.69	17.69	42.29	58.2	4,431	22.01
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

[1]Includes exploratory and development wells; excludes service wells, stratigraphic tests, and core tests.

Source: American Petroleum Institute.

PRICES

Price quotations in trade publications decreased slightly for some grades of barite. These prices may serve as a general guide but do not reflect actual transactions.

The reported average value per ton of domestic primary barite, based on actual sales, decreased nearly 15% f.o.b. plant. The average reported value per ton of ground barite from Texas and Louisiana was $81.95; the average value of that from California, Nevada, and Utah was $59.13 per ton. The average customs value of barite exported to Canada was about $350 per ton; the customs value of material exported to Mexico and Latin America was about $115 per ton.

Table 7.—Barite price quotations

Item	Price per short ton[1] 1983	Price per short ton[1] 1984
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	65.00- 75.00	55.00- 75.00
Barium chemicals:[3]		
Barium carbonate:		
Precipitated, bulk, carlots, freight equalized (per pound)	.24	.24
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)	55.00	46.00
Barium sulfate:		
Blanc fixe, technical-grade, bags, carlots	430.00	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. 184, No. 12, Dec. 1983, p. 21, and v. 185, No. 12, Dec. 1984, p. 27.
[3]Chemical Marketing Reporter. V. 224, No. 26, Dec. 26, 1983, p. 29, and v. 226, No. 27, Dec. 31, 1984, p. 21.

FOREIGN TRADE

Exports of natural barium sulfate or barite declined fifteenfold from 23,000 tons to nearly 1,500 tons. This represents a fifth year of decline from the record high of 1979, when 109,000 tons were exported, and the smallest amount of ground barite exported 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 60% was chemical, filler, or glass grade, and an estimated 40% was ground drilling-mud grade. Previously barite exports usually consisted of over 90% mud-grade material. No crude barite was exported in 1984. Canada, traditionally second among export recipients, replaced Mexico as the leading importer of U.S. ground barite and accounted for nearly 49% of the total exports. Exports to Mexico declined from nearly 18,000 tons in 1983 to below 100 tons. Both countries are relying more heavily on domestic production. The strong U.S. dollar also has had an adverse effect on barite exports.

Imports of crude barite increased 24% from 1.40 million tons to 1.73 million tons. The 1984 barite import figure was still 25% below the record high of 2.32 million tons set in 1982. The average unit c.i.f.[4] value of this material dropped about 14% to $41.43 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 mines to gulf coast area grinding plants, continued to take advantage of the more attractively priced foreign ores to meet their demands. Average value per ton for material shipped from the principal source countries was China, $44.23; Peru, $40.90; Morocco, $40.50; Thailand, $40.43; Ireland, $38.03; India, $37.35; Chile, $35.96; and Mexico, $21.45. The costlier, higher quality barite, generally material with a specific gravity greater than 4.3, is usually blended with lower grade ore, foreign or domestic, during grinding to meet American Petroleum Institute (API) specifications for 4.2 drilling-mud-grade barite.

Imports of ground barite increased more than thirtyfold to over 45,000 tons from about 1,300; of this, China and Morocco supplied 70% and 25%, respectively. Ground barite imports generally had been limited to premium-quality pharmaceutical grade from Belgium-Luxembourg, Canada, the Federal Republic of Germany, and the Netherlands, unavailable domestically and averaging $300 to $400 per ton. The average value of the Chinese and Moroccan imports, $53.88 and $79.82, respectively, suggests that this barite was probably drilling-grade material. No imports of ground mud-grade barite were recorded for either 1982 or 1983. The last significant imports of mud-grade barite occurred during the drilling boom years of the late 1970's and early 1980's when imports, mainly from Morocco, Mexico, Singapore, and China, averaged under 10,000 tons per year. Continued imports of ground drilling-grade barite, in an already depressed market, will probably not only result in the closure of some grinding plants but also affect the few domestic mines that still supply ore for blending. The value of imports from Thailand and Turkey, about $150 per ton, indicates that these ground materials were probably destined for domestic filler and extender markets that in the past had been supplied by U.S. producers.

For the most part, crude barite entered through customs districts located along the gulf coast for delivery to grinding plants in that area, which was near most drilling-mud markets. The import distribution by customs districts in 1984 (1983) was New Orleans, LA, 53% (51%); Houston, TX, 31% (28%); Laredo, TX, (Port of Brownsville, TX), 8% (12%); and Port Arthur, TX, (Port of Lake Charles, LA), 8% (9%).

Imports of barium chemicals increased 27% to about 35,000 tons valued at over $20.5 million. Barium carbonate imports rose 64% to nearly 14,500 tons. Brazil, China, France, the Federal Republic of Germany, Italy, and Japan were the major suppliers.

The U.S. Department of Commerce and the U.S. International Trade Commission (ITC) determined on October 17, 1984, that barium chloride from China was being sold at less than fair market value and that such sales were materially injuring the U.S. industry. Based on these findings, all unliquidated entries, or warehouse withdrawals for consumption of barium chloride from China, on or after April 6, 1984, were to be liable for possible assessment of a 14.5% antidumping duty. Furthermore, a cash deposit of estimated antidumping duties was to accompany each affected transaction.

The antidumping duty resulted from a petition filed on October 25, 1983, by the sole remaining domestic producer of barium chloride and barium carbonate, Chemical Products Co., Cartersville, GA.

In other actions, the ITC ruled separately on barium carbonate imports from China and the Federal Republic of Germany. On August 27, 1984, the ITC determined that barium carbonate from China was not being sold in the United States at less than fair market value and terminated its investigation. As a result of another review of two known manufacturers and/or exporters of West German barium carbonate, from February 18, 1981, through June 30, 1982, the ITC determined the existence of dumping margins during the period for one firm, Kali Chemie AG. A preliminary intention to assess dumping duties, equal to the calculated differences between the U.S. price and foreign market value, in each of its roles during that period was advanced on February 24, 1984.

Table 8.—U.S. exports of natural barium sulfate, by country

Country	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Argentina	238	$134	25	$9
Australia	3	13	--	--
Barbados	1,677	107	259	30
Canada	2,582	601	707	254
Colombia	26	19	--	--
Jamaica	4	1	--	--
Japan	--	--	62	20
Mexico	17,676	2,485	87	193
Philippines	56	21	36	13
Venezuela	45	21	39	21
Other	509	111	235	34
Total[1]	22,816	3,514	1,449	574

[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	1983 Quantity (short tons)	1983 Value[1] (thousands)	1984 Quantity (short tons)	1984 Value[1] (thousands)
Crude barite:				
Chile	81,601	$4,163	87,202	$3,136
China	777,955	38,974	905,158	40,038
India	24,251	1,221	133,785	4,997
Ireland	--	--	39,683	1,509
Mexico	131,467	4,433	59,446	1,275
Morocco	175,999	8,723	335,375	13,582
Peru	129,939	5,751	64,006	2,618
Thailand	48,005	2,213	64,753	2,618
Other[2]	26,745	1,556	41,552	1,937
Total[3]	1,395,964	67,034	1,730,960	71,708
Ground barite:				
Belgium-Luxembourg	56	21	103	41
Canada	579	163	1,565	374
China	--	--	31,382	1,691
France	40	12	80	24
Germany, Federal Republic of	160	55	324	92
Mexico	153	7	1	(4)
Morocco	--	--	11,112	887

See footnotes at end of table.

Table 9.—U.S. imports for consumption of barite, by country —Continued

Country	1983 Quantity (short tons)	1983 Value[1] (thousands)	1984 Quantity (short tons)	1984 Value[1] (thousands)
Ground barite —Continued				
Netherlands	295	$105	368	$115
Thailand	43	7	67	10
Turkey	--	--	22	3
Total	1,326	370	45,024	3,237

[1]C.i.f. value.
[2]Includes 26,462 tons valued at $1,527,100 in 1983 from Taiwan, not believed to have originated in Taiwan.
[3]Data may not add to total shown because of independent rounding.
[4]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)
1980	1,310	$599	7,752	$4,460	4,216	$980	2,917	$1,694
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

Year	Barium nitrate		Barium carbonate, precipitated		Other barium compounds	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1980	1,143	$243	6,876	$2,050	883	$597
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

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 Quantity (short tons)	Crude, unground Value (thousands)	Crushed or ground Quantity (short tons)	Crushed or ground Value (thousands)
1980	22,145	$713	62	$23
1981	7	2	92	85
1982	292	82	41	44
1983	1	4	49	12
1984	41	24	185	129

[1]Barium carbonate.

Source: Bureau of the Census.

WORLD REVIEW

Estimated world production of barite increased slightly to 6.3 million tons. The United States produced 12% of the world total and imported 27% of the world output.

Afghanistan.—A mineral map of the country, completed with help from the U.S.S.R., was released by the Ministry of Mines.[5] The survey, undertaken to establish the reserves of a number of mines, listed a barite mine in Logar, 50 miles south of Kabul.

Canada.—Cuvier Mines Inc. began an extensive exploration program to locate barite deposits in Nova Scotia and New Brunswick.[6] The company reportedly had several sites ready for drilling in the Walton area of Nova Scotia. Magcobar Minerals, a division of Dresser Industries, opened its Fireside, British Columbia, barite mine and installed a portable grinding plant at Watson Lake, also in British Columbia.[7]

The Buchans silver-lead-zinc-copper mine in Newfoundland was permanently closed at midyear.[8] The mine, owned by Abitibi-Price Ltd. and ASARCO Incorporated and operated by the latter, has been worked sporadically since 1981 to salvage remaining ore reserves. Barite recovery from the stored mill tailings was to continue on a seasonal basis.

China.—The Government continued its program to improve both its barite mines and transportation systems in order to maintain its position as the world's leading producer and exporter of barite.[9] The majority of the drilling-mud and chemical-grade barites are produced in Guangxi, Guizhou, and Hubei Provinces.

Germany, Federal Republic of.—Kali Chemie, a Solvay & Cie. S.A. subsidiary, was investing 20 million deutsche marks (DM) in expanding its production capacity by more than one-third for barium and strontium carbonates at its two plants.[10] The expansions, scheduled for completion either by yearend 1984 or early 1985, were to take place at both its Bad Honningen Works in the Federal Republic of Germany and at the Livorno plant of its Italian subsidiary, Societá Bario e Derivati.

Kali Chemie plans to produce high-specification-grade barium and strontium carbonates for consumer industries such as magnet-grade ferrites, electrical compensators, and television envelopes.

India.—The Cuddapah district in Andhra Pradesh, with over 70 million tons or one-third of India's total barite reserves, accounted for 98% of its production.[11] The other barite producing States were Rajasthan, Maharashtra, Himachal Pradesh, and Tamil Nadu.

The Government abolished the export duty on barite.[12] The removal of the 50-rupee-per-ton levy is expected to increase exports of barite, particularly to Iran, Iraq, the U.S.S.R., the United States, and some Persian Gulf States. This move was probably undertaken because of strong competition from Chinese, Moroccan, and Thai producers.

Mexico.—The Barita de Sonora S.A. de C.V. project in Villa Pesquiera, with a targeted capacity of nearly 200,000 tons per year, was near completion at yearend.[13]

Oman.—IMCO, was constructing a 50,000-ton-per-year grinding plant scheduled for opening by mid-1985.[14]

Peru.—NL Baroid/NL Industries purchased the grinding facilities of Baribent S.A., in Lima, to supply the local market.[15] The new company will operate the facilities as Minerales Andinos S.A.

Spain.—IMCO, has acquired a majority of the outstanding stock of Unibario Sociedad Anónima Comercial y Minera and will operate as a subsidiary of Halliburton.[16] Unibario is a producer and processor of barite and bentonite for the drilling-mud industry with a barite mine and processing plant at La Carolina and shipping facilities at Seville. The new company, with a capacity to produce over 30,000 and 5,000 tons per year of barite and bentonite, respectively, will serve IMCO's operations in north and west Africa and selected locations in Europe.

United Kingdom.—The Silverband barite mine of Horace Taylor (Minerals) Ltd. was sold to a new company, Silverband Barytes Co., based at Knock in Cumbria.[17] The Silverband Mine will continue to produce about 10,000 tons per year of mud-grade barite while Taylor's Derbyshire operation will supply 7,000 to 8,000 tons per year of filler-grade barites for use in paint, rubber, plastics, and friction materials.

Yugoslavia.—A new barite mine was scheduled to come on-stream by the end of 1985 at Pljevija in Montenegro.[18] The new mine was to have a production capacity of 27,000 tons per year.

Table 12.—Barite: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Afghanistan[3]	3	1	2	[e]2	3
Algeria	108	98	112	[e]120	120
Argentina	55	54	40	67	66
Australia	43	45	31	[e]44	44
Austria	([4])	--	--	--	--
Belgium[e]	33	44	44	44	44
Bolivia[5]	10	2	1	1	1
Brazil	115	128	[e]132	[e]130	130
Burma[6]	[r]5	8	18	12	12
Canada	104	95	31	[r e]50	55
Chile	249	286	322	126	130
China[e]	750	880	990	[r]1,100	1,100
Colombia	4	4	4	4	4
Czechoslovakia[e]	[7]67	67	67	67	67
Egypt	5	2	[e]3	4	4
France	261	210	172	165	155
German Democratic Republic[e]	39	39	39	39	40
Germany, Federal Republic of	193	182	183	181	200
Greece[8]	53	52	52	33	35
Guatemala	5	6	2	[r e]([4])	([4])
India	478	390	359	356	460
Iran[e]	165	83	88	94	100
Ireland	287	302	292	220	220
Italy	224	195	198	153	[7]118
Japan	62	62	66	77	[7]73
Kenya	7	7	--	([4])	([4])
Korea, North[e]	120	110	--	--	--
Korea, Republic of	([4])	--	--	1	--
Malaysia	--	21	28	24	40
Mexico	297	350	401	394	400
Morocco	353	513	593	311	330
Pakistan	15	26	29	31	33
Peru	457	451	413	[e]180	180
Philippines	6	2	10	3	[7]1
Poland	106	94	100	89	89
Portugal	1	1	[e]1	1	([4])
Romania[e]	[7]88	87	86	86	80
South Africa, Republic of	3	3	4	7	5
Spain	66	58	55	58	55
Thailand	336	338	365	207	[7]193
Tunisia	30	27	34	22	30
Turkey	141	205	118	85	200
U.S.S.R.[e]	560	560	570	570	600
United Kingdom	60	69	89	40	80
United States[9]	2,245	2,849	1,845	754	[7]775
Yugoslavia	53	49	35	[r e]33	40
Zimbabwe	([4])	--	1	1	1
Total	[r]8,262	[r]9,055	8,025	5,986	6,313

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 11, 1985.
[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]Less than 1/2 unit.
[5]Series represents exports only; Bolivia also produces barite for domestic consumption, but available data are not adequate for formulation of estimates or levels of production to meet internal needs.
[6]Data are for fiscal years beginning Apr. 1 of that stated.
[7]Reported figure.
[8]Barite concentrates.
[9]Sold or used by producers.

TECHNOLOGY

A comprehensive technical paper on barite in Nevada, with sections on its mineralogy, uses, history, past production, exploration, economics, and geology of deposits, was published.[19] The work included descriptions of 181 Nevada barite deposits and 2 maps, one showing barite deposits and occurrences in the State and the other showing barite production from its deposits. Another article on Nevada detailed the geology of the deposits and also highlighted the exploration, production history, and open pit mining methods of the major producing companies in the State.[20]

Indepth reviews were published on the industrial minerals of Canada[21] and the United Kingdom[22] that included sections on barite geology, mineralogy, and indigenous mining methods. Both works featured industrial minerals activities and recent developments in each of the major barite producing Canadian provinces, Scotland, and the Lake District and Derbyshire in England.

A symposium on barite was held during the year.[23] A total of 11 papers were presented that covered a variety of topics from the geological framework of barite deposits and possible area for future exploration to a more technical theme dealing with beneficiation, comminution, and classification of barites.

The chemistry, production methods, and specifications for nondrilling applications of barite were reviewed.[24] The main areas of consumption—fillers and extenders, chemicals, glass, and ceramics—were also examined in detail, and predictions of market trends were given. A feature outlined the major worldwide producers of barite for nondrilling usage.

Two methods for rapidly estimating the quantity of mud-grade barite consumed for a given well were developed.[25] The techniques, although not as precise as those employed by petroleum engineers, were stated to be of considerable use. The methods used hole and casing capacities along with mud systems and weights to calculate both barite quantities required and their costs.

The geology, mining methods, and production flowsheets for two underground Japanese copper-lead-zinc-barite mines were depicted.[26] Both operations, containing head feeds of about 10% barite, routinely produced concentrates containing over 96% barite with recoveries averaging over 50%.

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[1]Physical scientist, Division of Industrial Minerals.

[2]American Petroleum Institute. Quarterly Review of Drilling Statistics for the United States. 4th Quarter, 1984 and Annual Summary, 1984. V. 18, No. 4, Feb. 1985, 39 pp.

[3]Hughes Tool Co. 1984 Annual Report. P. 14.

[4]Costs, insurance, and freight.

[5]Industrial Minerals (London). Company News & Minerals Notes. No. 197, Feb. 1984, p. 63.

[6]———. Company News & Mineral Notes. No. 198, Mar. 1984, p. 70.

[7]Richardson, R. C. Barite. Min. Eng., v. 37, No. 5, May 1985, p. 461.

[8]Mining Magazine (London). World Highlights: North America-Buchans Exhausted. V. 151, No. 1, July 1984, p. 11.

[9]Castelli, A. V. Barite. Eng. and Min. J., v. 186, No. 3, Mar. 1985, pp. 115-116.

[10]European Chemical News. New Projects: Kali-Chemie Lifts Capacity. V. 43, No. 1142, Sept. 3, 1984, p. 30.

[11]U.S. Embassy, New Delhi, India. State Dep. Airgram A-11, p. 13.

[12]Mining Journal (London). Industry In Action: Government Measures—India Ends Barytes Duty. V. 302, No. 7762, May 25, 1984, p. 355.

[13]U.S. Embassy, Mexico City, Mexico. State Dep. Airgram A-48, p. 23.

[14]Work cited in footnote 7.

[15]Work cited in footnote 9.

[16]Industrial Minerals (London). World of Minerals: Spain—IMCO Buys Unibario. No. 201, June 1984, p. 11.

[17]———. World of Minerals: United Kingdom—Silverband Barytes Changes Hands. No. 203, Aug. 1984, p. 13.

[18]———. Company News & Mineral Notes. No. 201, June 1984, p. 61.

[19]Papke, K. G. Barite in Nevada. Bull. 98, Nevada Bureau of Mines and Geology, Reno, NV, 1984; available from Nevada Bureau of Mines and Geology, University of Nevada-Reno, Reno, NV 89557-0088, $10.

[20]Clarke, G. Barytes in Nevada—Back to Pre-1984 Levels. Ind. Miner. (London), No. 200, May 1984, pp. 53-61.

[21]Industrial Minerals (London). Industrial Minerals in Canada—A Review of Recent Developments. No. 200, May 1984, pp. 63-125.

[22]Clarke, G. Industrial Minerals in the U.K.—An Overview of Recent Developments. Ind. Miner. (London), No. 206, Nov. 1984, pp. 21-47.

[23]Transactions—Institution of Mining and Metallurgy, Section A: Mining Industry. July 1984, pp. A95-168.

[24]Griffiths, J. Barytes: Non-Drilling Applications. Ind. Miner. (London), No. 201, June 1984, pp. 21-33.

[25]Drawater, C. Estimation of Barytes Consumption During Oilwell Drilling. Ind. Miner. (London), No. 202, July 1984, pp. 63-65.

[26]Mining Magazine (London). Kosaka Mine and Smelter. V. 151, No. 5, Nov. 1984, pp. 403-409.

———. Hanaoka Mine. V. 151, No. 5, Nov. 1984, pp. 414-423.

Bauxite and Alumina

By Luke H. Baumgardner[1] and Ruth A. Hough[2]

World bauxite and alumina production increased substantially in 1984. Bauxite and alumina production in the United States also increased significantly, although domestic alumina capacity was reduced by 800,000 metric tons[3] at yearend when the Mobile, AL, refinery was permanently closed by the Aluminum Co. of America (Alcoa). Reynolds Metals Co. abandoned its bauxite mining and export operations in Jamaica, Kaiser Aluminum & Chemical Corp. disclosed plans to sell its refractories business, and Martin Marietta Corp. announced that Comalco Pty. Ltd., Australia, was buying most of its aluminum facilities. Production was started at two new alumina plants in Australia and one in Brazil. A full year of production was achieved at new alumina plants in Ireland and Venezuela.

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 nine operations to which a survey form was sent, all responded, representing 100% of 1984 U.S. bauxite production shown in tables 1, 2, and 18.

Table 1.—Salient bauxite statistics

(Thousand metric tons and thousand dollars)

	1980	1981	1982	1983	1984
United States:					
Production: Crude ore (dry equivalent)	1,559	1,510	732	679	856
Value	$22,353	$26,489	$12,334	$11,309	$15,643
Exports (as shipped)	21	20	49	74	82
Imports for consumption[1]	14,087	12,802	10,122	7,601	9,428
Consumption (dry equivalent)	15,962	13,525	9,217	r9,100	10,519
World: Production	r89,220	r85,426	78,144	p78,861	e84,664

eEstimated. pPreliminary. rRevised.
[1]Excludes calcined bauxite. Includes bauxite imported to the U.S. Virgin Islands.

Legislation and Government Programs.—National Defense Stockpile goals remained unchanged at 21.3 million tons of Jamaica-type and 6.2 million tons of Suriname-type metal grade bauxite. Goals for calcined abrasive grade and refractory grade bauxite were 1 and 1.4 million tons, respectively. At yearend, General Services Administration (GSA) listed an inventory of 11.6 million tons of Jamaica-type and 5.4 million tons of Suriname-type, metal grade bauxite. As a result of barter transactions with Jamaica, an additional 1 million tons of metal grade ore was held by the Commodity Credit Corp. Two contracts were awarded by GSA for the purchase of calcined refractory grade bauxite. Both contracts went to Cometals Inc., New York, to deliver a total of 75,000 tons of calcined bauxite produced in China. The yearend inventory of 203,000 tons of calcined refractory grade bauxite did not include the 75,000 tons ordered in 1984.

DOMESTIC PRODUCTION

Domestic bauxite production increased moderately, and virtually all shipments went to nonmetal uses such as chemicals, proppants, refractories, or specialty aluminas. In central Arkansas, Alcoa and American Cyanamid Co. mined bauxite in Saline County as a raw material for production of aluminum sulfate, proppants for the petroleum industry, and refining to specialty aluminas. Porocel Corp. purchased bauxite for the production of activated bauxite at its Pulaski County plant. Bauxite mines were operated in Alabama by A. P. Green Refractories Co. and Harbison-Walker Refractories Co., and in Alabama and Georgia by the Mullite Co. of America. All of the production went to supply the chemical, proppant, and refractory industries.

In the final quarter of 1984, Alcoa and Reynolds Metals permanently closed their respective Mobile, AL, and Hurricane Creek, AR, alumina plants. The closure of the two plants was not reflected in domestic alumina production because Bayer process operations at these plants had been shut down throughout the year. Domestic alumina capacity was reduced by 11% to 6.3 million tons per year by the closures. The average operating rate for U.S. refineries was about 74% of capacity.

Shipments of calcined alumina from domestic refineries to U.S. primary aluminum plants totaled 4.1 million tons. Exports and shipments to the abrasive, ceramic, chemical, and refractory industries accounted for the balance of the total 4.2 million tons of calcined alumina shipped.

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]
1982	896	732	12,334	1,411	1,247	35,322
1983	826	679	11,309	977	913	26,370
1984	1,054	856	15,643	1,332	1,227	35,719

[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
1983	293	140	225
1984	361	168	294

[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)	1980	1981	1982	1983	1984
From 8 to 15	62	65	63	W	W
More than 15	38	35	37	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]	Total[1] Calcined equivalent
Production:[e]				
1980	6,310	720	7,030	6,810
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	4,210	685	4,895	4,680
Shipments:[e]				
1980	6,160	720	6,880	6,660
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	4,200	680	4,880	4,675

[e]Estimated.
[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	1983	1984
Aluminum Co. of America:		
Bauxite, AR	340	340
Mobile, AL	800	--
Point Comfort, TX	1,400	1,400
Total	2,540	1,740
Martin Marietta Aluminum Inc.: St. Croix, VI	635	635
Kaiser Aluminum & Chemical Corp.:		
Baton Rouge, LA	955	955
Gramercy, LA	770	770
Total	1,725	1,725
Ormet Corp.: Burnside, LA	545	545
Reynolds Metals Co.:		
Hurricane Creek, AR	--	--
Corpus Christi, TX	1,700	1,700
Total	1,700	1,700
Grand total	7,145	6,345

[1]Capacity may vary depending upon the bauxite used.

CONSUMPTION AND USES

Approximately 90% of the bauxite used was refined to alumina, an estimated 88% of which was consumed by primary aluminum plants. Nonalumina uses of bauxite accounted for 1.1 million tons of ore, which was processed into abrasives, chemicals, proppants, and refractories. Nonmetal uses of alumina consumed 550,000 tons (calcined equivalent) for abrasives, ceramics, chemicals, and refractories. An average of 2.03 tons (dry basis) of bauxite was required to produce 1 ton of calcined alumina. The only domestic bauxite refined to alumina was mined by Alcoa at Bauxite, AR, and virtually all of this alumina went to nonmetal uses.

General Abrasives Co., a division of Dresser Industries Inc., brought its new proppant plant at Eufaula, AL, into production in June, and the Norton-Alcoa Proppant Co. was reported to have increased capacity to about 136,000 tons per year at its Fort Smith, AR, plant. Demand for tabular and substrate alumina increased significantly during the year, and Kaiser announced the startup in Baton Rouge, LA, of a plant to produce high-purity catalyst-grade alumina using a gel process. Arco Metals Co. planned to start production by yearend of high-performance ceramic aluminas at its Tucson, AZ, plant.

Approximately 4.12 million tons of calcined alumina was consumed by the 27 operating domestic aluminum smelters during the year. Aluminum fluoride and synthetic cryolite made from alumina were also consumed by the primary aluminum industry.

Table 7.—U.S. consumption of bauxite, by industry

(Thousand metric tons, dry equivalent)

Industry	Domestic	Foreign	Total[1]
1983:			
Alumina	555	7,720	8,275
Abrasive[2]	--	135	135
Chemical	[3]48	[3]281	281
Refractory	122	240	362
Other	W	W	48
Total[1] [2]	724	8,375	9,100
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

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]
1983:			
Crude and dried	570	[r]8,000	[r]8,571
Calcined and activated	154	375	529
Total	724	[r]8,375	[r]9,100
1984:			
Crude and dried	826	9,007	9,833
Calcined and activated	151	535	686
Total	977	9,542	10,519

[r]Revised.
[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 1983

Item	Number of producing plants	Production (thousand metric tons)	Total shipments including interplant transfers: Quantity (thousand metric tons)	Total shipments including interplant transfers: Value (thousands)
Aluminum sulfate:				
Commercial and municipal (17% Al_2O_3)	61	1,001	975	$125,516
Iron-free (17% Al_2O_3)	14	82	71	9,038
Aluminum chloride:				
Liquid and crystal (32° Bé)	3	W	W	W
Anhydrous (100% $AlCl_3$)	4	W	W	W
Aluminum fluoride, technical	3	W	W	W
Aluminum hydroxide, trihydrate (100% $Al_2O_3 \cdot 3H_2O$)	7	571	566	140,464
Other inorganic aluminum compounds[1]	XX	XX	XX	35,333

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	1983	1984
Producers and processors	r552	501
Consumers	r5,061	4,367
Government	16,326	17,338
Total	r21,939	22,206

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	1983	1984
Producers e	238	229
Primary aluminum plants	r1,455	1,485
Total e	r1,693	1,714

eEstimated. rRevised.
[1]Excludes consumers' stocks other than those at primary aluminum plants.

PRICES

Bauxite and alumina are seldom traded on world commodity markets, and contract prices are rarely made public. For these reasons trade journals list only spot sales prices and prices of specialty forms of these commodities.

The Bureau of Mines estimated the average 1984 value of domestic crude bauxite shipments, f.o.b. mine or plant, to be $14.97 per ton. The average value of domestic calcined bauxite shipments was estimated to be $97.74 per ton.

The Engineering and Mining Journal published monthly prices for imported, calcined, refractory grade bauxite from Guyana. The prices per ton quoted for carload lots, delivered f.o.b. Baltimore, MD, Mobile, AL, or Burnside, LA, were $168.28 in January and $164.20 in February through December 1984.

Domestic shipments of calcined alumina had an estimated average value of $223.80 per ton. Based on trade data of the Bureau of the Census, imported alumina had an average value of $218.62 per ton, f.a.s., at port of shipment, and $230.90 per ton, c.i.f., at U.S. ports.

Table 12.—Average value of U.S. imports of crude and dried bauxite[1]

(Per metric ton)

Country	1983		1984	
	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
Brazil	$30.82	$43.48	28.34	38.47
Guinea	26.49	35.89	28.85	36.42
Guyana	39.13	52.67	36.30	52.11
Jamaica	29.19	36.04	31.44	36.91
Suriname	42.96	52.95	38.22	48.27
Weighted average	28.71	37.36	29.79	36.99

[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	Jan. 2, 1984	Dec. 31, 1984
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

Exports in 1984 included 32,862 tons of dried bauxite, of which 21,351 tons went to Canada, and 49,372 tons of calcined bauxite, which was shipped to Mexico (91%), Canada, and Belgium. Exports of additional aluminum compounds included 2,789 tons of aluminum sulfate, 11,153 tons of aluminum oxide abrasives, and 38,065 tons of other aluminum compounds, such as aluminum fluoride and synthetic cryolite.

The rank of major suppliers of U.S. crude and dried bauxite imports changed from that of 1983. Jamaica regained first place over Guinea by a small margin, Brazil retained third place, and Australia made its first shipments to the United States since 1978 to become the fourth largest supplier. Australia became the major source of "other calcined bauxite" (chiefly abrasive grade) imports.

Calcined abrasive grade bauxite was processed in Canada into fused crude aluminum oxide that was subsequently shipped to U.S. plants for the manufacture of abrasive and refractory products.

Table 14.—U.S. exports of alumina,[1] by country

(Thousand metric tons, calcined equivalent, and thousand dollars)

Country	1982		1983		1984	
	Quantity	Value[r]	Quantity	Value[r]	Quantity	Value
Argentina	1	466	(2)	469	1	558
Belgium-Luxembourg	1	2,183	1	3,138	2	2,616
Brazil	1	1,230	21	5,881	(2)	268
Canada	r106	41,326	r25	19,664	80	37,238
France	r3	4,059	r3	3,474	2	3,412
Germany, Federal Republic of	3	7,341	3	6,086	3	6,008
Ghana	160	29,222	19	3,173	--	--
Japan	3	8,014	2	4,636	3	8,064
Mexico	84	24,522	99	29,697	111	33,376
Netherlands	1	2,089	r2	2,690	11	4,017
Norway	r163	42,385	265	59,794	369	81,228
Sweden	27	6,589	98	14,147	60	10,350
United Kingdom	r7	8,384	4	4,195	3	4,014
Venezuela	22	7,385	52	12,287	4	2,833
Other	r8	11,172	r8	12,588	10	15,127
Total[3]	r590	196,370	r602	181,920	659	209,110

[r]Revised.
[1]Includes exports of aluminum hydroxide (calcined equivalent) as follows: 1982—7,600 tons; 1983—8,100 tons; and 1984—13,100 tons, and aluminum oxide abrasives.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

Table 15.—U.S. imports for consumption of bauxite, crude and dried,[1] by country

(Thousand metric tons)

Country	1982	1983	1984
Australia	--	--	560
Brazil	512	555	786
Dominican Republic[2]	163	--	--
Guinea	4,198	3,600	3,718
Guyana	239	167	264
Haiti	500	--	--
Jamaica[2]	4,080	3,036	3,759
Suriname	409	239	325
Other	21	4	15
Total	10,122	7,601	[3]9,428

[1]Includes bauxite imported to the U.S. Virgin Islands from foreign countries.
[2]Dry equivalent of shipments to the United States.
[3]Data do not add to total 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: 1982—11,049,685 tons; 1983—7,903,202 tons; and 1984—10,436,135 tons.

Table 16.—U.S. imports for consumption of calcined bauxite, by country

(Thousand metric tons and thousand dollars)

Country	1983				1984			
	Refractory grade		Other grade		Refractory grade		Other grade	
	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]	Quantity	Value[1]
Australia	--	--	8	1,116	(2)	281	24	2,928
China	51	4,498	14	2,188	78	7,428	18	1,389
Guyana	66	9,230	22	2,531	110	14,763	--	--
Suriname	--	--	47	3,940	1	154	(2)	4
Other	--	--	1	78	--	--	(2)	56
Total[3]	117	13,728	92	9,852	190	22,626	42	4,377

[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.

Table 17.—U.S. imports for consumption of alumina,[1] by country

(Thousand metric tons, calcined equivalent, and thousand dollars)

Country	1982		1983		1984	
	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]
Australia	2,707	598,685	3,049	544,322	3,055	593,722
Brazil	11	3,511	3	1,565	39	7,123
Canada	130	51,334	159	67,762	204	91,603
France	5	13,183	6	10,982	9	14,455
Germany, Federal Republic of	11	14,341	13	15,797	20	24,080
Jamaica	196	49,651	399	87,973	572	125,974
Japan	1	1,243	25	7,927	3	3,680
Suriname	117	27,387	318	59,225	392	75,317
Venezuela	--	--	35	4,394	116	15,158
Other	5	11,109	r24	r11,073	55	25,253
Total[3]	3,182	770,444	4,030	811,021	4,466	976,364

rRevised.
[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.

WORLD REVIEW

In 1984, 24 countries produced 84.7 million tons of bauxite, an increase of 7% compared with 1983 production. Four countries, Australia, Guinea, Jamaica, and Brazil, in order of volume, contributed 67% of the total bauxite mined. World alumina production by 25 countries increased to 33 million tons, 10% greater than 1983 output and the highest level since 1980. Australia, the United States, and the U.S.S.R. accounted for 50% of total production.

Australia.—Bauxite and alumina production set new records in 1984, and annual alumina capacity was increased by 1.84 million tons during the year by the opening of two new refineries and the expansion of a third. The annual capacity of the Queensland Alumina Ltd. refinery at Gladstone was increased from 2.4 to 2.74 million tons per year. Comalco's mining operations at Weipa, Cape York Peninsula, produced 9.1 million tons of bauxite and shipped 8.5 million tons. Rotary kilns at Weipa produced 225,800 tons of calcined abrasive grade bauxite, and a portion of this was used in the production of proppants for the petroleum industry market. Comalco increased its interest to 37.5% in the Eurallumina S.p.A., Sardinia, alumina plant, a consumer of Weipa bauxite exports. The company also started work on a kaolin processing plant at Weipa that is to be supplied from the clay deposits underlying the bauxite ore.

Nabalco Pty. Ltd., the Swiss Aluminium Ltd. (Alusuisse) subsidiary at Gove, Northern Territory, reported bauxite production of 5.9 million tons and alumina production of 1.26 million tons, slightly in excess of the plant's rated 1.2-million-ton capacity.

Australia's major aluminum industry expansion took place in the State of Western Australia, where annual alumina capacity increased by 1.5 million tons to a total of 5.3 million tons. In February, Alcoa of Australia Ltd. (Western Australia) started operation of the 500,000-ton-per-year Wagerup refinery, and in May, the 1-million-ton-per-year Worsley Alumina Pty. Ltd. plant started production. Worsley Alumina is 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%). Both the Wagerup and Worsley plants move their alumina by rail to the Port of Bunbury for ocean shipment since there are no smelters in Western Australia. A discovery of gold in the bauxite ore at the mine near Boddington that supplies the Worsley plant offers a potentially economic coproduct. Feasibility studies on gold recovery are being carried out by Worsley Alumina.

Brazil.—Brazil's annual alumina capacity increased by 500,000 tons to a total of 1.15 million tons. The Alumínio do Maranhão S.A. (ALUMAR) refinery-smelter complex at São Luís do Maranhão began producing alumina in May and primary aluminum in July. This $1,300 million first stage of the ALUMAR project included a 500,000-ton-per-year alumina plant and a 100,000-ton-per-year reduction plant. Bauxite ore from the Mineração Rio do Norte S.A. (MRN) mine on the Trombetas River was supplied to the refinery, and ALUMAR shipped 40,000 tons of alumina in October from São Luís to Alcoa's Vancouver, WA, smelter. In July, soon after the smelter startup, the partners announced plans to increase the smelter capacity to 245,000 tons per year, in part financed by the sale of as much as $240 million in Alcoa Alumínio do Brasil S.A. stock over a 2-year period to Construcoes e Commércio Camargo Correa S.A., a large Brazilian construction firm. Billiton Metais S.A. planned a limited participation in the expansion, and its share in the project could be reduced to 28% by 1986. MRN expanded the Trombetas mine capacity in 1984 from 3.5 to 4.5 million tons per year, primarily to fulfill its new 10-year, $300 million contract to supply ALUMAR with 1.1 million tons per year of crude bauxite. At yearend, MRN placed an order for an 8.5-megawatt power station designed to burn wood. The plant is to use Outokumpu Oy's fluidized-bed technology and will replace a diesel unit at the Trombetas operation. Cia. Vale do Rio Doce (CVRD) announced the discovery of a 50-million-ton bauxite deposit similar in grade to the Trombetas ore and located near the Carajás-São Luís Railway line. The Votorantim Group shelved plans to build a new smelter in the Amazon Basin after locating a new 60-million-ton bauxite deposit at Cataguases, Minas Gerais, near its present plants.

The Alumínio Brasileiro Ltda. (ALBRÁS) joint smelter project of CVRD (60%) and Nippon Amazon Aluminum Co. (40%) was under construction near Belem, Pará, and was expected to start up late in 1985. Construction of an 800,000-ton-per-year alumina plant Alumina do Norte do Brazil S.A. planned for the same site has, however, been postponed indefinitely, and alumina is expected to be purchased to supply the ALBRÁS smelter.

China.—The aluminum industry of China was situated in the four Provinces of Shandong, Zhengzhou, Guizhou, and Shanxi, where there were reportedly 9 operating bauxite mines, 4 alumina plants, and 30 primary aluminum plants. Although the per capita aluminum consumption was only slightly above 1.1 pounds compared with 60 pounds in the United States in 1983, production did not meet demand because the plants were outdated and suffered from equipment breakdowns and raw material and power shortages. In 1984, China imported bauxite, alumina, and primary aluminum to supplement domestic production. The Government announced plans to construct at least one new plant each year until a level of self-sufficiency is reached.

In July, Kobe Steel Ltd. of Japan and the Nonferrous Metal Industry General Corp. of China formed a joint venture company that was to increase production capacity of raw materials, smelters, and metal fabrication of the aluminum and other nonferrous industries. Pechiney of France announced that it would provide technical assistance in a bauxite-mine-refinery-aluminum-smelter complex planned in Pingguo County, Guanqxi Zhuang Autonomous Region. Large local bauxite deposits were to be developed and a 300,000-ton-per-year refinery and a 100,000-ton-per-year primary aluminum plant were to be constructed. The Japanese firms Nissho-Iwai Corp. and Nippon Light Metal Co. Ltd. were also to provide engineering and technology for this $1,200 to $1,600 million project. During the last quarter of 1984, China reported the discovery of a new 100-million-ton bauxite deposit in Zunyi County, Guizhou Province.

Ghana.—The rail line between the bauxite mine at Awaso and the Port of Takoradi collapsed in April, forcing the Ghana Bauxite Co. (owned by British Alcan Aluminium Ltd.) to stop mining until a 75,000-ton backlog of ore could be moved to the port. The railroad was reported to be back in operation at the end of the year. An agreement was concluded between Ghana and the U.S.S.R., in which the U.S.S.R. was to provide a loan to rehabilitate a number of projects in Ghana and to aid in developing the Kibi bauxite deposits in the eastern region of the country.

Guinea.—Bauxite production at the Soviet-managed Office des Bauxite de Kindia (OBK) mine exceeded 3 million tons for the first time in the mine's history, and total production from all mines in Guinea was the highest since 1979. Martin Marietta sold 6% of it's 14% share in Halco (Mining) Inc. to Reynolds, reportedly giving Reynolds rights to take about 518,000 tons of bauxite per year through 1993 and 218,000 tons in 1994 and 1995. Under the new consortium structure, the Government of Guinea continued to hold 49% of Compagnie des Bauxites de Guinée (CBG), and the 51% controlled by Halco is owned by Aluminum Co. of Canada Ltd. (27%), Alcoa (27%), Pechiney (10%), Vereinigte Aluminiumverke AG (10%), Martin Marietta (8%), Billiton Aluminum BV (6%), Montecatini Edison S.p.A. (6%), and Reynolds (6%). A group of French banks agreed to extend credit valued at 100 million French francs to CBG for the purchase of French equipment and services for the bauxite mining operations. The Soviet Union agreed to lend Guinea 95 million rubles to renovate the OBK bauxite mine at Kindia, and Frialco Co. reported that it had obtained a loan from the European Investment Bank to upgrade the quality of the company's alumina product.

Guyana.—A countertrade agreement was reportedly signed in the first quarter of the year with Raznoimport Association, the U.S.S.R, in which Guyana would exchange 50,000 tons of bauxite for Soviet tractors and other equipment. Green Construction Co., based in the United States, continued to strip overburden at the East Montgomery Mine under Government contract, and the state-owned Guyana Mining Enterprise Ltd. completed major repairs on the eight rotary calcining kilns at Linden. The alumina plant at Linden remained shut down, but bauxite production increased in 1984, and Guyana marketed abrasive, cement, chemical, metallurgical, and refractory grades of bauxite.

Jamaica.—Nearly one-half of the 8.735 million tons of bauxite produced during the year was shipped to the island's four alumina plants. The balance was exported to the U.S. refineries of Kaiser and Reynolds (2.9 million tons), to U.S. Government stockpiles (0.9 million tons), and to the Soviet Union (0.8 million tons). For Reynolds, these were the final shipments of bauxite before it permanently closed Reynolds Jamaica Mines Ltd. mining operations at Lydford, St. Ann.

After months of negotiations between the Government and the aluminum companies, agreement was reached in April on a new bauxite production levy that would apply retroactively to production from January 1, 1984. Under the new agreement, the average levy plus royalty was to be about $16 per ton compared with about $17 per ton in the previous 5-year contract. The new levy plan provided an incentive for increased production levels, which reportedly could reduce the levy to about $13 per ton. The base rate for the levy is 6% of the annual average realized price for primary aluminum, as reported by the companies to the U.S. Internal Revenue Service.

The Alumina Partners of Jamaica refinery was shut down on June 1 for about 10 weeks by a strike over a wage dispute. At the same time, ARCO Metals Co. announced that it was seeking a buyer for its 27% interest in the 1.2-million-ton-per-year plant. In view of the oversupply of alumina, neither of the other two partners, Kaiser and Reynolds, nor any outside aluminum company, was reported to have expressed interest in the purchase. The Governments of Colombia and Jamaica signed a preliminary agreement to construct a primary aluminum plant in Colombia that would utilize local coal for low-cost power generation and alumina from Jamaica.

Suriname.—Despite mine closings in January and September, brought about by disputes over wages and increased income taxes, bauxite production increased about 20%. The Suriname Aluminum Co. (SURALCO), an Alcoa subsidiary, closed the nearly depleted Lelydorp mine near the Paranam alumina plant but continued mining operations at Moengo, 70 miles east of the plant. SURALCO began to draw on its newly acquired 24% rights to higher quality ore from the NV Billiton Maatschappij

Suriname mine in the Pará District. Because SURALCO had discontinued calcining abrasive and refractory grade bauxite in 1983, all 1984 bauxite production in Suriname was metal grade ore for export or for local refining to alumina.

Venezuela.—The new administration that took office in February reactivated plans to develop the Los Pijiguaos bauxite deposits near the Orinoco River. Bauxitas Venezolana C.A., the state bauxite company, was allocated funds to design the combination conveyor belt, rail, and barge system to transport the bauxite 400 miles from the minesite to the Interamericana de Alumina C.A. (INTERALUMINA) refinery in Puerto Ordaz. Initial production of 1 million tons per year from the 235-million-ton deposit was scheduled to start by yearend 1986, and full production of 3 million tons per year was planned by yearend 1987. Depending on demand, ultimate production could reach 4.5 million tons per year. The INTERALUMINA refinery started operation in 1983, using bauxite supplied from Brazil, Sierra Leone, and Suriname. During 1984, the first full year of operation, the Alusuisse-designed plant exceeded the 1.1-million-ton-per-year rated capacity.

Table 18.—Bauxite: World production, by country[1]

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Australia	[r]27,179	[r]25,441	23,625	24,540	29,300
Brazil	5,538	5,770	6,289	7,199	5,239
China[e]	1,500	1,500	1,500	[r]1,600	1,600
Dominican Republic[2]	606	457	141	--	--
France	1,921	[r]1,827	1,662	1,716	1,528
Germany, Federal Republic of	(3)	(3)	(3)	(3)	(3)
Ghana	225	181	64	70	115
Greece	3,286	3,216	2,853	2,455	2,800
Guinea[4]	11,862	11,112	11,827	12,421	[5]13,160
Guyana[2]	1,844	1,681	1,783	1,791	[5]1,556
Haiti[2] [6]	312	427	377	--	--
Hungary	2,950	2,914	2,627	2,917	[5]2,994
India	1,785	1,923	1,854	1,923	1,994
Indonesia	1,249	1,203	700	778	942
Italy	23	19	23	23	10
Jamaica[2] [7]	12,054	11,682	8,361	7,683	[5]8,734
Malaysia	920	701	589	502	657
Pakistan	2	2	1	4	4
Romania	710	[e]712	[e]680	650	620
Sierra Leone	766	[e]610	606	600	[5]1,000
Spain	[r]8	9	7	5	6
Suriname	4,646	4,100	3,059	2,886	[5]3,454
Turkey	533	575	508	296	[5]128
U.S.S.R.[e] [8]	4,600	4,600	4,600	4,600	4,600
United States[2]	1,559	1,510	732	679	856
Yugoslavia	3,138	3,249	3,668	3,500	3,347
Zimbabwe	4	5	8	23	20
Total	[r]89,220	[r]85,426	78,144	78,861	84,664

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 2, 1985.
[2]Dry bauxite equivalent of crude ore.
[3]Less than 1/2 unit.
[4]Dry bauxite equivalent of ore processed by drying plant.
[5]Reported figure.
[6]Shipments.
[7]Bauxite processed for conversion to alumina in Jamaica plus kiln-dried ore prepared for export.
[8]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: 1980—2,500; 1981—2,500; 1982—2,500, 1983—2,500; and 1984—2,500. Estimated alunite ore production was as follows, in thousand metric tons; 1980—600; 1981—605; 1982—605 (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[3]	1980	1981	1982	1983[p]	1984[e]
Australia	7,246	7,079	6,631	7,231	[4]8,390
Brazil	[r]517	497	606	787	800
Canada	1,202	1,208	[e]1,127	1,116	[4]1,126
China[e]	750	750	800	800	800
Czechoslovakia[e]	100	100	100	100	100
France	1,173	1,095	960	853	850
German Democratic Republic	43	[r]45	46	42	43
Germany, Federal Republic of	1,608	1,651	1,510	1,580	1,650
Greece	494	490	420	[r] [e]410	410
Guinea	708	608	549	583	[4]508
Guyana[5]	[r]214	[r]157	73	--	--
Hungary	805	792	710	836	[4]839
India[e]	500	500	500	450	560
Ireland	--	--	--	66	[4]654
Italy	900	786	698	476	750
Jamaica	2,456	2,556	1,758	1,907	1,690
Japan	1,936	1,344	959	1,065	[4]1,172
Romania[e]	534	540	514	[r]512	510
Spain	58	695	672	[e]650	660
Suriname	[r]1,329	[r]1,165	1,055	1,129	[4]1,208
Taiwan	(6)	(6)	(6)	--	--
Turkey	138	131	84	57	80
U.S.S.R.[e]	2,700	2,800	3,000	3,200	3,300
United Kingdom	102	90	88	93	70
United States[e]	6,810	5,960	4,130	4,000	4,680
Venezuela	--	--	--	560	1,130
Yugoslavia	1,058	1,037	1,017	[r] [e]1,015	1,000
Total	[r] [7]33,382	[r]32,076	28,007	29,518	32,980

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Figures presented generally represent calcined alumina; exceptions are noted individually.
[2]Table includes data available through July 2, 1985.
[3]In addition to the countries listed, Austria produces alumina (fused aluminum oxide), but output is entirely for abrasives production. Output totaled 28,223 metric tons in 1973; production data subsequent to 1973 are not available.
[4]Reported figure.
[5]Calcined alumina, plus calcined alumina equivalent of alumina hydrate.
[6]Revised to zero. Data published in previous editions of this table were found to be imports and as such were duplicative of production reported for other countries.
[7]Data do not add to total shown because of independent rounding.

Table 20.—World annual alumina capacity, by country

(Thousand metric tons, yearend)

Country	1982	1983	1984
Australia	7,840	7,910	9,750
Brazil	540	[r]650	1,150
Canada	1,225	1,225	1,225
China	[r]850	[r]850	850
Czechoslovakia	100	100	100
France	1,320	1,320	1,320
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
Italy	920	920	920
Jamaica	2,825	2,825	2,825
Japan	2,615	2,615	2,615
Romania	540	540	540
Spain	800	800	800
Suriname	1,350	1,350	1,350
Taiwan	160	160	160
Turkey	200	200	200
U.S.S.R.[e]	4,500	4,500	4,500
United Kingdom	140	140	140
United States	7,495	7,145	6,345
Venezuela	--	1,000	1,000
Yugoslavia	1,635	1,635	1,635
Total	[r]39,990	[r]41,620	43,160

[e]Estimated. [r]Revised.

TECHNOLOGY

The joint research project established between ARCO and Alcoa in 1983 continued work in 1984 to perfect a hydrochloric acid leach process to produce aluminum chloride from kaolin clay and to improve the fluid bed reactor and electrolytic refining stages of the Alcoa Smelting Process for the production of primary aluminum. Limited production of aluminum trichloride and other metallic chlorides was reported at the new Vacherie, LA, plant operated by Armant, a Louisiana limited partnership, using the Toth Aluminum Corp. carbochlorination process on Georgia kaolin clay. The next stage planned for development was to be the production of high-purity alumina for abrasives, electronic substrates, ceramics, and other specialty uses by oxidizing the aluminum chloride to aluminum oxide.

A study completed in 1984 by Kaiser Engineers & Constructors Inc. for the Electric Power Research Institute (EPRI), Palo Alto, CA, concluded that recovery of alumina and other minerals from coal fly ash would generate a 25% to 35% return on investment. The study considered the feasibility of a $200 million plant using a process being developed for EPRI by Oak Ridge National Laboratory to treat 1 million tons of fly ash per year to produce 150,000 tons of alumina plus iron oxide, gypsum, and alkali sulfates. The ash tested was from the Kingston, TN, powerplant of the Tennessee Valley Authority.[4]

Research by the Bureau of Mines on nonbauxite resources for aluminum production centered on methods for producing anhydrous aluminum chloride from kaolinitic clays. Processes examined included leaching raw and calcined clay with hydrochloric acid of different strengths and with various concentrations of aluminum chloride solution to form hydrated aluminum chloride compounds.[5] A paper reviewing current and recent research by the Bureau and others on nonbauxitic alumina technology and containing an extensive list of references was presented at the 1984 SME-AIME Bauxite Symposium in Los Angeles, CA.[6]

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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]Chemical Engineering. Recovery of Alumina and Other Minerals From Coal Flyash Could be Profitable. Aug. 20, 1984, p. 20.
[5]Bremner, P. R., L. J. Nicks, and D. J. Bauer. A Basic Chloride Method for Extracting Aluminum From Clay. BuMines RI 8866, 1984, 8 pp.
Sorensen, R. T., and D. L. Sawyer, Jr. Alumina Miniplant Operations—Separation of Aluminum Chloride Liquor From Leach Residue by Horizontal Belt Filtration. BuMines RI 8831, 1984, 44 pp.
[6]Barclay, J. A. Current Status of R&D on Alumina From Domestic Nonbauxitic Resources. Ch. in Proceedings of the 1984 Bauxite Symposium (Los Angeles, CA, Feb. 26-Mar. 1, 1984), ed. by L. Jacob Jr. Soc. Min. Eng. AIME, New York, Mar. 1984, pp. 165-199.

Beryllium

By Deborah A. Kramer[1]

Domestic and imported beryllium ore concentrates were converted to alloys of other metals, ceramics, and beryllium metal by the domestic beryllium industry. Consumption of concentrates increased as demand increased in several end-use markets. The increase in demand was met in part by withdrawals from stocks of concentrates. As a result of increased demand in several end-use sectors, a major U.S. beryllium producer completed expansions and announced plans for future expansions of its manufacturing facilities.

Imports of beryl decreased sharply from those of 1983, but imports of beryllium metal increased significantly. Exports of beryllium materials increased slightly. World production of beryllium raw materials declined slightly in 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, 12 responded, representing 100% of the total production shown in tables 1 and 4.

Table 1.—Salient beryllium mineral statistics

(Short tons unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Beryllium mineral concentrates:					
Shipped from mines[1]	r7,449	r7,334	5,451	6,665	6,030
Imports for consumption	1,703	2,138	2,652	2,194	1,332
Consumption[1]	8,508	8,141	5,387	6,989	9,003
Price, approximate, per short ton unit BeO, imported cobbed beryl at port of exportation	$69	$94	$121	$126	$88
Yearend stocks[1]	1,350	2,223	5,112	7,037	5,653
World: Production of beryl	r10,272	r10,579	8,875	p10,335	e9,670

eEstimated. pPreliminary. rRevised.

[1]Includes bertrandite ore that was calculated as equivalent to beryl containing 11% BeO.

Legislation and Government Programs.—At yearend, Government stocks were the same as those of 1983: beryl ore, 17,987 short tons; beryllium-copper master alloy, 7,387 tons; and beryllium metal, 229 tons. The National Defense Stockpile goals for these materials remained at 18,000 tons, 7,900 tons, and 400 tons, respectively. The General Services Administration, in an amendment to a 1983 contract, awarded a contract to Brush Wellman Inc. to sell the Government 30 tons of beryllium metal by yearend 1985, for inclusion in the National Defense Stockpile.

Beryllium occupational and health standards promulgated by the Occupational Safety and Health Administration in 1975 were still pending in 1984. A draft document reviewing and evaluating new health effects information on beryllium that became available since 1973, was prepared by the Environmental Protection Agency for use in reviewing and revising emission standards for beryllium under the Clean Air Act.[2]

Depletion allowances of 22% for domestic production and 14% for U.S. companies producing from foreign sources were provided by Federal income tax laws.

DOMESTIC PRODUCTION

Shipments of beryllium mineral concentrates from mines in 1984 declined slightly from those of 1983. Domestic production of beryllium-copper master alloy increased significantly, but production of beryllium metal and beryllium oxide ceramics declined slightly.

Brush Wellman remained the only major commercial producer of beryllium concentrates. Brush Wellman mined bertrandite ore at Spor Mountain, UT, and processed it into beryllium hydroxide at its processing plant near Delta, UT. A small quantity of beryl also was mined domestically.

Significant expenditures to increase capacities of its beryllium-copper alloy and beryllia ceramic manufacturing facilities were announced by Brush Wellman during the year. Brush Wellman announced plans to spend $57 million to nearly double its manufacturing capacity for beryllium-copper strip, reportedly owing to the increasing use of this material in electronic devices. Of this $57 million, $30 million was allocated for new casting furnaces, rolling equipment, and other facilities at the Elmore, OH, plant; $15 million for constructing the first finishing mill in the Federal Republic of Germany; $10 million to improve its finishing mill at the Reading, PA, plant; and $2 million to upgrade warehouses. Plans for an expenditure of $10 million also were announced to install additional beryllia ceramic production equipment at existing plants in Tucson, AZ, Hampton, NJ, and Newburyport, MA.

Brush Wellman also announced plans to spend $4 million to construct facilities to reclaim beryllium and copper from waste materials at its Elmore, OH, plant.

The Cabot Corp., Cabot Berylco Div., continued to produce beryllium-copper and other beryllium alloys at its plant in Reading, PA, from domestic and imported ores. Cabot completed a $16 million metalworking plant in Elkhart, IN, having the capability to produce beryllium-copper strip up to three times wider than that produced at the company's Reading, PA, plant. Cabot continued rolling operations at its Kokomo, IN, and Reading, PA, plants.

CONSUMPTION AND USES

Beryllium mineral concentrate consumption in 1984 increased significantly from that of 1983 and reached its highest level since 1979, owing to increased demand by several markets. This increased demand was met in part by withdrawals from inventories.

Copper-based beryllium alloys, containing about 2% beryllium, were the most widely used beryllium products. Physical properties of these alloys, such as high thermal conductivity and good resistance to corrosion and fatigue, allow them to be used in a wide range of applications in the forms of bar, plate, rod, strip, tube, and wire. Beryllium-copper alloy strip primarily was fabricated into connectors, springs, and contact parts for use in items such as automotive and aerospace devices, radar and communications equipment, computers, home appliances, instrumentation, and control systems. Beryllium-copper alloy round products, which include rod, tube, and wire, were used in oil and gas exploration equipment for drill bushings and bearings, drill collars, and instrument housings. Marine applications of the round products included housings for undersea communications signal boosters, and industrial applications included bearings and bushings for heavy machinery. Beryllium-copper alloy bar and plate were used in systems such as robotic welding machines and materials handling devices.

Beryllium metal was used mainly in aerospace and defense applications such as optical systems for satellites and guidance systems. Metallic beryllium's high stiffness-to-weight ratio, light weight, and excellent thermal conduction properties were important for these applications.

Beryllium oxide ceramic material with its high thermal conductivity, mechanical hardness and strength, and electrical insulation was used primarily by the electronics industry. Uses for these products include substrates for high-performance computers, microwave systems, automotive and defense electronics, and telecommunications systems.

PRICES AND SPECIFICATIONS

Throughout 1984, Metals Week quoted the price range for beryl ore at $100 to $120 per short ton unit.

At yearend, the American Metal Market quoted the following prices for beryllium materials, in dollars per pound, except for beryllium-copper master alloy, which is in dollars per pound of contained beryllium:

Vacuum cast ingot, 97% pure	$213
Metal powder, in 5,000-pound lots and 97% pure	178
Beryllium-copper master alloy	140
Beryllium-copper casting alloy	$4.95- 5.55
Beryllium-copper in rod, bar, wire	7.60
Beryllium-copper in strip	7.10
Beryllium-aluminum alloy, in 100,000-pound lots	230
Beryllium oxide powder	52.50

FOREIGN TRADE

Exports of beryllium increased slightly in quantity from those in 1983, but the total value declined. France, Japan, and Italy, in descending order of receipts, were the primary destinations.

Beryl was the only beryllium mineral ore imported into the United States. Imports of beryl declined sharply, with Brazil and China as the largest suppliers. The average value of the imported ore decreased from about $1,256 per ton in 1983 to $884 in 1984. In addition to the imports of beryl, 70,640 pounds of wrought, unwrought, and waste and scrap beryllium metal valued at $702,272 was imported, primarily from Brazil. Smaller quantities, in decreasing order of receipts, were imported from the United Kingdom, the Federal Republic of Germany, Hong Kong, and Japan. Imports of metal increased almost fourfold from those of 1983 owing to increased demand. Imports of beryllium oxide or carbonate and other beryllium compounds, totaling 43,238 pounds and valued at $127,672, were received from Belgium, the United Kingdom, and the Federal Republic of Germany.

Beginning January 1, 1984, the U.S. import duties for beryllium were as follows: beryllium ore and concentrate (TSUS 601.09), free for all nations; unwrought beryllium, waste and scrap (TSUS 628.05), 8.5% ad valorem for most favored nations (MFN) and 25% ad valorem for non-MFN; wrought beryllium (TSUS 628.10), 9% ad valorem for MFN and 45% ad valorem for non-MFN; beryllium-copper master alloy (TSUS 612.20), 7.7% ad valorem for MFN and 28% ad valorem for non-MFN; beryllium oxide or carbonate (TSUS 417.90), 3.7% ad valorem for MFN and 25% ad valorem for non-MFN; other beryllium compounds (TSUS 417.92), 4.2% ad valorem for MFN and 25% ad valorem for non-MFN.

Table 2.— U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap,[1] by country

Country	1983		1984	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Belgium-Luxembourg	487	$5	79	$1
Brazil	--	--	1,125	8
Canada	1,129	384	2,824	208
Costa Rica	5,130	9	--	--
Czechoslovakia	55	6	--	--
Finland	196	20	47	6
France	13,289	1,246	8,062	937
Germany, Federal Republic of	1,261	310	2,627	325
Hong Kong	--	--	3,114	32
India	--	--	100	1
Ireland	48	2	1,497	26
Israel	--	--	246	4
Italy	343	7	6,726	52
Japan	5,137	378	7,386	609
Korea, Republic of	2,561	33	772	34
Mexico	231	3	1,227	12
Netherlands	9	23	4	15
Portugal	150	1	490	7
Switzerland	4,886	126	433	23
Taiwan	--	--	1,051	14
United Kingdom	2,553	137	1,493	246
Other	12	3	12	2
Total	37,477	2,693	39,315	2,562

[1]Consisting of beryllium lumps, single crystals, powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.

Table 3.—U.S. imports for consumption of beryl, by country

Country	1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	14	$26	--	--
Brazil	1,006	1,217	744	$680
China	788	1,030	264	238
Hong Kong	32	40	--	--
Madagascar	33	22	--	--
Portugal	--	--	33	31
South Africa, Republic of	128	188	93	58
Switzerland	165	200	112	98
Zaire	9	11	--	--
Zimbabwe	19	21	86	72
Total	2,194	2,755	1,332	1,177

WORLD REVIEW

Including its production of bertrandite, the United States was the world's largest producer of beryllium raw materials. Estimated world production of beryl in 1984 was virtually unchanged from that of 1983. Brazil and the U.S.S.R. remained the major producers of beryl. China was also a substantial producer, but production data were unavailable.

Canada.—Exploration and development work continued on two beryllium prospects in the Northwest Territory and British Columbia. Reserves at Highwood Resources' 18,000-acre Thor Lake property, 65 miles southeast of Yellowknife, Northwest Territory, were estimated to be 1,789,000 tons, averaging 0.86% beryllium oxide. Metallurgical testing of these ores was conducted to determine the most economical method to recover the beryllium. Bearcat Exploration Ltd. and Colt Exploration (Western) Ltd. acquired mineral claims on a 5,500-acre beryllium prospect near Kimberley, British Columbia. A partial evaluation of the site, made about 20 years ago, indicated the presence of 500,000 tons of material grading 0.1% beryllium oxide. The prospect, containing a large pegmatitic intrusion, lends itself to open pit mining. Exploration work was started in 1984 to assess total beryllium resources.

Japan.—Brush Wellman acquired 100% of Brush Wellman (Japan) Ltd., its former 50% owned affiliate, which distributed the company's beryllium-copper alloy products in Asia. The buyout provided a basis for implementing marketing and manufacturing plans in other Asian markets.

Table 4.—Beryl: World production, by country[1]

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Argentina	34	8	7	27	17
Brazil (exports)	606	[r]941	1,171	[r e]1,380	1,380
Madagascar[e]	11	11	11	11	11
Mozambique	22	20	17	[e]17	17
Portugal	21	20	21	20	20
Rwanda	119	65	76	36	40
South Africa, Republic of	(2)	134	64	24	--
U.S.S.R.[e]	2,000	2,000	2,000	2,100	2,100
United States[3] (shipments)	[r]7,449	[r]7,334	5,451	6,665	[4]6,030
Zimbabwe	10	46	57	[e]55	55
Total	[r]10,272	[r]10,579	8,875	10,335	9,670

[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, and Kenya apparently produced small amounts until 1980. Table includes data available through Apr. 24, 1985.

[2]Less than 1/2 unit.

[3]Includes bertrandite ore, calculated as equivalent to beryl containing 11% BeO.

[4]Reported figure.

TECHNOLOGY

Brush Wellman introduced a new copper-based alloy containing 0.15% to 0.50% beryllium. The new alloy, Brush Alloy 174, has about four times the electrical conductivity and a comparable yield strength to that of phosphorus bronze, with which it was designed to compete. Brush Alloy 174 was targeted to manufacturers of connectors, switches, and relays for the electrical and electronics industries.[3]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Federal Register. Health Assessment Document for Beryllium. V. 49, No. 245, Dec. 19, 1984, p. 49369.

[3]American Metal Market. Brush Wellman Ready With Beryllium Alloy. V. 92, No. 185, Sept. 21, 1984, p. 6.

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 rose, and the price of bismuth increased about threefold owing to temporarily restricted supplies reportedly caused by several world producers diverting metal to centrally planned economy countries.

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.

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)

	1980	1981	1982	1983	1984
United States:					
Consumption	2,289	2,393	1,876	2,285	2,648
Exports[1]	129	79	53	306	312
Imports, general	2,217	2,436	2,026	1,972	1,948
Producer price, average per pound (ton lots)	(2)	(2)	(2)	(2)	(2)
Consumer stocks, Dec. 31	674	509	542	577	480
World: Production[3]	7,954	r8,268	8,733	p8,431	e8,675

eEstimated. pPreliminary. rRevised.
[1]Includes bismuth, bismuth alloys, and waste and scrap.
[2]Domestic producer's list price has been suspended since Oct. 1, 1980.
[3]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 from bismuth scrap materials by several firms.

CONSUMPTION AND USES

Domestic consumption increased in 1984 to the highest level since 1979, reflecting a general economic improvement. The major increase occurred in the category of chemicals, which includes bismuth used in cosmetics, industrial chemicals, and pharmaceuticals.

Table 2.—Bismuth metal consumed in the United States, by use

(Thousand pounds)

Use	1983	1984
Fusible alloys	623	609
Metallurgical additives	523	424
Other alloys	20	20
Chemicals[1]	1,104	1,573
Experimental	2	(2)
Other	13	22
Total	2,285	2,648

[1]Includes cosmetics, industrial and laboratory chemicals, and pharmaceuticals.
[2]Less than 1/2 unit.

PRICES

The price of bismuth increased sharply during the year, reportedly in response to a tightened supply situation caused by several leading world producers diverting their bismuth to centrally planned economy countries at premium prices. Asarco continued suspension of its producer list price throughout the year. The published price of a major foreign producer, Mining & Chemical Products Ltd. (United Kingdom), was $2.30 per pound at the beginning of the year and was steadily raised throughout the year to finish at $6.50 per pound. Domestic dealer quotations were $1.75 to $1.80 per pound at the beginning of the year and were raised throughout the year to finish at $6.50 to $6.70 per pound.

FOREIGN TRADE

Exports of bismuth remained at the relatively high level established in 1983, with the United Kingdom remaining the major export destination. Mexico remained the major source of U.S. imports, with Peru and the United Kingdom following closely.

Starting January 1, 1984, 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), 6.8% ad valorem for MFN and 45% ad valorem for non-MFN; and compounds (TSUS 418.00 and 423.80), 9.6% 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	1983 Quantity (pounds)	1983 Value (thousands)	1984 Quantity (pounds)	1984 Value (thousands)
Argentina	148	$1	--	--
Australia	26	3	--	--
Brazil	813	3	--	--
Canada	24,950	102	45,855	$290
China	38,486	83	--	--
Colombia	--	--	98	1
France	7	2	--	--
Germany, Federal Republic of	137	1	47,690	172
Greece	4,000	11	2,000	6
Hong Kong	--	--	10	1
Ireland	410	2	100	1
Israel	165	2	245	2
Italy	429	7	--	--
Japan	7,407	59	2,462	14
Korea, Republic of	9	1	188	15
Malaysia	100	2	--	--
Mexico	641	9	1,200	17
Netherlands	64,567	172	--	--
New Zealand	--	--	40	1
Peru	--	--	300	3
Singapore	891	8	863	28
South Africa, Republic of	69	2	136	2
Spain	1,464	12	22,267	95
Switzerland	30,110	66	66,431	251
Taiwan	1,258	55	1,099	27
Thailand	--	--	32	4
United Kingdom	129,940	93	120,495	161
Other	101	7	--	--
Total	306,128	703	311,511	1,091

Table 4.—U.S. general imports[1] of metallic bismuth, by country

Country	1983 Quantity (pounds)	1983 Value (thousands)	1984 Quantity (pounds)	1984 Value (thousands)
Belgium-Luxembourg	16,095	$24	75,807	$218
Canada	178,633	346	242,582	793
China	--	--	11,204	27
Germany, Federal Republic of	32,783	78	77,167	345
Japan	68,281	102	209,193	557
Korea, Republic of	55,112	83	124,943	410
Mexico	706,572	959	430,518	1,124
Peru	653,720	949	391,813	924
Poland	10	2	--	--
Spain	--	--	493	2
United Kingdom	260,750	578	384,674	1,492
Total	1,971,956	3,121	1,948,394	5,892

[1]General imports and imports for consumption were the same in 1983 and 1984.

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 & Chemical Products in the United Kingdom, and Société Industrielle d'Etudes et d'Exploitations Chimique and Métallurgie Hoboken-Overpelt SA in Belgium.

Table 5.—Bismuth: World mine production, by country[1]

(Thousand pounds)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Australia (in concentrates)[e 3]	2,650	[r]2,600	[r]3,310	[r]3,100	3,310
Bolivia (in concentrates)	24	24	11	13	7
Canada[4]	377	370	417	445	440
China (in ore)[e]	570	570	570	570	570
Japan (metal)	745	1,054	1,071	1,263	1,240
Korea, Republic of (metal)	271	220	209	[e]200	200
Mexico[5]	1,698	1,446	1,336	1,202	1,300
Peru[5]	1,096	1,409	1,351	1,179	1,160
Romania (in ore)[e]	180	180	180	180	180
U.S.S.R. (metal)[e]	160	170	170	180	180
United States (metal)	W	W	W	W	W
Yugoslavia (metal)[4]	183	[r]225	108	99	88
Total	7,954	[r]8,268	8,733	8,431	8,675

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; excluded from total.

[1]Table includes data available through Apr. 2, 1985.

[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.

TECHNOLOGY

A new procedure was developed to enhance rapid solidification of various tin-bismuth alloys. The procedure involves applying molten tin-bismuth alloy to a rapidly rotating wheel, where it solidifies as a ribbon or foil. The tin-bismuth foil is then stamped into a solder preform. This has the advantage of being used for soldering heat-sensitive components because of its low melting property.[2]

A lithium-silver bismuth chromate battery system was devised that was reported to have an extremely low level of self-discharge and uses a stable electrolyte, thereby enhancing its prospects for long service life applications.[3]

[1]Physical scientist, Division of Nonferrous Metals.

[2]The Bulletin of the Bismuth Institute. No. 45, 1984, pp. 4-5.

[3]———. No. 44, 1984, pp. 7-9.

Boron

By Phyllis A. Lyday[1]

U.S. production and sales of boron minerals and chemicals increased during the year because of the improved economy. Glass fiber insulation continued to be the largest use for borates, followed by textile-grade glass fibers 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 sodium-calcium borates. Domestic and world markets gained strength, and 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 and sodium-calcium borate ores and boric acid, primarily for textile-grade and insulation-grade glass fibers, 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 production 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)

	1980	1981	1982	1983	1984
United States:					
Sold or used by producers:					
Quantity:					
Gross weight[1]	1,545	1,481	1,234	1,303	1,367
Boron oxide (B_2O_3) content	783	740	607	637	667
Value	$366,760	$435,387	$384,597	$439,181	$456,687
Exports:					
Boric acid:[2]					
Quantity	47	46	35	38	45
Value	$23,735	$24,602	$19,082	$20,688	$24,402
Sodium borates:					
Quantity[3]	325	228	227	225	[4]501
Value[e]	$65,000	$58,000	$59,000	$51,000	$134,000
Imports for consumption:					
Boric acid:					
Quantity	10	1	4	8	8
Value	$6,393	$763	$1,903	$3,456	$3,449
Colemanite:					
Quantity	69	98	39	40	51
Value	$6,218	$15,202	$6,386	$8,309	$12,123
Ulexite:					
Quantity	6	44	35	[e]36	117
Value	$697	$2,690	[e]$2,800	$3,116	$10,202
Consumption: Boron oxide (B_2O_3) content[5]	384	373	266	341	375
World: Production	2,877	2,820	2,503	[p]2,446	[e]2,541

[e]Estimated. [p]Preliminary.
[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]Refined.
[4]Source: The Journal of Commerce Port Import/Export Reporting Service.
[5]See table 2.

Legislation and Government Programs.—The U.S. Department of the Interior's Bureau of Land Management streamlined several provisions of the existing regulations on leasing of solid minerals, including sodium borates. The most significant changes made by the final rulemaking were as follows: (1) The terms "valuable deposit" and "chiefly valuable" were defined; (2) existing provisions were clarified and new provisions added for exploration and development of hard-rock minerals; (3) the annual minimum royalty provisions were revised by the elimination of the annual adjustment and by setting the minimum royalty at $3 per acre per year; (4) the filing fee for application for leases and permits was increased from $10 to $25; (5) the amount of nationwide bond was revised from a fixed amount of $75,000 to a minimum of $75,000; (6) all references to 43 CFR Part 23 were eliminated; (7) the procedures to be followed and the information required in the preference right lease application adjudication process were revised; and (8) the period for extension of hard-rock mineral prospecting permits was increased from 2 years to 4 years.[2]

The National Institute for Occupational Safety and Health (NIOSH) was updating the status of the National Occupational Health Survey of Mining. Boron minerals were selected to be surveyed during 1984.[3]

DOMESTIC PRODUCTION

Boron minerals, sold and used, increased 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 ulexite-probertite, two similar sodium-calcium borates mined and sold as one, at its mine in Death Valley National Monument. The mine had a capacity of 350,000 short tons per month of ore containing 130,000 tons of salable product. Colemanite was ground and processed at the washing and calcining plant at Amargosa, NV. The mill had a capacity of 6,300 tons per month of concentrate. A flotation plant adjacent to existing facilities at Amargosa processed 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. Ulexite-probertite ore 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 ulexite-probertite were to manufacturers of glass fiber insulation.

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. At yearend, one of the evaporative boilers used to produce pentahydrate borax was operating to reduce process steam used in other operations to distilled water by extracting heat. The distilled water was recycled for boiler feed water in the coal-fired generator. 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 located at both plants. Shipments from Searles Lake were by rail via a company-owned spur to the Santa Fe Railroad at Ridgecrest, CA.

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 processed crude and refined hydrated sodium borates, their anhydrous derivatives, and anhydrous boric acid at the Boron refinery at Boron, in Kern County, CA. Crude sodium borates—Rasorite 46, a pentahydrate, and its anhydrous derivative—were produced for foreign markets. Installation of new equipment to improve the recovery of borax from the tailings was completed. Centrifuges separated clay matter from borax in water 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 produced technical-grade boric acid and waste sodium sulfate by a proprietary process from U.S.

Borax's extensive kernite ore reserves. Boric acid was produced to compete with colemanite used in glass manufacture. The boric acid plant, the world's largest, lowered energy requirements by using unrefined kernite ore as feedstock. The energy requirements of the kernite ore did not require the energy intensive process of refining tincal ore into borax before processing to boric acid.

In 1984, 4,000 tons of products was shipped from Boron each day via the Santa Fe Railroad. The majority of the 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.

Duval Corp. sought joint partners for a pilot project designed to produce boric acid from solution-mined colemanite.

CONSUMPTION AND USES

U.S. consumption of borates increased significantly. Glass fiber insulation and glass fiber reinforcement for plastics continued to be the largest consuming industries.

The improved market for thermal insulation for use in construction, especially in the building of new homes, increased demand for borax pentahydrate and ulexite-probertite used in the manufacture of glass fiber insulation. Glass fiber insulation was the largest area of demand for borates. Cellulosic insulation was the fifth largest area of demand.

The second major market for borates was textile-grade glass fibers. U.S.-produced colemanite, orthoboric acid, ulexite-probertite, pentahydrate borax, Turkish colemanite, and boric acid, primarily from Turkey, were essential raw materials for manufacturing high-tensile-strength glass fiber composites for use in a range of products that included aircraft, automobiles, and sports equipment. More than 90% of new pleasure boats were made of glass fiber-reinforced plastic. The glass fiber industry was composed of Owens-Corning, 51%; Manville Corp., 26%; CertainTeed Corp., 12%; PPG Industries Inc., 10%; and other, 1%.

Consumption of borates in the form of anhydrous borax, pentahydrate borax, orthoboric acid, and anhydrous boric acid for use in the manufacture of special borosilicate glasses remained a major end use. Boron compounds in cleaning and bleaching were also an important consumption sector; about one-quarter of these compounds was used to produce sodium perborate detergents. Boron compounds continued to find application in the manufacture of biological growth control chemicals for use in water treatment, algicides, fertilizers, herbicides, and insecticides. 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.

Many important but small-percentage end uses of borates and boron-containing chemical derivatives comprised a diverse miscellaneous category. Another group of borate compounds was sold to chemical distributors, but their ultimate end uses were unknown.

A patent dispute has taken place in the chemical industry involving a zeolite catalyst. The dispute between Mobil Oil Corp. and Amoco Chemicals Co. concerned boron-containing zeolites. Borosilicate molecular sieve material was important for catalytic activity and provided advantages in selectivity for xylene isomeric catalyst.[4]

Industrial Minerals Inc. of Kings Creek, SC, ground imported colemanite for several glass companies, including Manville Corp., Owens-Corning, and PPG Industries. Ore was transported from Charleston, SC, via railcars for grinding and storage. The plant operated three shifts per day in 1984.

Radioactive sludge from the Savannah River plant will be combined with fine particles of borosilicate glass and sealed into stainless steel canisters for permanent storage in an underground repository. Glass was chosen over crystalline ceramic because glass was a better developed process, although the two waste forms had similar radionuclide retention capability. The U.S. Department of Energy was expected to make a decision on the repository site by 1987, and waste storage was to begin in 1998.

Table 2.—U.S. consumption of boron minerals and compounds, by end use

(Short tons of boron oxide content)[1]

End use	1983	1984
Agriculture	14,185	15,003
Borosilicate glasses	34,637	32,418
Enamels, frits, glazes	11,176	11,172
Fire retardants:		
Cellulosic insulation	30,224	29,150
Other	1,313	1,752
Glass fiber insulation	91,433	117,451
Metallurgy	3,770	4,132
Nuclear applications	1,051	1,107
Soaps and detergents	30,411	28,705
Textile-grade glass fibers	58,787	69,870
Miscellaneous uses	24,188	20,615
Sold to distributors, end use unknown	39,481	43,226
Total	340,656	374,601

[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	1983	1984
Agriculture	194	142
Borosilicate glasses	6,984	5,730
Enamels, frits, glazes	371	410
Fire retardants:		
Cellulosic insulation	7,915	6,598
Other	1,299	1,694
Insulation-grade glass fibers	--	516
Metallurgy	792	703
Nuclear applications	754	926
Soaps and detergents	336	605
Textile-grade glass fibers	[r]14,072	17,403
Miscellaneous uses	10,572	11,998
Sold to distributors, end use unknown	12,710	15,864
Total	[r]55,999	62,589

[r]Revised.

Table 4.—Borate prices per short ton[1]

Product	Price, Dec. 31, 1984 (rounded dollars)
Borax, technical, anhydrous, 99%, bulk, carlots, works[2]	584
Borax, technical, anhydrous, 99%, bags, carlots, works[2]	629
Borax, technical, granular, decahydrate, 99.5%, bags, carlots, works[2]	226
Borax, technical, granular, decahydrate, 99.5%, bulk, carlots, works[2]	181
Borax, technical, granular, pentahydrate, 99.5%, bags, carlots, works[2]	253
Borax, technical, granular, pentahydrate, 99.5%, bulk, carlots, works[2]	208
Boric acid, technical, granular, 99.9%, bags, carlots, works[2]	597
Boric acid, technical, granular, 99.9%, bulk, carlots, works[2]	552
Boric acid, U.S. Borax & Chemical Corp., high-purity anhydrous, 99% B_2O_3, 100-pound bags, carlots, Boron, CA	2,215
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. 226, No. 27, Dec. 31, 1984, p. 20-28.

FOREIGN TRADE

Owens-Corning, through its American Borate subsidiary, imported colemanite, ulexite, and boric acid 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	1983			1984		
	Boric acid[1]		Refined sodium borates[2] (short tons)	Boric acid[1]		Sodium borates[3] (short tons)
	Quantity (short tons)	Value (thousands)		Quantity (short tons)	Value (thousands)	
Argentina	--	--	1	1	$1	--
Australia	2,916	$1,450	6,296	1,145	635	6,917
Austria	--	--	308	--	--	--
Belgium-Luxembourg	--	--	5,703	--	--	--
Brazil	744	358	2,822	160	128	3,187
Canada	5,053	2,450	43,671	7,657	3,902	--
Chile	2	4	--	2	4	783
Colombia	209	136	1,607	299	191	2,237
Costa Rica	12	6	415	7	6	42
Czechoslovakia	--	--	515	--	--	--
Denmark	325	77	516	21	12	--
Ecuador	3	4	530	64	37	563
El Salvador	--	--	58	2	3	22
Egypt	--	--	11	--	--	--
Finland	--	--	623	--	--	--
France	2	1	14,042	44	82	2
German Democratic Republic	--	--	752	--	--	1
Germany, Federal Republic of	(4)	1	13,243	168	278	--
Greece	--	--	17	--	--	--
Guatemala	2	2	--	--	--	173
Haiti	32	12	--	12	5	--
Honduras	44	17	--	37	13	--
Hong Kong	268	160	3,389	329	180	3,037
Hungary	--	--	552	--	--	--
India	6	2	2	9	3	6,884
Indonesia	100	57	2,515	81	46	4,834
Ireland	--	--	22	--	--	--
Israel	40	30	654	36	21	376
Italy	--	--	2,856	--	--	2
Ivory Coast	--	--	988	--	--	--
Jamaica	1	2	--	13	11	--
Japan	18,708	11,259	59,198	23,748	13,732	52,464
Kenya	--	--	39	--	--	27
Korea, Republic of	1,565	297	6,030	1,223	685	8,113
Leeward Island	3	2	--	--	--	--
Liberia	6	3	--	--	--	--
Malaysia	53	46	2,607	24	26	2,237
Mexico	5,093	2,372	19,860	3,002	1,336	445
Morocco	--	--	357	--	--	--
Netherlands	--	--	2,757	40	68	341,325
New Zealand	651	376	2,959	1,914	837	3,318
Nicaragua	--	--	485	--	--	91
Norway	--	--	280	--	--	--
Pakistan	--	--	301	--	--	305
Panama	2	3	--	10	10	59
Papua New Quinea	--	--	56	128	57	187
Peru	3	2	34	3	2	46
Philippines	564	353	1,476	252	222	1,360
Portugal	--	--	134	--	--	--
Puerto Rico	--	--	103	--	--	605
Saudi Arabia	--	--	246	--	--	--
Senegal	--	--	731	--	--	--
Singapore	244	119	822	199	111	1,690
South Africa, Republic of	4	10	4,163	787	8	3,818
Spain	--	--	1,123	--	--	42,415
Sri Lanka	15	8	63	7	4	12
Sudan	--	--	6	--	--	--
Sweden	21	17	1,731	64	37	114
Switzerland	2	4	403	--	--	--
Taiwan	1,291	727	8,494	1,537	861	10,377
Thailand	199	137	965	157	107	667
Tunisia	--	--	42	--	--	--
United Kingdom	46	20	5,188	20	15	122
Uruguay	7	3	14	131	43	25
Venezuela	259	167	743	1,378	680	1,648
Yugoslavia	--	--	559	--	--	--
Zambia	--	--	33	--	--	--
Zimbabwe	--	--	562	--	--	--
Other[5]	--	--	--	16	6	11
Total[6]	38,498	20,688	224,672	44,728	24,402	500,537

[1]Bureau of the Census.
[2]U.S. exporters of sodium borates.
[3]The Journal of Commerce Port Import/Export Reporting Service data.
[4]Less than 1/2 unit.
[5]Includes Bolivia and the Dominican Republic.
[6]Data may not add to totals shown because of independent rounding.

Table 6.—U.S. imports for consumption of boric acid, by country

Country	1983		1984	
	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)
Argentina	1,286	$485	--	--
Canada	--	--	(2)	(2)
France	139	105	139	$110
Germany, Federal Republic of	(2)	4	86	87
Italy	956	408	2,287	965
Japan	--	--	(2)	7
Turkey	5,500	2,453	5,236	2,280
United Kingdom	(2)	1	(2)	(2)
Total	7,881	3,456	7,748	3,449

[1]U.S. Customs declared values.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

Chile.—The AMAX Chemical Corp. and Molibdenos y Metales S.A. (Molymet) won the option for the new potassium, boric acid, and lithium concession in the Salar de Atacama. Further tests and negotiations will take 3 years before a final decision on the new project is reached. The initial $210 million investment planned would produce potassium chloride, potassium sulfate, and 31,000 tons of boric acid. The ownership was expected to be AMAX, 64%; Molymet, 11%; and Chile's State Development Corp., Corporación de Fomento de la Producción, 25%.[5]

Peru.—Production of ulexite at Laguna de Salinas in Peru averaged 32% to 36% boron oxide. The companies in production were Compañía del Boro y Derivados S.A., previously Boroquímica S.A.; Minerales y Servicios S.A., previously Boratos del Perú S.A.; and Minera Italboro S.A. The ulexite was exported to Brazil and Colombia and used domestically to produce boric acid.

In 1982, Química Oquendo S.A. began to operate a plant in Ventanilla, Callao, a district of Lima, to produce 660 tons of boric acid per year and increase to 1,300 tons.

The boric acid was exported to Brazil, Colombia, Ecuador, and Venezuela. In Peru, boric acid was used in the manufacture of borosilicate glass by Borosilicatos de Pisco S.A., a member of the Química Oquendo Group. The plant is located in Pisco City, 190 miles south of Lima.[6]

Turkey.—On August 18, 1984, Etibank, the Turkish state mining organization, officially inaugurated its boron derivatives plant at Kirka. The principal ore mineral for the plant was tincal, a sodium borate produced from an open pit mine having an average 25% boron oxide content. The major ore impurity was 10% clay. Ore was found at depths of 7 to 490 feet with an average overburden of 230 feet. Ore reserves totaled 550 million tons, which would last 500 years at current rates of production. The Kirka derivatives plant had a capacity of 176,000 tons per year of pentahydrate borax, 19,000 tons per year of decahydrate borax, and 66,000 tons per year of anhydrous borax. The product from the concentrator and derivatives plant was loaded onto trucks for transport to Degirmenozu, about 11 miles away to a rail terminal, or to the Port of Bandirma. Tincal concentrates are transported by rail in open cars but the derivations are transported in specially designed closed railcars. Although the product leaving the plant was refined borates rather than concentrates, the boron oxide capacity of the complex had not changed.[7]

The occurrence of the rare borate minerals veatchite-A, tunellite, teruggite, and cahnite were reported in the Emet borate deposit of Turkey. The borates were part of the Tertiary Age lacustrene sediments. The geochemical association of arsenic, boron, and sulfur suggest a common origin for all three elements at Emet as similar to the Kramer deposit in California. The Emet borates were believed to have formed in playa lakes fed by thermal springs.[8]

Table 7.—Boron minerals: World production, by country[1]

(Thousand short tons)

Country	1980	1981	1982	1983^{p}	1984^{e}
Argentina	172	138	136	125	132
Chile	4	4	(2)	1	1
China^{e}	30	30	30	30	30
Peru^{e}	23	18	15	^{r}11	11
Turkey	883	929	868	756	780
U.S.S.R.^{e}	220	220	220	220	220
United States[3]	1,545	1,481	1,234	1,303	[4]1,367
Total	2,877	2,820	2,503	2,446	2,541

^{e}Estimated. ^{p}Preliminary. ^{r}Revised.
[1]Table includes data available through May 21, 1985.
[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

Research in atomic physics provided a process by which atoms or groups of atoms assume a net electrical charge by losing or gaining electrons resulting in an intimate mixing of heretofore incompatible elements, and a repeal of some age-old laws of metallurgy. The new alchemy, called ion-beam processing or ion-beam implantation, was a common practice in the semiconductor industry, where silicon was doped with elements such as boron to alter its electrical properties. The most recent developments were in the treatment of metal, ceramic, or polymeric surfaces to upgrade hardness, optical properties, corrosion resistance, electrical conductivity, and other characteristics. Elements such as boron have also been implanted in copper, steel, and titanium, as well as in ceramics, glasses, and organic polymers. The useful life of steels used for naval aircraft turbine bearings was increased by a factor of 2.5 when the bearings were implanted with ions of boron, chromium, molybdenum, or a combination of these elements. The $52 ion beam treatment more than doubled the life of a $289 ball bearing and eliminated unscheduled maintenance cost. Nozzles made of cobalt superalloy or chrome carbide that were used to extrude glass or organic polymer fibers were treated with boron, silicon, titanium, or other ions. The integrity of the holes in the nozzles was enhanced, and oxidation was reduced.

Successful applications of ion implantation have worked to form cubic boron nitride crystals from boron and nitrogen. The ion-beam processing market is now worth about $250 million in annual revenues for equipment and service suppliers. The future of ion-beam processing in the materials industry depends on whether suppliers are able to find enough applications that warrant the technology's relative high cost of $0.15 to $1.00 per square centimeter.[9]

Structural components manufactured from composites were designed as multilayered configurations of unidirectional or woven material. A number of matrix-reinforced combinations have been investigated, but the most highly developed metal composite with the most applications was the boron-aluminum composite. The low-density fiber and matrix combination provided specific strength and stiffness properties that were attractive for limited applications in aircraft and some missiles and spacecraft. Titanium-based composites with boron and silicon carbide filaments provide useful engineering properties at temperatures up to 1,000° F.[10]

Boron was studied to trace the combustion of coal to determine origins and modes of transportation of pollution, particularly sulfate and acidity in the Northeast. Gaseous boron promised to be specific for coal pollution. Both gaseous and particulate boron from coal were influenced by marine boron in coastal areas. Boron offered an attractive way to measure the source of sulfur dioxide pollution from distant sources.[11]

Boron trichloride and chlorine were used to produce extremely narrow, sharp-edged aluminum lines on the surface of a silicon wafer. The processes used ions that bombard a thin aluminum film coating on a silicon wafer. Little radiation damage was reported from the ionizing radiation.[12] The process can be useful in electronics where silicon wafers, or chips, are used to record information.

Thin, corrosion-resistant boron compound layers onto silicon or gallium arsenide substrates of photoelectrochemical cell electrodes improve the performance of the cells. The new technique improves the stability of the silicon anodes by factors of more than 30,000 times.[13]

A method to change olefins to boranes of 100% optical purity was developed. The processes exist to convert the boranes to other organic chemicals such as alcohols and opens routes to synthesis of stereospecific compounds of nearly every type. The reaction was almost catalytic in nature and was useful for large-scale chemical preparations.[14]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Federal Register. Bureau of Land Management (Dep. Interior). Leasing of Solid Minerals Other Than Coal and Oil Shale, General; Amendment of Existing Regulations To Clarify and Streamline Provisions. V. 49, No. 81, Apr. 25, 1984, pp. 17892-17905.

[3]Groce, D. W. (Public Health Services). Private communication, 1984; available upon request from W. J. Campbell, BuMines, Avondale, MD.

[4]Science. Zeolites Catalyze Patent Dispute. V. 227, No. 4682, Jan. 4, 1985, p. 4682.

[5]Industrial Minerals (London). Chile—Amax and Molymet Win Lithium Concession. No. 204, Sept. 1984, p. 17.

[6]Algeria, Alberto (Mineral Italboro S.A.). Written communication, available on request from P. A. Lyday.

[7]Dickson, T. Etibank at Kirka—From Ore to Derivatives. Ind. Miner. (London), No. 210, Mar. 1985, pp. 65-68.

[8]Helvaci, C. Occurrence of Rare Borate Minerals: Veatchite-A, Tunellite, Teruggite, and Cahnite in the Emet Borate Deposits, Turkey. Miner. Deposita, v. 19, July 1984, pp. 217-226.

[9]Basta, N. Ion-Beam Implantation. High Technol., v. 5, No. 2, Feb. 1985, pp. 57-61.

[10]Persh, J. Department of Defense Program. Mater. and Soc., v. 8, No. 2, 1984, pp. 167-172.

[11]Rahn, K. A., and T. R. Fogg. Boron as a Tracer of Aerosol From Combustion of Coal (U.S. DOE contract DE 84004708, Univ. of RI). Dec. 15, 1983, 26 pp.

[12]Science News. Technology. V. 126, No. 8, Aug. 25, 1984, p. 121.

[13]Chemical Week. Technology Newsletter. V. 135, No. 11, Sept. 11, 1984, p. 37.

[14]Chemical & Engineering News. Method Synthesis Chiral Boranes in 100% Optical Purity. V. 62, No. 13, Mar. 26, 1984, pp. 28-29.

Bromine

By Phyllis A. Lyday[1]

Of the 856 million pounds of bromine produced in 1984, the United States produced 45%, followed by Israel, 23%; the U.S.S.R., 18%; the United Kingdom, 7%; and other countries, 7%. Five U.S. companies operated nine bromine-producing plants in Arkansas and Michigan. The quantity of bromine sold or used in the United States was estimated at more than 385 million pounds valued at $95 million. Exports of bromine compounds amounted to 53 million pounds. Prices of elemental bromine in bulk were between 33 and 34.5 cents per pound. The largest end use of bromine was in ethylene dibromide (EDB) manufactured for use as a scavenger for lead in gasoline. The 1983 ban on EDB use for agriculture eliminated the market for

Table 1.—Salient bromine and bromine compound statistics

(Thousand pounds and thousand dollars)

	1980	1981	1982	1983	1984
United States:					
Bromine sold:[1]					
Quantity	52,192	60,790	(2)	(2)	(2)
Value	$12,500	$11,000	(2)	(2)	(2)
Bromine used:					
Quantity	325,978	316,307	(2)	(2)	(2)
Value	$83,100	$75,100	(2)	(2)	(2)
Exports:					
Elemental bromine:					
Quantity	[3]8,100	[3]W	NA	[4]4,500	[4]68,200
Value	[3]$1,700	[3]W	NA	[4]$1,000	[4]$15,200
Bromine compounds:					
Gross weight	85,400	67,500	[5]55,600	[5]61,300	[5]53,200
Contained bromine	70,400	56,000	[5]47,200	[5]52,000	[5]45,100
Value	$35,900	$33,100	[5]$21,100	[5]$21,600	[5]$16,200
Imports:[4]					
Elemental bromine:					
Quantity	1	(6)	(6)	(6)	9
Value	$5	(6)	(6)	(6)	$17
Ethylene dibromide:					
Quantity	861	644	--	16	15
Value	$165	$139	--	$11	$10
Potassium bromate:					
Quantity	246	165	390	679	661
Value	$221	$323	$336	$572	$610
Potassium bromide:					
Quantity	667	107	281	436	367
Value	$457	$80	$204	$303	$268
Sodium bromide:					
Quantity	310	20	645	2,534	1,916
Value	$201	$12	$423	$971	$851
World: Production	756,105	[r]758,346	826,963	[p]788,863	[e]855,730

[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, and 385 million pounds in 1984, valued at $95 million.

[3]Exports reported to the Bureau of Mines by primary producers.

[4]Bureau of the Census.

[5]Bureau of the Census. Includes methyl bromine and ethylene dibromide.

[6]Negligible amount.

about 20 million pounds per year of elemental bromine. Production of EDB in 1984 was estimated at 73 million pounds. Exports accounted for about 58% of EDB production. Other uses of bromine included the production of compounds for oil and gas well fluids and for flame retardants.

Domestic Data Coverage.—Domestic production 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, one responded, representing an estimated 1% of total production. Production for the eight nonrespondents was estimated using information from domestic and foreign industry sources.

Legislation and Government Programs.—The U.S. Environmental Protection Agency (EPA) proposed that the quantity of lead in gasoline be reduced by 91% by January 1, 1986. EPA planned to lower the permissible lead limit from the current 1.1 grams per gallon of gasoline to 0.1 gram per gallon.[2] EDB reacts with lead during combustion of gasoline to form a lead bromide gas that is exhausted, thus preventing the deposition of lead in the engine. Aromatic chemicals were considered to be the likely replacement for lead and ethylene dibromide antiknock mixtures in gasoline, but these substances contribute to smog and may not be environmentally acceptable substitutes.

On February 3, EPA announced an emergency suspension of EDB use for grain fumigation. Citrus and papaya compliances were extended to November 1. A 300 parts per billion EDB tolerance for mangoes was to become effective on September 1, 1985.[3] At yearend 1984, EPA began accepting claims for indemnification and requests for disposal of EDB-containing pesticides used for fumigation of soil, grain, and grain milling equipment. All claims and requests were to be submitted by March 21, 1985. EPA was establishing procedures to identify and dispose of EDB. If only partial funding were available, the agency planned to place priority on the disposal funds.[4] Alternatives to EDB as a fumigant include carbon dioxide, irradiation, malathion, and methyl bromide. Preliminary laboratory data indicated that methyl bromide may pose a health hazard. The National Cancer Institute undertook epidemiology studies of grain workers exposed to EDB and methyl bromide. Irradiation, which has been used for fumigation in 28 countries, does not leave a residue, but it may take several years to install capacity capable of replacing EDB.

EPA set EDB tolerance levels of 900 parts per billion for grain, 150 parts per billion for intermediate products, and 30 parts per billion for ready-to-eat foods. Several States set stricter standards and removed contaminated foods from grocery shelves.[5]

In November, the first fatalities attributed to EDB occurred at a storage and distribution facility for agricultural chemicals. Two workers died during the cleaning of a pesticide holding tank, presumably because of a lack of adequate protective clothing. The measured concentration of EDB in the air was not high enough to have caused death from inhalation, according to Occupational Safety and Health Administration Safety and Health Standards; therefore, skin exposure was suspected.

Bromine tax rates under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, or Superfund, were scheduled to increase from $4.45 per ton in 1984.[6] In addition to taxes on bromine, Superfund also taxed the chlorine required to produce bromine, thus bromine companies payed the Superfund tax as both consumer and producer.

Superfund reauthorization was not approved by yearend 1984 but was expected to be debated in Congress early in 1985. At yearend 1984, EPA proposed to regulate the handling and disposal of wastes from the production of EDB by adding it to the list of hazardous wastes under Superfund. A feasibility study by the U.S. Department of the Treasury of a waste-end tax was to be completed by April 1985.

Union Carbide Corp. petitioned EPA to revise the definition of the tolerance for bromoxynil octanoate, a pesticide. Bromoxynil tolerances of 0.1 parts per million in or on corn fodder, forage, and grain, and sorghum fodder, forage, and grain were revised to permit the residues to also result from application of an additional derivative of the chemical.[7]

In April, the Arkansas Oil and Gas Commission, in El Dorado, was given the authority by EPA to administer petitions of the Federal programs to regulate reinjection wells.[8] Under the EPA classification system, the reinjection wells were classified as Class 5 wells for spent brine reinjected into the geologic formation of origin after extraction of halogens and their associated salts. An increase in the State severance tax from $2 to $2.45 per thousand barrels of brine went into effect during the year.

The Arkansas State Pollution Control and Ecology Department announced at yearend 1984 that a public hearing was to be held in 1985 on applications from Ethyl Corp. for a permit to construct and operate a new waste injection well and to continue operation of three existing wells near Magnolia.

DOMESTIC PRODUCTION

Three companies accounted for 91% of U.S. elemental bromine capacity. Great Lakes Chemical Corp. had become the largest producer in 1981 with its acquisition of the bromine assets of Velsicol Chemical Corp., giving Great Lakes control of 35% of the total plant capacity. In 1984, The Dow Chemical Co. and Ethyl accounted for 32% and 24% of capacity, respectively. Plant capacity did not reflect production capacity, which was dependent upon brine supplies, concentration of the bromine in the brine, and individual plant extraction processes. The only other domestic elemental bromine producer was Morton Thiokol Inc., which produced small quantities for captive use in inorganic bromides.

Dow operated one plant in Arkansas and two in Michigan. Complaints of spills from Dow's brine operations in Michigan resulted in close monitoring by the Michigan Department of Natural Resources. During the first 3 months of the year, 14 major spills totaling 100,000 gallons of brine were recorded. Michigan defined a major spill as 5 gallons or larger, whereas EPA defined a hazardous spill as 2,000 gallons of brine. Charged with violations of Michigan's Mineral Well Act, 1969, Dow announced plans in August to modernize the active brine wells, repair 150 miles of pipeline, build spill-containment systems at the 60 production and 28 reinjection wells, and improve its pumping surveillance. In October, plans to phase out brine production at its Midland, MI, plant and to increase brine operations at Ludington, MI, and Magnolia, AR, were announced. New wells were drilled during the year in Arkansas to increase the quantity of brine. Dow announced the completion of the decabromodiphenyl oxide (DBDPO) plant in Midland; DBDPO was used as a flame retardant. The new calcium bromide plant at Magnolia was to be completed by 1986.

Dow announced that it had sold one-half of Dowell and merged the remaining half into Dowell Schlumberger. An equal partnership continued between Dow and Schlumberger Ltd. to service the international drilling industry, excluding the United States and Canada; Schlumberger also planned to manage the expanded joint venture. Decreases in drilling activity during 1982 and 1983 contributed to making 1984 one of the worse years in Dow's 40-year history. Although Dow had been a leader in introducing bromine compounds as high-density, solids-free completion, packer, and workover fluids in the mid-1970's, bromine compounds were only about 5% of the available drilling industry market by 1984.

Ethyl announced the beginning of sodium bromide and calcium bromide production at its Magnolia, AR, plant and expansions of capacity at its octabromodiphenyl oxide (OBDPO) plant in Sayreville, NJ, and its DBDPO plant in Magnolia, AR. DBDPO and OBDPO were used as flame retardants in acrylonitrile-butadiene-styrene products. A 15-million-pound tetrabromobisphenol (TBBA) plant and a bromine chloride plant were completed. Bromine chloride was used to treat waste water. Bromochlorination was the most economical and practical substitute for chlorination. Ethyl announced the move of the Saytech flame retardant applications and research center into a new facility adjacent to the Sayreville plant. The company also expanded its brine supply by drilling a new well.

Great Lakes and the Federal Trade Commission (FTC) reached a final agreement in March 1984 concerning the Velsicol facilities acquired by Great Lakes in 1981. The agreement prohibited Great Lakes from acquiring any domestic and certain foreign concerns engaged in the production of elemental bromine or brominated flame retardants without prior FTC approval for a period of 10 years. The agreement also required Great Lakes to consent to license brominated flame retardant technology and know-how acquired from Velsicol to PPG Industries Inc. Great Lakes was also required to enter into a new agreement to govern the operation of Arkansas Chemicals Inc., a 50-50 joint venture with PPG. The agreement would eliminate certain restrictions on the use of bromine purchased from Arkansas Chemicals by PPG; allow PPG to use Arkansas Chemicals bromine in the production of brominated compounds; and require Great Lakes to purchase annually a specified quantity of bromine from Arkansas Chemicals.

Great Lakes operated four plants in Arkansas; one plant was a joint venture with PPG. In June, Great Lakes agreed to purchase the Newport, TN, plant of Syntex Chemicals Inc. Syntex was a manufacturer of specialty compounds, including brominated products. Great Lakes planned to manufacture selected flame retardants under a long-term agreement.

Table 2.—Bromine-producing plants in the United States in 1984

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	[2]5
Total				665

[1]Chemical Marketing Reporter. Chemical Profile. V. 221, No. 17, Apr. 26, 1982, p. 58.
[2]Chemical Marketing Reporter. Chemical Profile. V. 203, No. 20, May 14, 1973, p. 9.

CONSUMPTION AND USES

Demand for EDB decreased because of reduced demand for leaded gasoline as a consequence of the regulation of lead levels in gasoline that had become effective in 1982. The ban on EDB as a space and soil fumigant further decreased demand for EDB by approximately 20 million pounds during 1984. Despite the continuing decrease in use of EDB, demand for bromine in other products, such as flame retardants, clear well-completion fluids, and agricultural chemicals, increased worldwide.

U.S. methyl bromide production in 1984 was consumed as follows: soil fumigant, 65%; space fumigant, 15%; chemical processor, 10%. The remaining 10% of production was exported. During the year, Ethyl entered the market with 7 million pounds of methyl bromide capacity. Great Lakes was reported to have 36 million pounds of capacity. Dow had closed its 21-million-pound-per-year plant at Midland, MI, in August 1983.[9]

The rate of hydrocarbon well drilling in 1984 was 86% of the 1981 record. Brominated derivatives used in oil and gas drilling were not as severely affected by the decrease in well drilling as clay and barite. Estimates put the market for clear fluids at an excess of $200 million per year.[10]

Biocidal chemicals were used widely in industrial processes and products to keep equipment and working media free from biological contamination and to extend the life of such diverse materials as paint, cosmetics, food, and wood. One of the larger market sectors for biocides was industrial water treatment. Between 12 and 16 million pounds of chemicals were used; of which, sodium hypochlorite and chlorine accounted for about 90%, and the balance was proprietary biocides. Organo-bromine compounds were used because their quick hydrolysis and action suited them to systems with short contact times. These compounds were effective against a wide range of organisms.[11] Great Lakes manufactured Aquabrome (a bromine water treatment chemical that was less irritating to the eyes and skin than chlorine compounds) and SpaBrom sanitizers for hot tubs, in which high temperatures cause chlorine chemicals to break down.

Brominated hydrocarbons accounted for 14.1% of total flame retardants consumed in 1982. The U.S. merchant market for flame retardants was 412 million pounds valued at about $257 million in 1982. Approximately 85% of these flame retardants was used in plastics.[12] The largest markets in plastics were acrylonitrile-butadiene-styrene, epoxy resins, and polystyrene. Brominated organic chemicals were used in plastic electronic equipment, among other applications. Great Lakes DE-60F, pentabromodiphenyl-oxide, 60% bromine, was gaining usage in flexible foams, including polyester and polyester-based systems. The product satisfied the requirements of California Bulletin 117, passing its open-flame test at low loadings and providing effective smoldering resistance and maintenance of foam properties, particularly weight retention in the smolder test.[13] About 15% of total revenues at Great Lakes was attributed to TBBA. TBBA, other flame retardants, and the Halon line of fire-extinguishing agents accounted for almost one-third of the company's gross revenues in 1983.[14]

PRICES

Great Lakes announced an elemental bromine price increase, effective August 1, 1984, of 3 cents per pound. The company attributed the increase to the continued rising costs of raw materials and manufacturing. The increase followed a similar increase in July by Dow. Ethyl announced a price increase effective August 1 to raise the price of elemental bromine from 33 to 36 cents per pound, f.o.b. Magnolia, AR. The price increase was attributed to increased costs for drilling new wells and for raw materials, particularly chlorine.

On July 15, Ethyl reduced off-price allowances for spot purchases of Saytex 102, DBDPO, as allowed by contract terms. DBDPO, the brominated flame retardant having the second largest market, was used widely in polyolefins, polystyrene, and engineering plastics. The change in the allowance increased the list price from $1.80 to $1.85 per pound. This increase was necessary to meet higher production costs, principally the cost of chlorine. Other manufacturers were selling DBDPO for $1.59 to $1.80 per pound.

On October 1, Great Lakes increased the prices of two major flame retardant products, BA-59 and BA-59P grades of TBBA, by 4 cents per pound. The new prices applied to standard truckload and less-than-truckload quantities and reflected increases in raw material and manufacturing costs.

Great Lakes announced price increases for bromine-based workover and completion fluids used by the oil and gas drilling industries to become effective January 1, 1985. Prices for dry calcium and sodium bromides were to increase by 2 cents per pound, and prices for calcium-, sodium-, and zinc-bromide solutions by 1 cent per pound. At yearend, list prices for solutions were as follows: calcium bromide, 25 cents per pound; sodium bromide, 27 cents per pound; and zinc bromide, 62.5 cents per pound. New list prices for dry material were calcium bromide, 71 cents per pound, and sodium bromide, 56.5 cents per pound. All prices were for material delivered to the gulf coast. The increases were attributed to higher raw material costs and to capital investments required to assure long-term supply of elemental bromine.

Table 3.—Yearend 1984 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]	20 - 25
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. 226, No. 27, Dec. 31, 1984, pp. 20-27.

FOREIGN TRADE

Exports of bromine-containing compounds reported by the Bureau of the Census decreased during the year. The majority of these exports was EDB.

Approximately 81% by quantity and 77% by value of imports of bromine and bromine compounds reported by the Bureau of the Census were from Israel. The closer proximity of Israel to overseas markets gave Israeli bromine an advantage in transportation costs compared with that of U.S. exports. Other countries from which bromine and bromine compounds were imported by the United States were France, 8%; the United Kingdom, 7%; and other, 4%. These imports included sodium bromide, 64%; potassium bromate, 22%; potassium bromide, 12%; and negligible quantities of elemental bromine and EDB, 2%. Because imported bromine compounds were contained in many products, some of the compounds were not easily identified through Census data.

In July, the office of the U.S. Trade Representative (USTR) announced the acceptance of petitions to remove duty-free status from a beneficiary developing country for a product on the list of eligible articles for the Generalized Systems of Preference (GSP). The U.S. Bromine Alliance, including Dow, Ethyl, and Great Lakes, submitted 13 petitions to modify the eligibility of brominated compounds. The Bromine Alliance suggested that many of these compounds would not be eligible for GSP if they were not included in categories that hid the magnitude of imports. The GSP subcommittee of the USTR accepted the petitions to remove GSP from ammonium bromide, bromotrifluoromethane, calcium bromide, dibromoneopentyl glycol, ethyl bisbromonorbornane, hydrobromic acid, methyl bromide, monobromoacetic acid, potassium bromate, sodium bromate, zinc bromide, and mixtures in whole or part bromine. The Trade Policy Staff committee of the USTR held hearings in October for submissions in support of or in opposition to any petition contained in the announcement. The International Trade Commission (ITC) also held hearings in October to determine the import sensitivity of the articles petitioned. Statutory authorization for the GSP program was scheduled to expire on January 3, 1986.

The Bromine Alliance opposed the inclusion of bromine chemicals in a free trade agreement with Israel. Israel had been the only major bromine producer in the market economy countries, other than the United States. The position of the Bromine Alliance was that (1) the inclusion of bromine chemicals in the proposed free trade zone would cause severe adverse economic consequences to the domestic bromine industry, (2) the domestic industry had been affected by environmental regulations, including the phaseout of EDB as a gasoline additive in leaded gasoline, the ban on EDB as a soil and space fumigant, and the Superfund tax, and (3) Israel already had duty-free access under the GSP and most-favored-nation status for about 90% of these imports. Furthermore, imported bromine compounds were not subject to a Superfund tax, although they contributed to hazardous wastes for which disposal was paid through Superfund tax contributions by the domestic industry.

The ITC found that a number of bromine products were vulnerable to Israeli competition. In September, the USTR agreed to a 3-year moratorium on including bromine products in the proposed free-trade agreement with Israel. The USTR agreed not to reduce tariffs on import-sensitive products from Israel before its negotiating authority expires on January 3, 1988. Israel was also to be asked to phaseout Government subsidy of its bromine industry.

WORLD REVIEW

European Economic Community.—In response to growing pressure from environmentalists, the European Economic Community (EEC) planned to mandate the use of unleaded gasoline and tighten regulations on automobile exhaust emission levels. The reduced emission of lead would also reduce the use of EDB as a lead scavenger. The EEC commission was expected to move to U.S. standards. Many European car makers favored two gasoline grades, such as 91 and 96 octane.

Israel.—Israel produced bromine at capacity during 1980-84 from the waste bitterns of potash production along with chlorine and caustic soda. Israeli bromine exports during 1984 were shipped to Europe, 60%; the Far East, 20%; and other countries, 20%. Total exports of bromine and bromine compounds to the United States had doubled since 1981.

Bromine Compounds Ltd. (BCL), a 50-50 venture between Dead Sea Works Ltd. (DSW) and Dead Sea Bromine Co. Ltd. (DBC), produced bromine and bromine compounds at its new plant at Ramat Hovav and its old plant at Beersheba. DBC was 100% owned by DSW, an 89% Government-owned company.

Table 4.—World bromine plant capacities and sources

Country and company	Location	Capacity (million pounds)	Source
China:			
NA	Iksaydam	NA	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	Beersheba	154	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	Underground brines.
United Kingdom:			
Associated Octel Co. Ltd	Amlwch	66	Do.

NA Not available.

Table 5.—Bromine: World production, by country[1]

(Thousand pounds)

Country[2]	1980	1981	1982	1983[p]	1984[e]
France[e]	[3]36,332	36,000	20,000	22,000	25,000
Germany, Federal Republic of	8,832	7,864	6,775	6,914	7,000
India[e]	[3]736	770	770	770	770
Israel	97,133	97,047	[e]154,000	[e]154,000	198,400
Italy[e]	1,300	[r]1,320	1,320	1,100	1,100
Japan[e]	26,500	26,500	26,500	26,500	26,500
Spain[e]	900	900	800	700	660
U.S.S.R.[e]	148,000	150,000	150,000	150,000	154,000
United Kingdom	58,202	60,848	65,698	56,879	57,300
United States[4]	378,170	377,097	[e]401,100	[e]370,000	385,000
Total	756,105	[r]758,346	826,963	788,863	855,730

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 30, 1985.
[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.

Israel developed a new process for production of calcium bromide. The new process used an organic solvent to extract the chemical from the waste bitterns of potash production, thus deleting intermediate processing steps. The conventional energy consuming and costly process had used the reaction of hydrogen bromide with calcium hydroxide. BCL began construction of a pilot plant to make 2 to 4 million pounds of calcium bromide per year. Pending the success of the pilot plant, BCL planned to build a commercial-scale plant. In addition, ICL planned to spend $1 billion during the next 5 years on expansion and new projects, including expanded bromine and bromine compound production to 240 and 220 million pounds per year, respectively.[15]

TECHNOLOGY

Texaco Inc. was developing a new method of homogeneous catalysis for making basic organic chemicals from synthesis gas. Since 1960, 90% of new acetic acid production uses a methyl iodide catalyst. The catalyst precursor used three elements, including a low melting quarternary phosphonium-salt, such as tetrabutylphosphonium bromide as the reactor medium. Homogeneous catalysis by metals is inherently selective and reproducible, and usually exhibits good yields. Molten salts have good heat transfer properties, dissolve a wide range of materials, and generally promote high reaction rates. A ruthenium compound couple dispersed in a bromide system was selected for an intensive study of the reaction mechanisms. The system had demonstrated that the catalyst can be recycled. Methanol was produced by the initial reaction, but ethylene glycol can also be produced.[16]

A mixture of potassium bromide and graphite between the faces of two diamond anvils was compressed and subjected to a powerful laser that converted the graphite to diamond and partially melted a tiny portion of the diamond anvil face. This was the first time that melting of a diamond face had occurred.[17]

Modern studies identified Tyrian purple as a brominated form of indigotin, the color-producing compound in indigo dye. The bromine gives Tyrian purple its reddish tinge. The dye, a secreted mucus from a sea snail, was a 50-50 mix of plain and brominated indigotin.[18]

Methyl bromide was encapsulated in zeolites to obtain a free-flowing powder from which the nematocide could be released slowly. The microencapsulation was technically difficult and required a low-temperature system for slow release.[19]

Potassium bromate crystals were grown from aqueous solutions of sodium nitrate-promoted monoclinic crystals and lead nitrate-promoted rhombohedral crystals. Halogen crystals are not symmetrical and are important in nonlinear optics, acoustic electronics, and other areas of applied physics.[20]

Electrochemistry can deal with compounds more highly functional than simple petrochemicals. The conditions can be as forcing or as mild as required, merely by setting the voltage. Using electrochemistry, a bromine compound can be used as a redox catalyst to obtain benzoates in very high yields at the potential that would normally only give the acetals, and the catalyst was recycled over 2,500 times. A bromine catalyst has been used to make calcium gluconate using electrochemistry. In India, bromoform was produced from ethanol by an electroorganic process.[21]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Federal Register. U.S. Environmental Protection Agency. Regulation of Fuels and Fuel Additives; Lead Phase Down. V. 49, No. 150, Aug. 2, 1984, pp. 31032-31050.

[3]———. U.S. Environmental Protection Agency. Ethylene Dibromide; Proposed Tolerance. V. 49, No. 156, Aug. 10, 1984, pp. 32088-32090.

[4]———. U.S. Environmental Protection Agency. Ethylene Dibromide Pesticide Products; Procedures for Submission of Claims for Indemnification and Disposal. V. 49, No. 247, Dec. 21, 1984, pp. 49796-49802.

[5]———. U.S. Environmental Protection Agency. Ethylene Dibromide. Proposed Revocation of Exemption From the Requirement of a Tolerance. V. 49, No. 36, Feb. 22, 1984, pp. 6696-6700.

[6]Pesticide & Toxic Chemical News. Ways and Means Superfund Taxation Scheme Accepted by House. V. 12, No. 40, Aug. 15, 1984, pp. 20-30.

[7]Federal Register. Tolerance and Exemptions From Tolerences for Pesticide Chemicals in or on Raw Agricultural Commodities; Bromoxynil. V. 49, No. 46, Mar. 7, 1984, pp. 8441-8442.

[8]———. Arkansas Oil and Gas Commission; Underground Injection Control; Program Approval. V. 49, No. 59, Mar. 26, 1984, p. 11179.

[9]Chemical Marketing Reporter. Chemical Profile. V. 227, No. 7, Feb. 18, 1985, p. 54.

[10]Chemical Week. Great Lakes Chemical. V. 134, No. 12, Mar. 21, 1984, pp. 74-77.

[11]Manufacturing Chemist. Chemicals as Biocides. V. 55, No. 2, Feb. 1984, pp. 24-26.

[12]Goodwin, W. Flame Retardant Manufacturers: In Control of Their Own Destiny? Chem. Mark. Rep., v. 225, No. 19, May 7, 1984, p. 39.

[13]Work cited in footnote 2.

[14]Wood, A. S. Additives for Hybrids, Low-Smoke Phosphorus; Wherever You Look There's Something New in Flame Retardants for Urethane Foams. Mod. Plast., v. 61, No. 5, May 1984, p. 60.

[15]Chemical Week. International Newsletter. V. 136, No. 11, Mar. 13, 1985, p. 17.

[16]Chemical & Engineering News. Texaco Developing Melt Catalysis System. V. 62, No. 17, Apr. 23, 1984, p. 27.

[17]———. Science. Cornell Team Uses Laser to Melt Diamond Surface. V. 62, No. 36, Sept. 3, 1984, p. 25.

[18]Science News. Science News of the Week. Blue-Purple Dye of Antiquity Reborn. V. 126, No. 10, Sept. 8, 1984, p. 148.

[19]Markus, A., I. Eger, M. Mhasalkar, Z. Pelah, and A. Galun. Encapsulation of Methyl Bromide in Zeolites. J. of Colloid and Interface Sci., v. 94, No. 1, July 1983, pp. 284-285.

[20]Kidyarov, B. I., R. R. Nev'Yantseva, N. D. Dandaron, and L. F. Zaytseva. Growing Potasium Bromate Crystals From Aqueous Solutions of Lead and Sodium Nitrate. Novosibirsk Izvestiya Sibirskogo Otdeleniya Akademii Nauk SSSR: Seriya Khimicheskikh Nauk. (in Russian), v. 15, No. 5, Sept. 1984, pp. 51-55.

[21]Jansson, R. Organic Electrosynethesis. Chem. & Eng. News, v. 62, No. 47, Nov. 19, 1984, pp. 43-57.

Cadmium

By Patricia A. Plunkert[1]

Domestic production of cadmium metal increased significantly in 1984. A low level of cadmium stocks held by producers and distributors at the end of 1983 contributed to the need for increased domestic production during 1984. Large volumes of metal were also shipped to cadmium compound producers as the demand for various compounds, especially cadmium oxide, continued to be strong. The tightness of cadmium supply, especially during the first half of 1984, contributed to a rapid rise in metal prices during that period. As the supply of cadmium increased, prices began to decrease and closed the year slightly above the 1983 yearend price levels.

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 compound-producing operations to which a survey request was sent, 10 responded, representing an estimated 99% of the total compound production shown in tables 3 and 4. Production for the remaining nonrespondent was estimated using prior year production levels.

Table 1.—Salient cadmium statistics

	1980	1981	1982	1983	1984
United States:					
Production[1] ---- metric tons--	1,578	1,603	1,007	1,052	1,686
Shipments by producers[2] ---- do----	1,271	1,382	1,832	1,495	1,811
Value ---- thousands--	$5,219	$3,838	$2,628	$1,786	$2,581
Exports ---- metric tons--	236	239	11	170	106
Imports for consumption, metal ---- do----	2,617	3,090	2,305	2,196	1,889
Apparent consumption ---- do----	3,534	4,378	3,728	3,763	3,371
Price: Average per pound[3] ----	$2.84	$1.93	$1.11	$1.13	$1.69
World: Production ---- metric tons--	r18,238	r17,381	16,378	p16,725	e17,687

eEstimated. pPreliminary. rRevised.

[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 March 8, the Environmental Protection Agency (EPA) 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 cadmium varied according to type of manufacturing operation and effluent source.[2]

On March 9, EPA also issued final regulations that established effluent limitations guidelines and standards to be met by existing and new battery manufacturing operations. The cadmium subcategory, which is one of seven subcategories covered by these regulations, limits discharges of pollutants into navigable waters and into publicly owned treatment works from the manufacturing of cadmium anode batteries. The cadmium effluent limitations varied according to the type of electrode produced and the electrode manufacturing process that was used.[3]

During the year, EPA also issued final regulations covering effluent discharges from the production of cadmium pigments and salts including cadmium chloride, cadmium nitrate, and cadmium sulfate salts.[4]

The Hazardous and Solid Waste Amendments of 1984, Public Law 98-616, which was signed by the President on November 8, set limits on the disposal of toxic materials such as cadmium in landfills. Land disposal of liquid wastes containing cadmium metal or cadmium compounds at concentrations greater than or equal to 100 milligrams per liter, cadmium content, were prohibited. This law was to take effect 32 months after enactment.

The National Defense Stockpile goal for cadmium metal remained at 5,307 metric tons. As of December 31, 1984, the stockpile inventory was 2,871 tons of cadmium metal.

DOMESTIC PRODUCTION

Domestic production of cadmium metal and compounds increased significantly compared with that of 1983. Because cadmium stocks were low and imports declined during 1984, cadmium consumers relied on increased domestic production to meet their needs. Also contributing to the increase in domestic production was the reopening of ASARCO Incorporated's zinc refinery in Corpus Christi, TX, which recovered cadmium from residues generated during the processing of zinc ores and concentrates. This plant, which had been closed since October 1982, resumed production in April 1984.

On May 10, Gulf + Western Industries Inc. (G+W) announced the sale of its 60% interest in Jersey Minière Zinc Co. to Union Zinc Co., the U.S. subsidiary of G+W's Belgian partner, Union Minière SA. Included in the sale were the zinc refinery at Clarksville, TN, and two operating zinc mines, also situated in Tennessee, the Gordonsville and Elmwood Mines.

In early August, Fluor Corp., the parent of St. Joe Resources Co., announced that it had purchased the National Zinc Co. from Intercontinental Development Corp. National Zinc operated an electrolytic zinc refinery in Bartlesville, OK.

Table 2.—Primary cadmium producers in the United States in 1984

Company	Plant location
AMAX Inc	Sauget, IL.
ASARCO Incorporated	Corpus Christi, TX, and Denver, CO.
Jersey Minière Zinc Co	Clarksville, TN.
National Zinc Co	Bartlesville, OK.

Table 3.—U.S. production of cadmium compounds other than cadmium sulfide[1]

(Metric tons)

Year	Quantity (cadmium content)
1980	826
1981	885
1982	971
1983	1,024
1984	1,510

[1]Includes plating salts and oxide.

Table 4.—U.S. production of cadmium sulfide[1]

(Metric tons)

Year	Quantity (cadmium content)
1980	801
1981	527
1982	374
1983	670
1984	771

[1]Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Apparent consumption of cadmium decreased compared with that of 1983. 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%.

Table 5.—Supply and apparent consumption of cadmium

(Metric tons)

	1982	1983	1984
Stocks, Jan. 1	1,844	1,417	732
Production	1,007	1,052	1,686
Imports, metal	2,305	2,196	1,889
Total supply	5,156	4,665	4,307
Exports	11	170	106
Stocks, Dec. 31	1,417	732	830
Apparent consumption[1]	3,728	3,763	3,371

[1]Total supply minus exports and yearend stocks.

STOCKS

Total inventories of cadmium in all forms increased 13% compared with those of 1983 but were still considered to be at a low level. Stocks of the metal form continued to decline and reached their lowest level in over 30 years. The increase in total cadmium stocks during 1984 was due mainly to a buildup in cadmium compound stock levels held by compound manufacturers and metal producers.

Table 6.—Industry stocks, December 31

(Metric tons)

	1983		1984	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	209	W	208	W
Compound manufacturers	49	378	59	509
Distributors	91	5	52	2
Total	349	383	319	511

W Withheld to avoid disclosing company proprietary data; included with "Compound manufacturers."

PRICES

At the beginning of 1984, AMAX Inc. was the only domestic producer with a published price for cadmium metal. In January, AMAX listed a price of $1.25 per pound for cadmium metal, which was raised to $1.50 per pound on March 1. AMAX announced a further price increase to $2.25 per pound on April 1. On July 12, National Zinc, which had suspended list prices during 1983, published a price of $1.55 per pound for cadmium metal. On August 1, AMAX lowered its price to $1.55 per pound where it remained through yearend. In late November, however, National Zinc announced a further price reduction to $1.25 per pound for cadmium metal.

Dealer prices in January were listed at $0.90 to $0.95 per pound for cadmium metal. These prices fluctuated during the first part of the year and reached a record high of

$1.75 to $1.80 per pound in late April. In mid-May, dealer prices began to decrease. This trend continued throughout the latter half of 1984, and dealer prices for cadmium metal closed the year at $1.11 to $1.15 per pound.

FOREIGN TRADE

Exports of cadmium metal and cadmium in alloys, dross, flue dusts, residues, and scrap decreased compared with those of 1983 and remained well below the average amount of material exported during the previous 5-year period. The three largest recipients in 1984, in descending order of receipts, France, Canada, and Finland, received approximately 90% of U.S. cadmium exports.

Cadmium metal imports for consumption continued to decrease and reached their lowest level since 1974. The principal supplying countries, in descending order of receipts, were Canada, Australia, Mexico, and the Federal Republic of Germany.

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)
1982	11	$126
1983	170	351
1984	106	208

Table 8.—U.S. imports for consumption[1] of cadmium metal, by country

Country	1983		1984	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	713	$1,160	363	$792
Belgium-Luxembourg	15	54	([2])	3
Canada	[3]938	1,877	[3]862	2,817
Finland	67	87	47	126
France	43	79	[3]27	119
Germany, Federal Republic of	21	34	155	343
Japan	([2])	([2])	([2])	2
Korea, Republic of	50	77	84	191
Mexico	126	163	174	344
Netherlands	17	23	--	--
Norway	35	58	35	94
Peru	154	206	103	227
Sweden	--	--	10	25
United Kingdom	17	24	19	13
Yugoslavia	--	--	10	37
Total	[3]2,196	3,842	[3]1,889	5,133

[1]General imports were as follows, in metric tons: 1983—2,191 and 1984—1,898.
[2]Less than 1/2 unit.
[3]Includes waste and scrap (gross weight).

WORLD REVIEW

The European Economic Community (EEC) announced a tightening of the regulations on cadmium and lead levels in ceramic plates and food storage containers. The regulations, to take effect in 1987, covered the amount of lead or cadmium likely to be leached from these articles rather than the total metal content. Both cadmium and lead can be used as pigments in housewares.[5]

Brazil.—Cia. Industriel e Mercantil Inga S.A. announced that it expected to raise cadmium production capacity levels from 3 tons per month to 6 tons per month during 1985, with a target of 12 tons per month in 1986.[6]

Chile.—El Toqui lead-zinc-silver mine was inaugurated in November 1983 by Sociedad Contractual Minera el Toqui Ltda. A concentration plant was designed to process 750 tons of ore per day. The zinc concentrates and lead-silver concentrates produced were expected to contain significant amounts of cadmium as well as copper, silver, and gold.[7]

India.—Hindustan Zinc Ltd. announced the opening of the Rajpura-Dariba Mine located in Rajasthan State, northeast of Udaipur. The mine was inaugurated in April 1983. The rated capacity of this mine was 900,000 tons of ore per year. The cadmium content of the 93,000 tons of zinc concentrates, 25,000 tons of lead concentrates, and just under 4,000 tons of copper concentrates expected to be produced annually was estimated at 173 tons per year.[8]

Thailand.—In November, the Padaeng Industry Co. began production of high-grade slab zinc at its new electrolytic zinc refinery at Tak. At yearend, the byproduct cadmium cake, containing 23% cadmium plus other residual metallic salts, was being carefully stored to prevent environmental contamination. Commercial cadmium extraction from this cake was not considered viable at the time but could become so in the future.[9]

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

(Metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Algeria[e]	[2]60	65	65	[r]50	50
Argentina	18	--	21	[e]19	20
Australia (refined)	1,012	1,031	1,010	1,100	1,200
Austria	36	55	48	46	45
Belgium	[r]1,524	1,176	996	800	850
Brazil	41	45	73	189	180
Bulgaria[e]	[r]210	[r]210	200	200	200
Canada (refined)	1,303	1,298	809	1,107	1,200
China[e]	250	270	300	300	300
Finland	581	621	566	616	600
France	789	663	[3]793	540	500
German Democratic Republic[e]	16	16	16	16	16
Germany, Federal Republic of	1,194	1,192	1,030	1,095	1,100
India	89	113	131	131	120
Italy	568	[3]489	[3]475	450	400
Japan	2,173	1,977	2,034	2,214	2,400
Korea, North[e]	140	140	100	100	100
Korea, Republic of	365	300	320	[r e]320	300
Mexico (refined)	778	590	607	642	650
Namibia	69	--	110	[e]25	25
Netherlands	455	518	497	521	525
Norway	130	117	104	117	110
Peru	172	307	421	451	460
Poland	698	580	570	[e]570	570
Romania[e]	85	85	80	80	80
Spain	309	303	286	278	250
U.S.S.R.[e]	2,850	2,900	2,900	3,000	3,000
United Kingdom	375	278	354	340	340
United States[3]	1,578	1,603	1,007	1,052	[2]1,686
Yugoslavia	201	208	174	48	100
Zaire	168	[3]230	281	308	310
Zambia	1	1	--	--	--
Total	[r]18,238	[r]17,381	16,378	16,725	17,687

[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. 17, 1985.

[2]Reported figure.

[3]Includes secondary.

TECHNOLOGY

Chemische Fabrik Kalk GmbH of the Federal Republic of Germany announced the development of a low-cost method for removing cadmium from wet-process phosphoric acid in fertilizer production. The process removes cadmium from the acid by countercurrent liquid extraction, using a heavy amine hydrochloride. The process reportedly has been on-stream at the Budenheim plant since the middle of 1983.[10]

Uranium Pechiney of France reportedly developed an ionic flotation process to extract cadmium from phosphoric acid that is produced by digestion of phosphate rock. The ionic flotation process utilizes a complexing agent that combines with the cadmium cations to form an insoluble deposit. After aeration, the cadmium-containing precipitate floats to the surface in a foam, which can then be scraped off the top.[11]

The National Aeronautics and Space Administration's Jet Propulsion Laboratory in Pasadena, CA, reportedly developed a multistep process that would form semiconductor devices on macrocrystalline films of cadmium or zinc. The metal film would reside on a sheet metal substrate, such as steel. Devices such as solar cells could be made economically by forming the desired surface substance directly on the metal film by chemical reaction.[12]

Developments in cadmium technology during the year were abstracted in Chemical 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. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 49, No. 47, Mar. 8, 1984, pp. 8742-8831.

[3]———. Battery Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 49, No. 48, Mar. 9, 1984, pp. 9108-9152.

[4]———. Clean Water; Inorganic Chemicals Manufacturing Point Source Category Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 49, No. 164, Aug. 22, 1984, pp. 33402-33429.

[5]Metal Bulletin (London). No. 6940, Nov. 23, 1984, p. 13.

[6]———. No. 6957, Jan. 29, 1985, p. 10.

[7]Mining Magazine (London). El Toqui, Chile, On Stream. V. 150, No. 2, Feb. 1984, pp. 121-123.

[8]Jain, N. C., and K. C. Rakesh. Rajpura-Dariba Lead-Zinc Mine. Min. Mag. (London), v. 150, No. 1, Jan. 1984, pp. 22-31.

[9]Business In Thailand. Padaeng Zinc Refinery Opens. V. 16, No. 1, Jan. 1985, pp. 24-29.

[10]Chemical Engineering. V. 91, No. 3, Feb. 6, 1984, p. 12.

[11]Chemical Week. Low-Cadmium H_3PO_4 for Fertilizer Use. V. 136, No. 8, Feb. 20, 1985, p. 25.

[12]NASA Tech Briefs. Hot-Dipped Metal Films as Epistaxial Substrates. V. 8, No. 3, Spring 1984, pp. 412-413.

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 is called lime or quicklime. Information on these materials can be obtained in the Fluorspar, 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 primarily 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 and two companies in Michigan. Synthetic calcium chloride was manufactured by one company in Louisiana, one company 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, 6 responded, representing an estimated 19% of the total production shown in table 1. Production for the five nonrespondents was estimated using prior year production levels and information gathered from trade journals and research reports adjusted by economic trends and other guidelines.

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. 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 began a second operation near Cadiz Lake. Total output in California increased by 20%. 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. Estimated total output in Michigan was not directly comparable to that of 1983 because of improved sources of information in 1984. Actual output probably increased slightly. Dow Chemical announced that it will phase out, over the next 2 years, all brine operations at its 80-year-old plant in Midland, MI, and relocate its calcium chloride operations to Ludington, MI.

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 oxide from purchased hydrochloric acid and limestone at its plant near Lake Charles, LA; Reichold Chemicals Inc. recovered synthetic calcium chloride as a byproduct of pentachlorophenol manufacture at Tacoma, WA; and Occidental Chemical Corp. manufactured calcium chloride at Tacoma using limestone and hydrochloric acid. Total output of synthetic calcium chloride was unchanged. Total U.S. capacity for natural and synthetic calcium chloride in all forms, that is, flake, solid, anhydrous, and liquid, converted as necessary to 78% basis, was reported to be 1.5 million short tons per year.[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. Demand in 1984 was estimated to be between 65,000 and 70,000 tons.[3]

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)
1980	581,012	$47,950	230,123	$26,150	811,135	$74,100
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

[e]Estimated.

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 tantalum, uranium, and zirconium 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.

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. The price of calcium-silicon alloy remained unchanged. Yearend published prices and specifications were as follows:

	Value per pound	
	1983	1984
Calcium metal, 1-ton lots, 50-pound full crowns, 10 by 18 inches, Ca+Mg 99.5%, Mg 0.7%	$3.05	$3.25
Calcium-silicon alloy, 32% calcium, carload lots, f.o.b. shipping point	.72	.72

Source: Metals Week. V. 55, No. 1, Jan. 2, 1984, p. 5; Metals Week. V. 55, No. 53, Dec. 31, 1984, 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 air-tight 55-gallon steel drum.

Calcium chloride was sold as flake or pellet averaging about 75% $CaCl_2$, or as a liquid concentrate averaging 40% $CaCl_2$. Yearend 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. 226, No. 27, Dec. 31, 1984, p. 21.

FOREIGN TRADE

Calcium chloride was exported to 52 countries and territories. Exports of calcium phosphates were 40,000 tons valued at $33 million compared with 48,000 tons valued at about $33 million in 1983. The leading destinations, in descending order, were Mexico, Venezuela, Taiwan, and Canada, with material sent to a total of 54 countries and territories.

Exports of other calcium compounds, including precipitated calcium carbonate, totaled 37,000 tons valued at $17 million compared with 20,000 tons valued at $13.7 million in 1983. Material in this category was sent to 64 countries, mainly to in descending order, Mexico, the Netherlands, the United Kingdom, and Canada.

Crude calcium chloride imports increased 61% to 21,800 tons valued at $1.3 million, mainly from Canada. Other calcium chloride imports amounted to 278 tons valued at $476,000, mainly from Canada and the Federal Republic of Germany.

Imports of other calcium compounds included 16,900 tons of calcium carbide valued at $5.6 million from Canada; 4,400 tons of calcium hypochlorite valued at $5.4 million from Japan; 275,000 tons of crude calcium carbonate chalk valued at $1.9 million from the Bahamas; 16,750 tons of calcium carbonate chalk whiting valued at $3.2 million, mainly from France; 10,459 tons of precipitated calcium carbonate valued at $4.2 million, primarily from, in descending order, the United Kingdom, France, and Japan; and 170,000 tons of calcium nitrate valued at $17.6 million, mainly from Norway.

Calcium metal was imported from four countries. China supplied 179,897 pounds; Canada, 54,539 pounds; France, 12,332 pounds; and Switzerland, 2,205 pounds. U.S. import duties in effect during the year for calcium metal were 5.3% 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.

The U.S. International Trade Commission was conducting a final antidumping investigation under section 735(b) of the Tariff Act of 1930 concerning imports of calcium hypochlorite from Japan. The investigation was a result of an affirmative preliminary determination by the U.S. Department of Commerce that imports of calcium hypochlorite from Japan were being sold in the United States at less than fair value. The investigation was requested in a petition filed by Olin of Stanford, CT.

Table 2.—U.S. exports of calcium chloride, by country

Country	1983		1984	
	Short tons	Value	Short tons	Value
Brazil	461	$149,985	209	$67,916
Cameroon	3,768	623,076	885	277,159
Canada	18,382	2,435,362	20,976	2,658,345
Egypt	442	49,161	816	7,086,176
Mexico	454	138,009	295	113,470
Netherlands	1,660	1,742,495	2,340	7,634,897
Norway	--	--	1,453	344,531
Saudi Arabia	4,922	921,967	27	29,098
Sweden	37	16,873	1,541	752,141
Trinidad and Tobago	1,104	483,107	895	323,492
United Arab Emirates	4,916	1,764,269	2,364	377,780
United Kingdom	751	159,687	606	203,065
Venezuela	2,619	373,233	474	221,441
Other	r1,081	r693,103	1,181	478,150
Total	40,597	9,550,327	34,062	20,567,661

rRevised.

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]
1980	227,814	$581,525	46,439	$2,071,463
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	r1,317,016
1984	248,973	669,586	22,078	1,816,915

rRevised.
[1]U.S. Customs, insurance, freight.

Source: Bureau of the Census.

Table 4.—U.S. imports for consumption of calcium chloride, by country

Country	1983		1984	
	Short tons	Value[1]	Short tons	Value[1]
Canada	9,099	$603,754	18,320	$1,188,591
Germany, Federal Republic of	67	r67,632	87	246,331
Mexico	4,584	156,713	2,424	69,753
Sweden	--	--	1,214	261,761
Other	34	r488,917	33	50,479
Total	13,784	r1,317,016	22,078	1,816,915

rRevised.
[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.

Canada, with a calcium chloride capacity of approximately 170,000 tons, has produced about 120,000 tons per year.

[1]Physical scientist, Division of Industrial Minerals.
[2]Chemical Marketing Reporter. V. 225, No. 24, June 11, 1984, p. 57.
[3]———. V. 226, No. 17, Oct. 22, 1984, p. 45.

Cement

By Wilton Johnson[1]

U.S. cement production and consumption increased to near record high levels, reflecting a growth of building and construction activity and continuing improvement in the U.S. economy. According to the U.S. Department of Commerce, new construction put in place increased 19% to $312 billion. Housing starts increased only slightly, from 1.70 million units in 1983 to 1.75 million units in 1984. Public buildings, highways and streets, and other public construction accounted for the bulk of construction activity.

Imports, a sensitive indicator of domestic cement demand, increased 107% to 8.8 million short tons, the second highest level in U.S. history. Clinker imports were 25% of the total.

Shipments of portland and masonry cement from U.S. plants, excluding Puerto Rico, increased 13% to 80 million tons. Shipments increased to all geographical regions. The following regions had the largest consumption gains: Pacific, 26%; New England, 21%; and South Atlantic, 20%.

Plant modernization and expansion in California and Texas added about 700,000 tons of new cement production capacity. Three plants that were idled in Colorado, Illinois, and Wisconsin in 1983 resumed production.

Acquisition of U.S. cement plants by foreign firms continued. By yearend, approximately 30% of clinker and 32% 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 145 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)

	1980	1981	1982	1983	1984
United States:[1]					
Production[2]	75,224	71,710	63,355	70,420	77,700
Shipments from mills[2 3]	76,242	71,748	64,066	r70,933	80,166
Value[2 3 4] thousands	$3,886,488	r$3,723,096	$3,263,585	r$3,543,324	$4,152,258
Average value per ton[2 3 4]	$50.98	$51.89	$50.94	$49.95	$51.80
Stocks at mills,[2] Dec. 31	6,825	7,372	6,753	6,711	6,866
Exports	186	300	201	118	80
Imports for consumption	5,244	3,963	2,911	4,221	8,689
Consumption, apparent[5 6]	77,599	73,321	65,623	r73,435	84,313
World: Production	r973,458	r977,181	972,498	p1,008,418	e1,058,721

eEstimated. pPreliminary. rRevised.
[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 145 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. 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, increased 8% to 68.9 million tons, and clinker imports reported by U.S. cement producers increased 154% to 1.9 million tons. A total of 74.4 million tons of portland cement was ground in the United States. Stocks at mills increased by 116,000 tons to 6.4 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 10.7% to 0.3%. The five largest producers provided 33% of total clinker production; the 10 largest producers provided a combined total of 54%. The 10 largest companies, in terms of clinker production, were Lone Star Industries Inc., General Portland Inc., Ideal Basic Industries Inc., Southwestern Portland Cement Co., Lehigh Portland Cement Co., Kaiser Cement Corp., Gifford-Hill & Co., Cal Mat Co., Dundee Cement Co., and National Gypsum Co.

At yearend, 272 kilns located at 130 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 90.3 million tons. An average of 38 days downtime was reported for kiln maintenance and replacing refractory brick. The industry operated at 76% of its apparent capacity. Average annual clinker capacity of U.S. kilns was 332,000 tons, average plant capacity was 695,000 tons, and average company capacity was about 2.0 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 essentially unchanged at 104 million tons.

Clinker was produced by wet-process kilns at 56 plants and by dry-process kilns at 69 plants; 5 additional plants operated both wet- and dry-process kilns. Although the trend toward plant modernization and expansion continued at a much lower level than in past years, most work focused on the installation of dry-process kilns equipped with preheaters or precalciner systems. At yearend 1984, there were 57 suspension and 20 grate preheaters in operation.

Capacity Added in 1984.—National Portland Cement Co. of Florida Inc. doubled the capacity of its grinding facility to 700,000 tons per year. Cement clinker is obtained from France and Spain.

Southwestern Portland Cement completed expansion and modification work on its Victorville, CA, clinker production plant, increasing its capacity from 1.1 to 1.4 million tons.

Capitol Cement Corp. added a new 500,000-ton-per-year dry-process line at its plant in San Antonio, TX, increasing the clinker production capacity to 830,000 tons per year.

Gifford-Hill completed its modernization and expansion work on the preheater kiln system at its Harleyville, SC, plant, increasing its annual clinker production capacity from 550,000 to 600,000 tons.

Capacity Additions Planned.—Beehive Cement Co. was seeking financing to construct a 550,000-ton-per-year cement plant at Santaquin, UT.

Box-Crow Cement Co., formerly Dal-Tex Cement Corp., continued construction of a 1-million-ton-per-year cement plant near Midlothian, TX.

Florida Crushed Stone Co. continued planning for construction of its 600,000-ton-per-year cement plant in Brooksville, FL. Start of construction, originally scheduled for 1983, was delayed while financing and permits were obtained.

Gifford-Hill continued to evaluate plans for a 2-million-ton-per-year-capacity expansion of its Oro Grande, CA, cement plant. Plans included installation of new secondary crushing, preblending, and raw mill facilities; homogenizing silos; a preheater-precalciner kiln; clinker storage; and a cement mill. The company was also planning an expansion of its Clarkdale, AZ, plant.

Plant Closings.—General Portland closed its Miami, FL, cement plant indefinitely and signed a cement supply contract with a foreign cement importer, Eagle Cement Corp.

Genstar Cement and Lime Co.'s San Andreas, CA, plant remained closed throughout the year.

Ideal Basic Industries curtailed kiln operations at its Theodore, AL, plant to facilitate equipment changes to accommodate new source raw materials.

Corporate Changes.—Ash Grove Cement Co. changed the name of its wholly owned subsidiary, Oregon Portland Cement Co., to Ash Grove Cement West Inc.

Blue Circle Industries PLC of the United Kingdom acquired Melwire Inc., a San Diego, CA, importer, and moved its headquarters to Phoenix, AZ. The move was designed to supply cement markets in Phoenix and Tucson, AZ, and in San Diego, Los Angeles, and the San Fernando Valley, CA.

California Portland Cement Co. of Los Angeles, CA, merged with Conrock Co., a large Los Angeles-based rock products and concrete company, to form a new firm called Cal Mat Co.

Coplay Cement Manufacturing Co. of Nazareth, PA, acquired Louisville Cement Co., including plants located in Logansport and Speed, IN.

Giant Portland Cement Co. of Columbia, SC, acquired controlling interest in Keystone Portland Cement Co.

Independent Cement Corp. acquired Lone Star Industries' Catskill, NY, cement plant and four distribution terminals and an oceangoing barge.

Kaiser Cement wrote off its $50 million investment in China Cement Co., its Hong Kong joint venture.

Lone Star Industries sold its Seattle, WA, cement plant to Ash Grove Cement. It also acquired 50% interest in Pacific Coast Cement Corp., a Long Beach, CA, import terminal.

SME Industries Inc. acquired the Zanesville, OH, cement plant and West Virginia and Ohio terminals of Columbia Cement Corp. and formed the Columbia Portland Cement Co.

Southwestern Portland Cement acquired Martin Marietta Corp.'s final two plants in Lyons, CO, and Leamington, UT.

Table 2.—Portland cement production, capacity, and stocks in the United States, by district[1]

District	1983					1984				
	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	2,914	4,018	72.5	293	6	3,198	4,199	76.2	248
Pennsylvania, eastern	8	4,103	4,848	84.6	351	9	4,476	5,102	87.7	371
Pennsylvania, western	4	997	2,441	40.8	119	4	1,338	2,441	54.8	131
Maryland, Virginia, West Virginia	5	3,025	3,610	83.8	335	5	3,307	3,880	85.2	255
Ohio	6	1,630	2,603	62.6	212	6	1,508	2,603	57.9	245
Michigan and Wisconsin	7	3,814	7,096	53.7	348	8	5,006	7,375	67.9	512
Indiana and Kentucky	5	2,581	3,862	66.8	282	5	2,772	3,845	72.1	291
Illinois	4	1,889	2,640	71.6	229	4	1,876	2,640	71.1	119
Georgia and Tennessee	4	1,809	2,690	67.2	145	4	2,013	2,483	81.1	144
South Carolina	4	1,976	4,278	46.2	114	3	2,313	3,400	68.0	146
Florida	6	3,344	4,553	73.4	214	6	3,268	4,258	76.7	199
Alabama	6	3,195	5,661	56.4	367	6	3,678	5,523	66.6	390
Arkansas, Louisiana, Mississippi	4	2,327	2,790	83.4	128	4	2,375	2,790	85.1	133
South Dakota	1	593	1,806	32.8	56	1	618	1,806	34.2	50
Iowa	4	1,675	3,001	55.8	307	4	1,763	3,001	58.7	347
Missouri	5	3,541	4,950	71.5	444	5	3,979	4,950	80.4	384
Kansas and Nebraska	7	2,394	4,114	58.2	394	7	2,654	4,019	66.0	319
Oklahoma	3	1,705	2,180	78.2	165	3	1,784	2,080	85.8	217
Texas, northern	9	4,872	5,542	87.9	313	9	5,044	5,489	91.9	353
Texas, southern	10	4,780	7,132	67.0	243	9	5,277	6,870	76.8	256
Idaho, Montana, Utah	6	1,480	2,381	62.2	241	6	1,754	2,365	74.2	234
Colorado and Wyoming	3	1,437	3,112	46.2	103	4	1,767	2,700	65.4	134
Alaska, Oregon, Washington	5	1,719	2,750	62.5	242	6	1,655	2,800	59.1	233
Arizona, Nevada, New Mexico	4	1,970	3,083	63.9	126	4	2,088	3,095	67.5	109
California, northern	3	2,124	3,937	53.9	166	3	2,518	3,937	64.0	235
California, southern	8	5,386	8,893	60.6	305	8	6,204	9,396	66.0	307
Hawaii	2	210	560	37.5	38	2	181	560	32.3	34
Total or average	139	67,490	104,531	64.6	6,280	141	74,414	103,607	71.8	6,396
Puerto Rico	2	927	2,210	41.9	32	2	999	2,210	45.2	33

[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 (10 in 1983 and 11 in 1984) as follows: Alaska (1 in 1984 only), Florida (1), Illinois (1 in 1983 only), Michigan (2), New York (1), Pennsylvania (1 in 1983 and 2 in 1984), Texas (3 in 1983 and 2 in 1984), and Wisconsin (1 in 1983 and 2 in 1984).

[2]Includes cement produced from imported clinker (1983—762,000 tons and 1984—1,938,000 tons).

[3]Grinding capacity based on fineness necessary to grind Types I and II cement, making allowances for downtime required for maintenance.

[4]Includes imported cement shipped by domestic producers. Source of imports withheld to avoid disclosing company proprietary data.

Table 3.—Clinker capacity and production in the United States,[1] by district, as of December 31, 1984

District	Active plants: Process used: Wet	Dry	Both	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	1	--	5	6	11.6	44	3,719	2,991	80.4
Pennsylvania, eastern	2	5	--	7	16	14.6	33	4,843	4,207	86.9
Pennsylvania, western	3	1	--	4	8	6.3	42	2,036	1,382	67.9
Maryland, Virginia, West Virginia	2	3	--	5	15	11.8	36	3,888	3,230	83.1
Ohio	2	3	1	6	11	8.1	42	2,617	1,445	55.2
Michigan and Wisconsin	2	2	--	4	13	16.9	40	5,494	3,928	71.5
Indiana and Kentucky	2	3	--	5	10	11.7	41	3,788	2,651	70.0
Illinois	--	4	--	4	8	8.5	40	2,759	1,748	63.4
Georgia and Tennessee	1	2	1	4	7	7.1	33	2,355	2,013	85.5
South Carolina	2	1	--	3	7	7.3	31	2,437	2,240	91.9
Florida	4	1	--	5	8	10.5	35	3,466	2,982	86.0
Alabama	1	5	--	6	8	13.8	38	4,508	3,427	76.0
Arkansas, Louisiana, Mississippi	4	--	--	4	8	7.7	28	2,593	2,086	80.4
South Dakota	--	--	1	1	4	3.3	45	1,056	538	50.9
Iowa	1	3	--	4	8	8.8	42	2,844	1,679	59.0
Missouri	2	3	--	5	7	14.3	41	4,637	4,030	86.9
Kansas and Nebraska	4	3	--	7	18	10.6	42	3,425	2,534	74.0
Oklahoma	1	2	--	3	7	5.5	26	1,862	1,709	91.8
Texas, northern	5	4	--	9	24	14.9	27	5,029	4,696	93.4
Texas, southern	2	4	1	7	9	15.2	39	4,954	4,155	83.9
Idaho, Montana, Utah	5	1	--	6	10	6.9	40	2,243	1,758	78.4
Colorado and Wyoming	2	2	--	4	7	6.6	39	2,153	1,734	80.5
Alaska, Oregon, Washington	3	2	--	5	8	5.3	37	1,737	1,338	77.0
Arizona, Nevada, New Mexico	--	4	--	4	11	8.2	28	2,761	1,990	72.1
California, northern	--	3	--	3	3	9.2	43	2,962	2,467	83.3
California, southern	1	6	1	8	29	29.5	41	9,570	5,710	59.7
Hawaii	1	1	--	2	2	1.8	40	585	204	34.9
Total or average	56	69	5	130	272	276.0	38	90,321	68,872	76.3
Puerto Rico	2	--	--	2	9	7.4	100	1,960	861	43.9

[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
1983:				
Less than 1,150	23	37	19,207	[r]6.9
1,150 to 1,700	33	63	49,075	17.5
1,700 to 2,300	25	50	51,952	[r]18.5
2,300 to 2,800	22	48	55,579	19.9
2,800 and over	27	80	104,309	37.2
Total	130	278	280,122	100.0
1984:				
Less than 1,150	25	44	21,334	7.5
1,150 to 1,700	28	47	38,708	13.7
1,700 to 2,300	29	55	55,077	19.4
2,300 to 2,800	22	47	54,797	19.3
2,800 and over	28	88	113,532	40.1
Total	132	281	283,448	100.0

[r]Revised.
[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	1982	1983	1984
Calcareous:			
Limestone (includes aragonite, marble, chalk)	71,307	73,075	78,484
Cement rock (includes marl)	18,593	21,644	27,010
Coral	1,773	2,030	1,103
Argillaceous:			
Clay	5,007	5,736	6,045
Shale	3,282	3,011	3,087
Other (includes staurolite, bauxite, aluminum dross, pumice, alumina, volcanic material, other)	209	118	47
Siliceous:			
Sand and calcium silicate	1,568	1,669	1,958
Sandstone, quartzite, other	508	691	696
Ferrous: Iron ore, pyrites, millscale, other iron-bearing material	958	1,058	1,232
Other:			
Gypsum and anhydrite	3,148	3,474	3,967
Blast furnace slag	69	49	27
Fly ash	550	870	841
Other, n.e.c	108	103	296
Total	107,080	113,528	124,793

[1]Includes Puerto Rico.

MASONRY CEMENT

Production of masonry cement increased 12% to 3.3 million tons. At yearend, 95 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	1983			1984		
	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	66	11	4	77	14
Pennsylvania, eastern	6	205	35	6	240	31
Pennsylvania, western	3	68	12	3	68	12
Maryland, Virginia, West Virginia	5	256	27	5	276	27
Ohio	4	98	21	4	103	23
Michigan and Wisconsin	5	165	43	5	206	55
Indiana and Kentucky	4	343	58	5	393	69
Illinois	1	W	W	2	W	W
Georgia and Tennessee	4	150	21	4	171	24
South Carolina	3	256	22	2	W	W
Florida	5	305	24	5	390	20
Alabama	5	205	28	7	236	29
Arkansas, Louisiana, Mississippi	4	99	12	3	97	8
South Dakota	1	2	1	1	6	2
Iowa	3	32	9	3	40	8
Missouri	3	137	18	3	143	23
Kansas and Nebraska	6	70	32	6	71	32
Oklahoma	3	46	5	3	52	9
Texas, northern	7	214	17	7	219	18
Texas, southern	5	67	10	5	73	9
Idaho, Montana, Utah	3	6	5	4	7	6
Colorado and Wyoming	2	W	W	2	W	W
Alaska, Oregon, Washington	3	5	4	1	W	W
Arizona, Nevada, New Mexico	3	85	5	3	95	7
California, southern	1	W	W	1	W	W
Hawaii	2	6	2	2	5	2
Other	--	44	9	--	318	42
Total or average	95	[2]2,930	431	96	[3]3,286	470

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes imported cement.
[2]Includes 2,641,000 tons produced from clinker and 289,000 tons produced from cement.
[3]Includes 2,987,000 tons produced from clinker and 308,000 tons produced from cement.

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

The trend toward energy conservation continued with most plant modernization and expansion programs featuring the installation of dry-process preheater-precalciner systems to promote energy efficiency.

Approximately 80% 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 decreased 4% to 4.7 million British thermal units (Btu).

The average consumption of electrical energy decreased slightly from 142.1 kilowatt hours per ton in 1983 to 140.3 kilowatt hours per ton in 1984. 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 5.9 million Btu per ton.

Average fuel consumption for kiln firing in wet-process plants, 5.3 million Btu per ton, was 26% higher than average fuel consumption in dry-process plants, 4.2 million Btu per ton. Approximately 58% of clinker production was by the dry process.

Kilns without preheaters averaged 5.1 million Btu per ton of clinker produced; those with suspension preheaters averaged 3.6 million Btu per ton; and those with grate-type preheaters averaged 4.7 million Btu per ton.

Coal accounted for 94% of kiln fuel consumption, natural gas accounted for 4%, and oil accounted for the remainder.

Energy-saving additives used in cement production such as fly ash and blast furnace slags declined. The use of fly ash decreased 3% to 841,000 tons following a 58% increase in 1983. The use of slags declined 45% to 27,000 tons, the fifth consecutive year of decline following the peak consumption year of 1979.

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)
1983:						
Coal	20	9,970	15.5	2,177	--	--
Oil	--	--	--	--	--	--
Natural gas	1	61	.1	--	--	235,532
Coal and oil	32	16,157	25.0	2,899	632	--
Coal and natural gas	58	27,778	43.1	4,829	--	10,716,278
Oil and natural gas	1	108	.2	--	164	24,572
Coal, oil, natural gas	18	10,415	16.1	1,774	579	3,496,708
Total	130	64,489	100.0	11,679	1,375	14,473,090
1984:						
Coal	26	12,923	18.5	2,822	--	--
Oil	--	--	--	--	--	--
Natural gas	--	--	--	--	--	--
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

[1]Includes Puerto Rico.
[2]Includes 95.8% bituminous coal and 4.2% petroleum coke in 1983; 0.6% anthracite coal, 94.7% bituminous coal, and 4.7% petroleum coke in 1984.

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)
1983:						
Wet	59	25,373	39.3	5,297	536	5,208,394
Dry	66	36,310	56.3	5,865	834	7,095,044
Both	5	2,806	4.4	517	5	2,169,652
Total	130	64,489	100.0	11,679	1,375	14,473,090
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

[1]Includes Puerto Rico.
[2]Includes 95.8% bituminous coal and 4.2% petroleum coke in 1983; 0.6% anthracite coal, 94.7% bituminous coal, and 4.7% petroleum coke in 1984.

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)
1983:								
Wet	--	--	60	3,543	3,543	36.4	26,793	132.2
Dry[2]	4	350	76	5,383	5,733	59.0	38,686	148.2
Both	--	--	5	449	449	4.6	2,938	152.8
Total or average	4	350	141	9,375	9,725	100.0	68,417	142.1
Percent of total electric energy used	--	3.6	--	96.4	--	--	--	--
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	--	--	--	--

[1]Includes Puerto Rico. Includes grinding plants and white cement facilities.
[2]Includes data for grinding plants.

TRANSPORTATION

U.S. shipments of portland cement to consumers were primarily in bulk (94%); by truck (95%); and made directly from cement manufacturing plants (69%), rather than from distribution terminals. This pattern of cement transport did not differ significantly from that of recent years.

With respect to shipments of cement from plants to terminals, the preferred modes of transportation were railroads (42%) and waterways (38%); transportation by truck accounted for 19%. Cement used at producing plants accounted for the remaining 1%.

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				Total shipments
			From terminal to consumer		From plant to consumer		
	In bulk	In containers	In bulk	In containers	In bulk	In containers	
1983:							
Railroad	8,316	103	229	285	2,959	46	3,519
Truck	2,148	125	18,205	571	42,770	3,444	64,990
Barge and boat	6,900	91	72	--	171	15	258
Unspecified[2]	530	--	67	2	103	3	175
Total	17,894	319	18,573	858	46,003	3,508	[3]68,942
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	[4] [5]77,881

[1]Includes Puerto Rico and imported cement shipped by domestic producers.
[2]Includes cement used at plant.
[3]Bulk shipments were 93.7%, and container (bag) shipments were 6.3%.
[4]Bulk shipments were 94.5%, and container (bag) shipments were 5.5%.
[5]Data do not add to total shown because of independent rounding.

CONSUMPTION AND USES

Cement consumption in the United States, excluding Puerto Rico, increased 15% to 84.3 million tons. The increase in cement demand reflected increased activity in the construction industry and improvement of the U.S. economy. Domestic producers' shipments increased 13% to 80.2 million tons, which included 2.5 million tons of imported cement. Additional imports of 4.0 million tons were shipped by certain other importers and accounted for the difference between consumption and domestic shipments.

Domestic shipments of cement to all regions of the United States increased. Regions registering the largest increases were Pacific (26%), New England (21%), and South Atlantic (20%). Increases in shipments to all other regions ranged from 8% to 16%.

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 69% of the total quantity shipped by domestic producers. Manufacturers of concrete products used 13% of the total to produce concrete blocks, pipe, 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 19% to $312 billion.[3] Of this total value, 43% was in private housing; 25% was in private industrial and commercial building, including farms; 6%

was in public buildings; 5% was in highways and streets; and the remainder was in other public construction.

Total private construction put in place increased 21% to $256 billion. The value of residential units put in place increased 22% to $135 billion, and industrial-commercial construction put in place increased 20% to $121 billion. Total public construction put in place increased 12% to $56 billion; of which, public buildings remained essentially unchanged at $18 billion, highway construction increased 21% to $17 billion, and other public construction increased 11% to $21 billion.

Housing starts were essentially unchanged at 1.75 million units, consisting of 1.08 million single units and 665,000 multiunits, according to the U.S. Department of Commerce. On a regional basis, housing starts decreased 7% in the South to 865,000 units and increased 21% in the Northeast to 203,000 units, 14% in the West to 435,000 units, and 11% in the North Central region to 243,000 units.

Table 11.—Portland cement shipped by producers in the United States, by district[1]

District	1983			1984		
	Quantity (thousand short tons)	Value (thousands)	Average per ton	Quantity (thousand short tons)	Value (thousands)	Average per ton
New York and Maine	2,889	$117,300	$40.60	3,263	$163,527	$50.12
Pennsylvania, eastern	4,107	176,752	43.04	4,427	224,707	50.76
Pennsylvania, western	1,046	41,787	39.95	1,308	56,882	43.49
Maryland, Virginia, West Virginia	3,015	136,833	45.38	3,412	167,064	48.96
Ohio	1,575	71,599	45.46	1,525	69,810	45.78
Michigan and Wisconsin	3,680	165,924	45.09	4,610	208,232	45.17
Indiana and Kentucky	2,061	80,523	39.07	2,351	96,039	40.85
Illinois	1,857	74,975	40.37	1,997	82,622	41.37
Georgia and Tennessee	2,036	85,370	41.93	2,183	102,569	46.99
South Carolina	1,986	83,734	42.16	2,319	103,891	44.80
Florida	3,329	164,048	49.28	3,564	172,548	48.41
Alabama	3,279	150,255	45.82	3,656	167,191	45.73
Arkansas, Louisiana, Mississippi	2,314	119,342	51.57	2,303	119,651	51.95
South Dakota	603	37,435	62.08	619	30,773	49.71
Iowa	1,644	87,836	53.43	1,730	92,699	53.58
Missouri	3,499	157,249	44.94	3,981	178,225	44.77
Kansas and Nebraska	2,298	119,112	51.83	2,689	145,717	54.19
Oklahoma	1,719	83,685	48.68	1,732	84,701	48.90
Texas, northern	5,084	310,839	61.14	5,029	300,613	59.78
Texas, southern	4,676	223,460	47.79	5,394	256,808	47.61
Idaho, Montana, Utah	1,504	79,060	52.57	1,724	94,469	54.80
Colorado and Wyoming	1,470	90,376	61.48	1,738	109,780	63.16
Alaska, Oregon, Washington	1,675	92,570	55.27	1,711	94,916	55.47
Arizona, Nevada, New Mexico	2,053	124,006	60.40	2,209	148,704	67.32
California, northern	2,281	117,660	51.58	2,507	149,566	59.66
California, southern	5,286	303,289	57.38	6,208	370,460	59.67
Hawaii	216	20,673	95.71	186	18,282	98.29
Total or average[2] [3]	67,183	3,315,690	49.35	74,376	3,810,446	51.23
Foreign imports[4]	827	41,317	49.96	2,509	121,935	48.60
Puerto Rico	931	82,509	88.62	997	87,568	87.83
Grand total or average[3]	68,942	3,439,516	49.89	77,881	4,019,948	51.62

[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 (10 in 1983 and 11 in 1984) as follows: Alaska (1 in 1984 only), Florida (1), Illinois (1 in 1983 only), Michigan (2), New York (1), Pennsylvania (1 in 1983 and 2 in 1984), Texas (3 in 1983 and 4 in 1984), and Wisconsin (1 in 1983 and 2 in 1984).

[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	1983 Quantity (thousand short tons)	1983 Value (thousands)	1983 Average per ton	1984 Quantity (thousand short tons)	1984 Value (thousands)	1984 Average per ton
New York and Maine	69	$4,597	$66.62	78	$5,086	$65.21
Pennsylvania, eastern	198	12,298	62.11	226	14,779	65.39
Pennsylvania, western	64	4,797	74.95	71	6,069	85.48
Maryland, Virginia, West Virginia	246	16,974	69.00	273	16,912	61.95
Ohio	97	7,454	76.85	101	8,092	80.12
Michigan and Wisconsin	170	9,807	57.69	216	14,264	66.04
Indiana and Kentucky	331	17,522	52.94	383	21,965	57.35
Illinois	W	W	W	W	W	W
Georgia and Tennessee	160	10,459	65.37	174	12,165	69.91
South Carolina	234	14,182	60.61	W	W	W
Florida	313	19,557	62.48	383	24,624	64.29
Alabama	210	13,417	63.89	259	17,247	66.59
Arkansas, Louisiana, Mississippi	100	6,409	64.09	104	6,738	64.79
South Dakota	4	359	89.75	5	283	56.60
Iowa	37	3,425	92.57	42	3,260	77.62
Missouri	146	7,339	50.27	143	7,033	49.18
Kansas and Nebraska	71	3,778	53.21	70	4,244	60.63
Oklahoma	45	3,074	68.31	49	3,506	71.55
Texas, northern	196	14,184	72.37	202	16,905	83.69
Texas, southern	80	5,520	69.00	89	7,503	84.30
Idaho, Montana, Utah	5	424	84.80	6	416	69.33
Colorado and Wyoming	W	W	W	W	W	W
Alaska, Oregon, Washington	6	598	99.67	W	W	W
Arizona, Nevada, New Mexico	85	5,999	70.58	94	7,013	74.61
California, southern	W	W	W	W	W	W
Hawaii	6	641	106.83	5	792	158.40
Other	45	3,425	76.11	310	20,980	67.68
Total[2] or average	2,921	186,240	63.76	3,281	219,877	67.02
Foreign imports[3]	2	77	38.50	([4])	1	75.62
Grand total or average	2,923	186,317	63.74	3,281	219,878	67.02

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Excludes 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] 1982	Portland cement 1983	Portland cement 1984	Masonry cement 1982	Masonry cement 1983	Masonry cement 1984
Destination:						
Alabama	930	1,088	1,204	64	85	94
Alaska[3]	171	180	197	W	W	W
Arizona	1,245	1,645	2,001	W	W	W
Arkansas	553	655	717	31	41	44
California, northern	2,170	2,608	3,166	([4])	--	W
California, southern	3,864	4,427	6,150	--	W	W
Colorado	1,464	1,478	1,674	24	26	30
Connecticut[3]	611	626	759	13	15	16
Delaware[3]	154	145	164	7	9	11
District of Columbia[3]	139	116	105	2	1	1
Florida	4,081	4,866	6,253	317	396	480
Georgia	1,775	2,256	2,775	145	189	209
Hawaii	229	216	186	6	6	5
Idaho	241	268	276	1	1	1
Illinois	1,085	1,053	1,236	23	28	31
Chicago, metropolitan[3]	1,224	1,188	1,378	31	36	41
Indiana	1,015	1,148	1,248	61	68	76
Iowa	1,158	1,147	1,204	12	12	14
Kansas	956	983	1,243	18	21	23
Kentucky	888	813	973	66	76	81
Louisiana	2,453	2,490	2,650	67	74	80
Maine	198	223	265	8	8	10
Maryland	1,069	1,266	1,351	89	113	129
Massachusetts[3]	991	1,077	1,292	32	34	44
Michigan	1,313	1,457	1,903	58	70	90

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		
	1982	1983	1984	1982	1983	1984
Destination —Continued						
Minnesota[3]	1,112	1,124	1,173	33	38	40
Mississippi	673	716	790	39	51	60
Missouri	1,249	1,383	1,650	29	37	48
Montana	228	264	252	1	2	2
Nebraska	678	715	823	9	11	12
Nevada	405	459	503	--	--	--
New Hampshire[3]	288	260	314	9	8	15
New Jersey[3]	1,235	1,337	1,672	53	56	68
New Mexico	543	598	618	10	12	10
New York, eastern	447	366	488	20	22	31
New York, western	753	746	773	32	36	40
New York, metropolitan[3]	1,072	1,312	1,403	38	51	50
North Carolina	1,379	1,472	1,724	153	196	224
North Dakota[3]	266	317	346	6	6	6
Ohio	2,040	2,311	2,607	99	116	129
Oklahoma	1,857	1,758	1,751	55	66	60
Oregon	573	553	609	1	1	(4)
Pennsylvania, eastern	1,391	1,481	1,649	44	54	57
Pennsylvania, western	816	828	920	59	54	60
Rhode Island[3]	129	147	197	4	3	5
South Carolina	755	858	984	81	106	116
South Dakota	194	274	224	3	4	4
Tennessee	1,055	1,207	1,371	99	127	142
Texas, northern	4,501	4,936	5,466	146	171	182
Texas, southern	4,684	5,138	5,584	97	114	123
Utah	598	792	973	1	1	1
Vermont[3]	110	133	145	4	4	4
Virginia	1,357	1,646	1,946	108	147	166
Washington	1,016	1,077	1,156	6	6	7
West Virginia	457	444	445	30	29	29
Wisconsin	1,048	1,247	1,418	32	36	40
Wyoming	403	380	394	2	2	2
U.S. total	63,289	69,698	80,738	2,378	2,876	3,243
Foreign countries[5]	363	231	190	60	91	103
Puerto Rico	950	920	1,000	--	--	--
Total shipments	64,602	70,849	81,928	2,438	2,967	3,346
Origin:						
United States[6]	61,080	67,183	74,376	2,364	2,921	3,281
Puerto Rico	986	931	997	--	--	--
Foreign:[7]						
Domestic producers	605	827	2,509	17	2	(4)
Others	1,931	1,908	4,046	57	44	65
Total shipments	64,602	70,849	81,928	2,438	2,967	3,346

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 (1982—158,000 tons; 1983—211,000 tons; and 1984—225,000 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]Includes cement produced from imported clinker by domestic producers.
[7]Imported cement distributed by domestic producers, Canadian cement manufacturers, and other importers. Source of imports withheld to avoid disclosing company proprietary data.

Table 14.—Cement shipments,[1] by region and subregion

Region and subregion[2]	Portland cement				Masonry cement			
	Thousand short tons		Percent of grand total		Thousand short tons		Percent of grand total	
	1983	1984	1983	1984	1983	1984	1983	1984
Northeast:								
New England	2,466	2,972	3.5	3.7	72	94	2.5	2.9
Middle Atlantic	6,069	6,905	8.7	8.5	273	306	9.5	9.4
Total	8,535	9,877	12.2	12.2	345	400	12.0	12.3
South:								
Atlantic	13,070	15,747	18.7	19.5	1,186	1,365	41.2	42.1
East Central	3,824	4,338	5.5	5.4	339	377	11.8	11.6
West Central	14,977	16,168	21.5	20.0	466	489	16.2	15.1
Total	31,871	36,253	45.7	44.9	1,991	2,231	69.2	68.8
North Central:								
East	8,404	9,790	12.1	12.1	354	407	12.3	12.6
West	5,943	6,663	8.5	8.3	129	147	4.5	4.5
Total	14,347	16,453	20.6	20.4	483	554	16.8	17.1
West:								
Mountain	5,884	6,691	8.5	8.3	44	46	1.5	1.4
Pacific	9,061	11,464	13.0	14.2	13	12	.5	.4
Total	14,945	18,155	21.5	22.5	57	58	2.0	1.8
Grand total	69,698	80,738	100.0	100.0	2,876	3,243	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 Bureau of the Census.

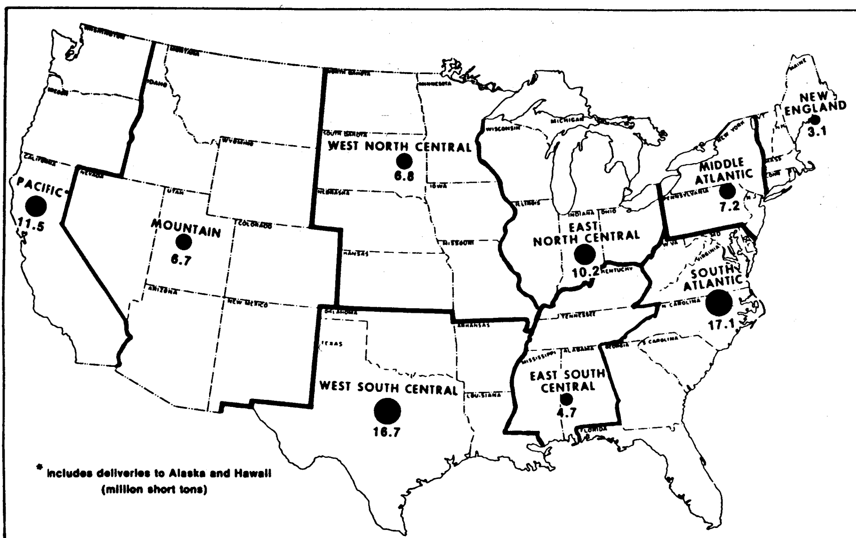

Figure 1.—Shipments of cement by geographic region of destination in 1984.

Table 15.—Portland cement shipments in 1984, by district of origin and type of customer[1]

District of origin	Building material dealers: Quantity (thousand short tons)	Building material dealers: Percent	Concrete product manufacturers: Quantity (thousand short tons)	Concrete product manufacturers: Percent	Ready-mixed concrete: Quantity (thousand short tons)	Ready-mixed concrete: Percent	Highway contractors: Quantity (thousand short tons)	Highway contractors: Percent	Other contractors: Quantity (thousand short tons)	Other contractors: Percent	Federal, State, and other government agencies: Quantity (thousand short tons)	Federal, State, and other government agencies: Percent	Miscellaneous including own use: Quantity (thousand short tons)	Miscellaneous including own use: Percent	Total[2] (thousand short tons)
New York and Maine	209	6.4	575	17.6	2,355	72.2	28	0.9	91	2.8	--	--	5	0.1	3,263
Pennsylvania, eastern	391	8.8	1,057	23.9	2,845	64.3	31	.7	46	1.0	--	--	56	1.3	4,427
Pennsylvania, western	230	17.6	208	15.9	750	57.3	68	5.2	51	3.9	--	--	1	.1	1,308
Maryland, Virginia, West Virginia	178	5.2	539	15.8	2,461	72.1	84	2.5	51	1.5	36	1.1	62	1.8	3,412
Ohio	114	7.5	261	17.1	1,075	70.5	68	4.5	5	.3	--	--	2	.1	1,525
Michigan and Wisconsin	157	3.4	603	13.1	3,501	75.9	218	4.7	95	2.1	7	.2	29	.6	4,610
Indiana and Kentucky	111	4.7	312	13.3	1,711	72.8	119	5.1	38	1.6	1	(3)	60	2.5	2,351
Illinois	53	2.6	227	11.4	1,516	75.9	105	5.3	54	2.7	--	--	42	2.1	1,997
Georgia and Tennessee	151	6.9	610	27.9	1,316	60.3	35	1.6	58	2.7	8	.4	5	.2	2,183
South Carolina	61	2.6	386	16.7	1,735	74.8	68	2.9	22	1.0	17	.7	30	1.3	2,319
Florida	461	12.9	380	10.7	2,462	69.1	69	1.9	131	3.7	13	.4	48	1.3	3,564
Alabama	224	6.1	557	15.2	2,441	66.8	188	5.1	139	3.8	25	.7	83	2.3	3,656
Arkansas, Louisiana, Mississippi	162	7.0	209	9.1	1,313	57.0	124	5.4	322	14.0	15	.6	159	6.9	2,303
South Dakota	11	1.8	35	5.7	298	48.1	123	19.9	103	16.6	--	--	49	7.9	619
Iowa	39	2.3	289	16.7	1,099	63.5	218	12.6	15	.9	--	--	69	4.0	1,730
Missouri	148	3.7	414	10.4	2,844	71.4	409	10.3	74	1.9	--	--	93	2.3	3,981
Kansas and Nebraska	78	2.9	204	7.6	1,941	72.2	229	8.5	158	5.9	2	(3)	78	2.9	2,689
Oklahoma	89	5.1	73	4.2	1,160	67.0	75	4.3	299	17.3	6	.4	30	1.7	1,732
Texas, northern	305	6.1	426	8.5	2,468	49.1	299	5.9	1,344	26.7	30	.6	157	3.1	5,029
Texas, southern	285	5.3	492	9.1	3,628	67.3	173	3.2	718	13.3	19	.3	80	1.5	5,394
Idaho, Montana, Utah	54	3.1	106	6.1	1,261	73.1	57	3.3	236	13.7	1	.1	10	.6	1,724
Colorado and Wyoming	53	3.1	152	8.7	1,330	76.5	32	1.8	170	9.8	--	--	1	.1	1,738
Alaska, Oregon, Washington	41	2.4	135	7.9	1,380	80.6	94	5.5	28	1.6	--	--	34	2.0	1,711
Arizona, Nevada, New Mexico	94	4.3	312	14.1	1,498	67.8	21	.9	242	11.0	3	.1	39	1.8	2,209
California, northern	188	7.5	318	12.7	1,834	73.1	34	1.4	113	4.5	1	(3)	20	.8	2,507
California, southern	462	7.4	904	14.6	4,415	71.1	39	.6	303	4.9	6	.1	79	1.3	6,208
Hawaii	14	7.5	24	12.9	134	72.1	--	--	14	7.5	--	--	--	--	186
Foreign imports[4]	25	1.0	--	--	2,484	99.0	--	--	--	--	--	--	--	--	2,509
Total[2] or average	4,389	5.7	9,807	12.8	53,254	69.3	3,007	3.9	4,919	6.4	190	.2	1,319	1.7	76,884
Puerto Rico	477	47.9	62	6.2	440	44.1	--	--	16	1.6	--	--	2	.2	997

[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	1983			1984		
	Quantity (thousand short tons)	Value[2] (thousands)	Average per ton	Quantity (thousand short tons)	Value[2] (thousands)	Average per ton
General use and moderate heat (Types I and II)	62,549	$3,044,691	$48.68	70,648	$3,576,736	$50.63
High-early-strength (Type III)	2,331	120,251	51.59	2,505	136,375	54.44
Sulfate-resisting (Type V)	423	22,065	52.16	479	25,633	53.51
Oil well	1,993	136,411	68.45	2,273	133,760	58.85
White	249	38,172	153.30	278	46,987	169.02
Portland slag and portland pozzolan	691	35,312	51.10	808	43,960	54.41
Expansive	45	3,316	73.69	50	3,909	78.18
Miscellaneous[3]	662	39,299	59.36	839	52,588	62.68
Total[4] or average	68,942	3,439,516	49.89	77,881	4,019,948	51.62

[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 increased 4%, the first increase following 2 consecutive years of decline. The average reported unit mill value of masonry cement prepared at cement plants increased 5%, following a 4% average annual rate of increase from 1980 to 1983.

According to Engineering News-Record (ENR), yearend prices of bulk portland cement for 20 U.S. cities averaged $63.74 per ton.[3] This was 24% 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 $76.15 per ton for Denver, CO.

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
1980	$50.89	$62.11	$51.32
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

[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

This section contains U.S. trade data reported by the U.S. Department of Commerce, Bureau of the Census. Import and export totals contain data for the United States plus U.S. possessions and territories.

Exports of hydraulic cement and clinker decreased 32% to 80,000 tons, the third consecutive year of decline and the lowest level since 1978. 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 59 other countries.

Imports of hydraulic cement and clinker increased 107% to 8.8 million tons, the highest level since 1979. Canada supplied 33% of the total followed by Mexico, 23%; Spain, 20%; Venezuela, 12%; and 19 other countries, 12%. Cement imports accounted for about 10% of apparent U.S. consumption.

Imports of white nonstaining portland cement increased 58% to 252,000 tons. Six countries, Belgium-Luxembourg, Canada, Denmark, Mexico, Spain, and Venezuela, accounted for 92% of white cement imports.

Imports of clinker increased 120% to 2.2 million tons. Three countries, Canada, Mexico, and Spain, accounted for 67% of clinker imports.

Table 18.—U.S. exports of hydraulic cement and cement clinker, by country

Country	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Bahamas	515	$70	220	$43	118	$31
Canada	134,340	18,748	106,011	12,183	72,409	10,704
Chile	468	156	61	36	102	43
Colombia	255	101	302	152	133	41
Dominican Republic	249	139	196	126	241	63
Mexico	54,878	5,145	6,121	2,921	3,464	1,525
Norway	38	22	95	55	132	77
Peru	428	79	24	34	104	56
Trinidad	--	--	1,489	230	2,002	247
Other[1]	r12,195	r2,996	r3,875	r1,579	1,302	709
Total[2]	203,366	27,456	118,393	17,360	80,007	13,496

r Revised.
[1]Includes 50 countries in 1982, 40 in 1983, and 52 in 1984.
[2]Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

Table 19.—U.S. imports for consumption of hydraulic cement and clinker, by country

(Thousand short tons and thousand dollars)

Country	1982 Quantity	1982 Value Customs	1982 Value C.i.f.[1]	1983 Quantity	1983 Value Customs	1983 Value C.i.f.[1]	1984 Quantity	1984 Value Customs	1984 Value C.i.f.[1]
Canada	2,074	76,798	82,432	2,201	86,198	92,851	2,945	116,815	128,920
Colombia	1	65	74	68	3,345	4,169	227	5,133	6,927
France	131	6,058	6,296	153	6,435	7,507	225	7,044	9,180
Japan	87	3,153	4,519	([2])	100	118	183	5,237	7,595
Korea, Republic of	19	748	757	69	3,228	4,144	332	10,046	12,129
Mexico	132	6,154	6,228	826	30,844	33,539	2,003	64,574	74,877
Spain	245	8,626	11,891	737	23,833	29,303	1,760	49,584	61,218
Venezuela	--	--	--	60	1,705	2,138	1,022	25,281	32,224
Other	r241	r9,284	r12,715	r154	r5,751	r7,756	149	10,493	10,412
Total	[3]2,929	110,886	124,912	4,268	161,439	181,525	8,846	294,207	343,482

r Revised.
[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.

Table 20.—U.S. imports for consumption of clinker, by country

(Thousand short tons and thousand dollars)

Country	1982 Quantity	1982 Value Customs	1982 Value C.i.f.[1]	1983 Quantity	1983 Value Customs	1983 Value C.i.f.[1]	1984 Quantity	1984 Value Customs	1984 Value C.i.f.[1]
Canada	320	11,326	12,621	446	14,786	16,534	485	16,947	19,406
France	130	6,057	6,296	152	6,389	7,439	225	7,491	9,180
Japan	--	--	--	--	--	--	69	2,927	2,693
Mexico	20	995	995	192	6,899	7,373	477	11,608	13,077
Spain	--	--	--	214	5,559	6,437	523	11,885	14,860
Other	([2])	7	8	--	--	--	435	8,942	11,419
Total[3]	470	18,385	19,920	1,005	33,633	37,784	2,215	59,801	70,635

[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.

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	1983			1984		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Anchorage: Canada	36	1,871	2,302	82	4,839	5,607
Baltimore:						
Denmark	--	--	--	6	444	831
Japan	--	--	--	(2)	17	23
Netherlands	(2)	(2)	(2)	(2)	2	2
United Kingdom	(2)	5	6	--	--	--
Total	(2)	5	6	6	463	856
Boston: Canada	--	--	--	10	320	335
Bridgeport: Canada	--	--	--	1	22	22
Buffalo: Canada	650	26,635	30,207	713	27,643	30,438
Chicago:						
Belgium-Luxembourg	--	--	--	(2)	10	11
Canada	(2)	4	4	--	--	--
Germany, Federal Republic of	--	--	--	(2)	15	20
Japan	(2)	12	15	(2)	1	1
Yugoslavia	--	--	--	(2)	5	7
Total	(2)	16	19	(2)	31	39
Cleveland: Yugoslavia	--	--	--	(2)	4	8
Detroit:						
Belgium-Luxembourg	(2)	12	15	(2)	6	7
Canada	314	16,339	17,095	293	18,588	19,243
Netherlands	--	--	--	(2)	7	9
Total[3]	314	16,350	17,110	293	18,601	19,259
Duluth: Canada	92	3,200	3,654	156	5,077	6,312
El Paso: Mexico	173	7,660	7,660	318	11,683	11,683
Great Falls: Canada	3	290	290	2	130	130
Honolulu:						
Japan	--	--	--	6	341	511
Korea, Republic of	37	2,398	2,824	18	1,604	1,714
Total	37	2,398	2,824	24	1,945	2,225
Houston:						
China	1	102	152	--	--	--
Colombia	4	141	180	42	830	1,316
Germany, Federal Republic of	--	--	--	(2)	62	76
Italy	--	--	--	29	964	985
Mexico	86	2,442	2,870	124	2,654	3,250
Spain	164	4,074	4,864	230	5,987	6,767
Sweden	(2)	5	7	--	--	--
Yugoslavia	(2)	59	74	(2)	80	126
Total[3]	255	6,822	8,147	425	10,577	12,520
Laredo:						
Canada	--	--	--	(2)	1	1
Mexico	81	2,926	2,926	88	3,210	3,210
Venezuela	--	--	--	1	5	5
Yugoslavia	--	--	--	(2)	51	90
Total	81	2,926	2,926	89	3,267	3,306
Los Angeles:						
Australia	46	W	W	--	--	--
Germany, Federal Republic of	--	--	--	(2)	10	15
Japan	--	--	--	24	631	775
Korea, Republic of	--	--	--	243	6,550	8,027
Spain	39	W	W	107	2,823	3,764
Yugoslavia	1	W	W	1	81	198
Total[3]	87	2,727	3,903	375	10,095	12,779
Miami:						
Bahamas	--	--	--	2	68	90
Belgium-Luxembourg	3	223	371	3	220	1,671
Colombia	39	1,050	1,397	--	--	--

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	1983 Quantity	1983 Value Customs	1983 Value C.i.f.[1]	1984 Quantity	1984 Value Customs	1984 Value C.i.f.[1]
Miami —Continued						
Costa Rica	([2])	1	2	--	--	--
Denmark	23	792	995	--	--	--
France	([2])	1	1	--	--	--
Mexico	175	5,565	6,574	279	8,460	10,876
Spain	146	3,690	4,819	284	7,257	9,583
Venezuela	57	1,550	1,951	230	5,984	7,362
Total[3]	443	12,871	16,111	798	21,989	29,582
Milwaukee: Canada	94	2,909	3,361	93	2,844	3,159
Mobile:						
Canada	--	--	--	([2])	3	3
Colombia	5	175	222	--	--	--
Spain	--	--	--	78	1,725	2,464
Venezuela	--	--	--	104	1,778	2,672
Total	5	175	222	182	3,506	5,139
New Orleans:						
Canada	21	1,083	1,463	182	8,151	11,084
Colombia	--	--	--	16	301	506
France	--	--	--	76	1,727	2,383
Mexico	29	820	967	216	4,780	6,033
Spain	--	--	--	65	2,029	2,620
Venezuela	--	--	--	81	2,001	2,780
Total[3]	50	1,902	2,430	636	18,989	25,406
New York City:						
Canada	--	--	--	44	1,406	1,587
France	--	--	--	27	447	572
Germany, Federal Republic of	([2])	2	2	--	--	--
Italy	--	--	--	([2])	4	6
Norway	24	605	788	--	--	--
Spain	184	4,842	6,137	413	12,010	14,994
Venezuela	--	--	--	131	2,449	2,914
Total[3]	208	5,448	6,927	615	16,316	20,073
Nogales: Mexico	50	2,162	2,162	157	7,097	7,361
Norfolk:						
Canada	--	--	--	([2])	3	3
France	26	2,739	3,536	28	3,001	3,475
Germany, Federal Republic of	([2])	3	6	--	--	--
Mexico	([2])	1	1	--	--	--
Venezuela	--	--	--	28	732	979
Total[3]	26	2,743	3,544	56	3,736	4,457
Ogdensburg: Canada	246	7,918	7,918	415	13,168	13,178
Pembina: Canada	46	2,340	2,340	65	3,390	3,390
Philadelphia: Germany, Federal Republic of	--	--	--	([2])	3	7
Port Arthur: Colombia	--	--	--	20	345	462
Portland, ME: Canada	10	329	329	21	763	763
Portland, OR:						
Canada	--	--	--	42	1,695	1,857
Japan	([2])	36	37	([2])	40	42
Yugoslavia	([2])	5	10	--	--	--
Total[3]	([2])	40	47	42	1,735	1,899
Providence:						
Canada	--	--	--	4	107	358
Venezuela	--	--	--	10	413	687
Total	--	--	--	14	520	1,045
St. Albans: Canada	582	18,567	18,570	571	18,101	18,139
San Diego:						
Colombia	--	--	--	40	652	462
Japan	--	--	--	94	2,241	3,648

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	1983 Quantity	1983 Value Customs	1983 Value C.i.f.[1]	1984 Quantity	1984 Value Customs	1984 Value C.i.f.[1]
San Diego —Continued						
Korea, Republic of	32	830	1,320	--	--	--
Mexico	159	7,043	7,751	451	15,581	19,121
Venezuela	--	--	--	7	139	259
Total	191	7,873	9,071	592	18,613	23,490
San Francisco:						
Germany, Federal Republic of	--	--	--	(2)	7	9
Japan	(2)	46	55	60	2,298	2,559
Korea, Republic of	--	--	--	71	1,892	2,389
Sweden	--	--	--	(2)	8	10
Total	(2)	46	55	131	4,205	4,967
San Juan, PR:						
Barbados	--	--	--	5	240	294
Belgium-Luxembourg	8	665	1,013	9	884	1,297
Brazil	--	--	--	1	39	45
Canada	3	454	558	1	1	1
Colombia	1	23	28	48	1,170	1,331
Costa Rica	15	638	711	19	1,039	1,261
Denmark	--	--	--	1	146	175
Dominican Republic	--	--	--	6	206	262
France	(2)	1	2	--	--	--
Panama	--	--	--	24	231	272
Spain	12	830	1,107	12	598	833
Venezuela	3	155	187	8	293	447
Total[3]	42	2,767	3,607	135	4,847	6,218
Savannah:						
Germany, Federal Republic of	--	--	--	(2)	5	6
Italy	1	153	157	--	--	--
Venezuela	--	--	--	10	279	347
Total	1	153	157	10	284	353
Seattle:						
Canada	78	3,206	3,691	251	10,563	11,761
Japan	(2)	6	11	(2)	22	37
United Kingdom	(2)	1	2	--	--	--
Yugoslavia	(2)	14	24	--	--	--
Total[3]	79	3,227	3,727	251	10,585	11,798
Tampa:						
Canada	25	1,053	1,071	--	--	--
Colombia	25	765	975	10	233	338
Costa Rica	--	--	--	(2)	3	3
Denmark	19	1,956	2,342	25	W	W
France	127	W	W	94	W	W
Germany, Federal Republic of	--	--	--	(2)	16	20
Mexico	74	2,226	2,629	362	10,645	12,803
Spain	192	W	W	565	17,143	19,990
Venezuela	--	--	--	414	11,884	13,620
Total[3]	462	18,812	21,596	1,469	45,691	53,345
Virgin Islands of the United States:						
Colombia	--	--	--	2	128	129
Dominican Republic	--	--	--	4	120	142
Leeward and Windward Islands	5	255	305	7	285	441
Mexico	--	--	--	8	464	513
Panama	--	--	--	2	73	91
Total	5	255	305	23	1,070	1,316

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	1983			1984		
	Quantity	Value		Quantity	Value	
		Customs	C.i.f.[1]		Customs	C.i.f.[1]
Wilmington:						
Brazil	--	--	--	2	72	84
Colombia	--	--	--	49	1,474	2,130
Spain	--	--	--	6	167	202
Total	--	--	--	57	1,713	2,416
Grand total[3]	4,268	161,439	181,525	8,846	294,207	343,482

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.

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)
1980	3,232	115,271	1,917	73,931	114	6,371	5,263	195,573
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

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

Source: Bureau of the Census.

WORLD REVIEW

World cement production increased 5% to 1.06 billion tons. The United States accounted for 7% of world production. In order of production, the U.S.S.R., China, and Japan were the three principal producing countries, accounting for 34% of world production. The 10 largest cement-producing countries accounted for 60% of the world's total. Exporting countries continued to seek markets for their excess cement, particularly Colombia, Mexico, Spain, and Venezuela, all reporting increases in exports with Spain dominating the export market.

Rock Products' magazine report on the world cement industry described significant activities in cement plant construction, modernization, and expansion.[4]

Australia.—Adelaide Brighton Cement Ltd. continued work on its 550,000-ton-per-year grinding plant. The plant, scheduled for completion in July 1985, will increase the country's grinding capacity to about 9 million tons.

Belgium.—SA des Cimenteries CBR was completing work on its 2,870-ton-per-day clinker production line at its Antoing plant. The line, which is designed to burn low-volatile fuels with an ash content of 30% to 40%, was scheduled to be completed by the end of 1985.

Brazil.—Although cement consumption averaged only about 60% of production, there was considerable activity by cement producers to increase production capacity. S.A. Indústrias Votorantim, Santa Helena, was converting its kiln to a 1,400-ton-per-day precalciner kiln; Companhia Nacional de Cimento Portland S.A. resumed production after installing a precalcining system and converting the plant to coal firing;

Cimento Tocantins S.A., Brasília, added a 1,100-ton-per-day dry-process kiln; Cia. de Cimento Portland Rio Branco, Curitiba, added a second 2,400-ton-per-day dry-process kiln; and Cia. de Cimento Itambe continued work to expand the clinker production capacity of its Campo Largo plant from 1,400 to 2,200 tons per day.

China.—China's cement production continued to expand, exceeding 100 million tons for the third consecutive year. Seventy-five percent of China's cement production comes from small-capacity plants throughout the country. These plants have developed rather vigorously during the last 10 years; in 1984 there were nearly 5,000. However, work continued on construction of large- and medium-sized plants, including a 2,200-ton-per-day $48 million plant at Shunchang, Fujian Province, scheduled to be fully operational in 1988, and a new 3,500-ton-per-day plant due online in early 1986.

France.—Ciments Français was modernizing its facilities at Beaucaire by adding a five-stage preheater kiln with a precalcining system, which will increase production by 3,000 tons per day. The company is also adding a precalcining and traveling grate cooler to the Dopol kiln system at its Bussac plant, which will increase production by nearly 900 tons per day.

India.—The Indian cement industry continued to aggressively expand its production capacity. Audra Cement Co. Ltd. continued expansion work on its Durga plant by installing a coal mill and precalciner system, which will more than double its capacity to 3,300 tons per day. Birla Cement Works, Chittorgarh, continued its expansion program by adding a 2,000-ton-per-day precalciner kiln. The Cement Corp. of India continued construction of its 1-million-ton-per-year plant at Tandur. The plant was expected to go into production in early 1986. The company was also completing work on a 1-million-ton-per-year expansion of its Neemuch plant. Chettinad Cement Corp. Ltd. began a major modernization program to replace its wet-process kilns with a new 1,900-ton-per-day dry-process precalciner kiln. Gujarat Industrial Investment Corp. continued work on a 1-million-ton-per-year cement project at Veraval due to go on-line in 1986. Gwalior Rayon Corp. Ltd. continued work on its 2,000-ton-per-day plant near Incor, a new dry-process operation designed to use low-Btu Indian coal. Madras Cements Ltd. was completing work on its new Jayanthipuram 2,000-ton-per-day precalciner plant scheduled to go on-stream early in 1986. Modi Rubber Ltd. began work on a 1-million-ton-per-year project with Blue Circle Industries of the United Kingdom. The project is scheduled for completion by mid-1986. Several other companies were also planning plant construction and modernization programs.

Mexico.—Cementos Mexicanos S.A. was constructing a new 3,500-ton-per-day plant with a precalciner kiln at Huichapan. The plant is scheduled to start production by early 1986.

Turkey.—Turkiye Cimento Sanayii TAS began operation of three new plants at Ladik, Ergani, and Siirt with a combined capacity of 1.9 million tons. Three other plants at Urfa, Edirne, and Denizli, also with a combined capacity of 1.9 million tons, were scheduled to go on-stream in 1985-86.

United Kingdom.—Blue Circle Industries continued its plant modernization program that began in 1980. Improvements at the company's Cauldon works was completed and involved conversion of the three-kiln semidry-process plant into a single precalciner kiln operation, increasing the production capacity from 780,000 to 870,000 tons per year. RTZ Cement Ltd. was adding a new 1-million-ton-per-year dry-process kiln to its Ketton plant. The new line was expected to go on-stream in 1986.

Table 23.—Hydraulic cement: World production, by country[1]

(Thousand short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Afghanistan[e] [2]	55	105	132	165	165
Albania[e]	[r]1,102	[r]1,213	[r]1,102	[r]1,213	1,213
Algeria	4,581	4,916	[r] [e]5,512	[e]5,512	5,291
Angola[e]	265	276	[r]276	[r]243	386
Argentina	7,863	7,331	6,199	6,198	5,512
Australia	5,938	6,554	6,332	5,331	5,512
Austria	6,013	5,829	5,525	5,411	[3]5,512
Bahamas	520	32	71	29	69
Bangladesh[4]	[r]370	380	360	338	[3]301
Barbados	--	--	--	--	165
Belgium	8,247	7,376	6,967	6,304	[3]6,300
Benin	314	327	347	[e]331	331
Bolivia	[r]327	413	358	361	360
Brazil	29,975	28,716	28,268	23,005	27,558
Bulgaria	5,907	[r]6,000	6,188	6,221	[3]6,302
Burma	[r]426	[r]350	379	369	[3]343
Cameroon	560	[e]569	584	672	672
Canada	11,571	11,183	9,288	8,676	9,559
Chile	1,745	2,054	1,248	1,389	1,354
China	88,030	92,594	103,697	119,325	[3]133,468
Colombia	4,796	[r]4,915	5,546	5,204	5,401
Congo	37	54	43	17	17
Costa Rica	610	[r]507	467	425	386
Cuba	3,121	3,629	3,487	3,562	[3]3,689
Cyprus	1,359	1,141	1,177	1,039	[3]940
Czechoslovakia	[r]11,625	11,735	11,381	11,572	[3]11,607
Denmark	2,113	1,766	1,951	1,827	1,874
Dominican Republic	1,119	[r]1,049	[r] [e]1,058	1,173	1,157
Ecuador	1,531	[r]1,365	1,747	1,565	1,543
Egypt	3,338	[r]3,857	4,696	4,182	5,512
El Salvador	573	505	461	476	474
Ethiopia[e]	121	143	154	165	176
Fiji	93	101	97	[e]105	105
Finland	[r]2,001	[r]2,054	2,102	2,170	1,874
France	32,082	31,117	28,825	26,843	[3]26,455
Gabon	121	165	193	132	[3]229
German Democratic Republic	13,713	13,453	12,920	12,987	[3]13,007
Germany, Federal Republic of	[r]37,684	[r]34,721	33,155	33,583	[3]34,723
Ghana	[r]324	437	322	[r] [e]320	320
Greece	13,977	14,721	7,619	15,648	[3]16,535
Guadeloupe	202	176	[e]176	[e]176	176
Guatemala	627	[r]567	558	498	496
Haiti	268	[r]260	234	[r] [e]238	243
Honduras	491	[r]343	306	535	551
Hong Kong	1,641	[r]1,673	1,582	1,892	[3]2,037
Hungary	5,137	[r]5,109	4,816	4,677	[3]4,569
Iceland	134	134	137	127	[3]130
India	19,511	22,884	24,800	27,950	[3]32,000
Indonesia	6,417	[r]7,596	8,268	9,025	11,795
Iran[e]	8,818	8,818	10,472	11,023	11,574
Iraq	6,063	6,173	[r] [e]6,173	[e]6,173	8,818
Ireland	2,059	2,136	1,742	1,638	[3]1,653
Israel	[r]2,030	[r]2,271	2,413	2,269	[3]2,082
Italy	46,046	45,804	43,793	43,229	44,092
Ivory Coast	[e]1,433	1,323	1,213	702	[3]591
Jamaica	159	182	233	305	288
Japan	96,957	[r]93,506	88,943	89,167	[3]86,918
Jordan	1,006	1,063	876	1,401	[3]2,192
Kenya	1,402	[r]1,433	[e]1,433	[e]1,433	1,433
Korea, North[e]	8,818	8,818	8,818	8,818	8,818
Korea, Republic of	[r]17,209	17,215	19,717	23,459	[3]22,501
Kuwait	1,441	1,707	1,712	1,720	[3]1,736
Lebanon	1,636	2,636	[e]1,984	[e]1,102	882
Liberia	117	95	88	[e]66	66
Libya[e]	3,527	[r]3,527	4,409	5,512	6,614
Luxembourg	358	377	379	389	[3]419
Madagascar	66	[r]39	40	[r] [e]39	39
Malawi	101	86	58	77	83
Malaysia	2,589	3,123	3,443	3,562	3,671
Mali	22	[e]22	30	[e]22	22
Martinique	198	198	[e]220	[e]220	220
Mauritania	--	66	66	[e]66	NA
Mexico	[r]17,905	[r]19,817	21,272	18,814	19,842
Mongolia	196	231	386	370	386
Morocco	3,915	3,975	4,115	4,242	4,409
Mozambique	[5]260	[r]256	386	463	496

See footnotes at end of table.

Table 23.—Hydraulic cement: World production, by country[1] —Continued

(Thousand short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Nepal	34	34	[e]28	50	44
Netherlands	4,128	3,655	3,420	3,425	[3]3,583
New Caledonia	62	55	59	[e]66	66
New Zealand	794	837	861	838	[3]907
Nicaragua	170	[r]184	[e]110	[e]110	110
Niger	45	41	[e]42	[e]42	42
Nigeria	[r]2,205	[r]2,756	[e]3,968	[e]3,968	3,968
Norway	[r]2,432	[r]2,025	1,969	1,783	[3]1,607
Pakistan	3,677	[r]2,798	4,031	4,603	4,960
Panama	623	573	386	360	364
Paraguay	195	[r]172	122	169	154
Peru	2,391	3,395	2,855	2,535	2,425
Philippines[5]	4,939	4,508	4,795	5,504	5,512
Poland	20,330	[r]15,681	17,747	17,857	[3]18,409
Portugal	6,336	6,280	6,393	6,683	[3]6,614
Qatar	230	284	288	273	303
Romania	17,208	16,255	16,529	15,397	[3]15,653
Saudi Arabia	[r]3,209	[r]5,219	7,885	8,957	[3]9,921
Senegal	[r]426	410	401	435	[3]424
Singapore	2,152	2,484	2,971	3,476	[3]3,417
South Africa, Republic of	7,937	8,923	8,830	8,705	[3]9,025
Spain (including Canary Islands)[6]	30,876	[r]31,693	32,594	33,771	[3]33,069
Sri Lanka	629	708	[e]717	558	551
Sudan	204	165	202	[e]220	[3]194
Suriname	76	78	79	82	55
Sweden	2,695	2,555	2,538	2,459	2,646
Switzerland	4,687	[r]4,793	4,513	4,564	[3]4,409
Syria	2,199	[r]2,370	3,142	3,142	[3]5,512
Taiwan	15,501	15,809	14,806	16,325	[3]15,690
Tanzania	[r,5]331	[5]433	[r,e]441	[r,e]463	463
Thailand	5,883	6,904	7,285	8,006	[3]9,083
Togo	334	314	308	256	254
Trinidad and Tobago	205	[r]154	209	430	430
Tunisia	1,962	2,227	1,965	[r,e]2,777	2,866
Turkey	[r]14,192	16,582	17,392	14,987	[3]17,348
Uganda[e]	11	22	33	44	44
U.S.S.R	137,843	140,180	136,335	141,268	[3]143,300
United Arab Emirates	1,896	[r]2,448	2,280	4,415	4,465
United Kingdom	[r]16,320	[r]14,031	14,288	13,702	[3]13,999
United States (including Puerto Rico)	76,709	72,932	64,341	71,347	[3]78,699
Uruguay	[r]891	[r]818	726	472	383
Venezuela	[r]5,339	[r]5,375	5,988	4,899	4,841
Vietnam	707	601	[r,e]882	1,023	1,213
Yemen (Sanaa)	89	90	261	661	[3]1,532
Yugoslavia	10,268	10,781	10,712	10,573	[3]10,582
Zaire	488	450	[r,e]441	[e]441	441
Zambia	[r]177	[r]159	170	171	[3]266
Zimbabwe	517	[r]648	635	[r,e]639	639
Total	[r]973,458	[r]977,181	972,498	1,008,418	1,058,721

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through July 2, 1985.
[2]Data are for the year beginning Mar. 21 of that stated.
[3]Reported figure.
[4]Data are for the year ending June 30 of that stated.
[5]Converted from officially reported data provided in terms of 94-pound cement bags.
[6]Excludes natural cement.

TECHNOLOGY

Cement.—Researchers at Brookhaven National Laboratory concluded a study to (1) develop commercially available calcium silicates (such as portland cement Type III) for in situ desulfurization of coal gases, and (2) to investigate the catalytic effect of these and related sorbents on gasification efficiency of coal and coal char in low- and medium-Btu coal fluidized-bed gasifiers (FBG). The study concluded that agglomerated cement sorbent (ACS) pellets were highly efficient as a regenerative, attrition-resistant sorbent at higher gasification temperatures compared with limestone and iron oxide, which cannot withstand the high operating temperatures necessary for desulfurizing FBG gases. The ACS pellet material also indicated enhancement in gasification efficiency of coal and coal char compared with other sorbents.[5]

Three Japanese companies, Kobe Steel Ltd., Onoda Cement Co. Ltd., and Onoda Engineering and Consulting Co. Ltd., jointly developed a new type of roller mill, known as the OK Series, for cement clinker grinding. Traditionally, roller mills were used for raw material grinding. Although numerous attempts have been made to apply this technology to clinker grinding because of its energy-saving feature, problems associated with vibration, product quality control, and accelerated wear of grinding segments prevented full implementation. Test data show roller mills have practical application to clinker grinding with as much as 60% to 70% energy savings over that of conventional tube mills.[6]

Concrete.—Bureau of Mines research demonstrated the use of sulfur concrete as a corrosion-resistant construction material. Compared with portland cement concrete, sulfur cement showed no signs of degradation in more than 4 years of industrial testing in 50 process environments. The study concluded that sulfur concrete should find widespread use in metallurgical, chemical, and fertilizer industries as a replacement for materials that fail in acid and salt environments.[7]

Another Bureau of Mines investigation determined the technology for preparing densifiable sulfur concrete materials composed of modified sulfur cements and dense-graded aggregates that can be mixed, laid, and compacted into place with conventional hot-mixed asphalt paving equipment. Results of laboratory corrosion tests in sulfuric acid in concentrations up to 60% showed no material loss or deterioration of physical properties over a 1-year test period at ambient temperatures. Preliminary results of field testing for durability to weathering, corrosion, and traffic showed no evidence of material failure, thus increasing its potential for use in road construction and repair as well as industrial applications.[8]

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[1]Mineral specialist, Division of Industrial Minerals.

[2]U.S. International Trade Administration (Dep. Commerce). Construction Review. V. 31, No. 1, Jan.-Feb. 1985, pp. 31-39.

[3]Engineering News-Record. ENR Materials Prices. V. 212, No. 1, Jan. 10, 1985, p. 51.

[4]Rock Products. International Cement Review. V. 88, No. 4, Apr. 1985, pp. 45-70.

[5]Yoo, H. P., and M. Steinburg. Calcium Silicate Cement Sorbent for Hydrogen Sulfide and Improved Gasification Processes. Brookhaven Nat. Lab., Upton, NY, Oct. 1984, 29 pp.; NTIS DE 82-003245.

[6]World Cement. Newly Developed Roller Mill for Cement Clinker Grinding. V. 15, No. 7, Sept. 1984, pp. 230-232.

[7]McBee, W. C., T. A. Sullivan, and B. W. Jong. Industrial Evaluation of Sulfur Concrete in Corrosive Environments. BuMines RI 8766, 1983, 15 pp.

[8]———. Sulfapave: Densifiable Sulfur Concrete Materials for Corrosive Environments. BuMines RI 8905, 1984, 14 pp.

Chromium

By John F. Papp[1]

In 1984, reported chromium consumption was 314,820 short tons, an increase over that of 1983 (303,929 tons). The reported consumption of chromium by metallurgical, refractory, and chemical consumers increased. Increased metallurgical industry chromium consumption reflects National Defense Stockpile (NDS) conversion. Imports for consumption of chromite and ferrochromium also increased.

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 accounted for 100% of the chromite consumption data in table 5. In 1984, 83% of the metallurgical companies, 100% of the refractory companies, and 66% 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." The six metallurgical industry companies listed in table 3 represented 100% of domestic production shown in table 4. Of the companies listed in table 3, 83% responded to both surveys, production for the remaining 17% was estimated.

Table 1.—Salient chromium statistics

(Thousand short tons, gross weight)

	1980	1981	1982	1983	1984
CHROMITE					
United States:					
Exports	6	71	8	11	55
Reexports	44	67	57	5	4
Imports for consumption	982	898	507	190	305
Consumption	977	889	r558	r320	512
Stocks, Dec. 31: Consumer	675	728	545	r455	327
World: Production	r10,915	r10,224	9,193	p9,387	e10,468
CHROMIUM FERROALLOYS[1]					
United States:					
Production[2]	239	226	119	36	95
Exports	32	14	5	4	15
Reexports	1	1	(3)	2	1
Imports for consumption	302	440	148	282	434
Consumption	412	423	262	388	395
Stocks, Dec. 31: Consumer	58	54	26	26	25
World: Production	r2,236	r2,114	1,956	p1,814	e3,231

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.—As a result of a request by the Government of Spain, the International Trade Commission investigated and determined that revocation of the countervailing duty order on ferrochromium from Spain would not cause material injury to a U.S. industry. Consequently, the U.S. Department of Commerce revoked the countervailing duty order.

In 1981, the Ferroalloy Association, a domestic trade group, petitioned the President for relief under section 232 of the Trade Expansion Act of 1962. As a result of this petition, Commerce investigated the effect of chromium ferroalloys and metal imports on the national security. Commerce submitted its investigation report and recommendations to the President in 1982, after which it was reviewed by the National Security Council and the Office of Management and Budget. At that time, the President directed further investigation into the impact of duties, tariffs, and breakpoint prices on imports and foreign trade. At the same time, the President endorsed upgrading of stockpiled chromite. The General Services Administration (GSA) first contracted in 1983 to convert 121,753 tons of chromium ore. At GSA's suggested program conversion of 1,297,000 tons of ore to 518,500 tons of ferrochromium, about 2.5 tons of ore yield 1 ton of ferrochromium. At this conversion rate, about 49,000 tons of ferrochromium was produced for the NDS in 1984. That conversion was carried out in 1984. The GSA awarded a second contract in 1984 to convert 141,601 tons of chromium ore to high-carbon ferrochromium. Also in 1984, the Commerce investigation was completed and reported to the President. The investigation found that imports of high-carbon ferrochromium pose a threat to national security and that imports of low-carbon ferrochromium, ferrochromium-silicon, and chromium metal do not pose such a threat. Recommended remedial options were (1) upgrade NDS chromite ore to ferrochromium, (2) impose quotas, (3) impose a breakpoint tariff, and (4) impose an import duty. Following submission of the Commerce investigation report, the President determined that ferroalloy imports do not threaten to impair the U.S. national security.

A National Materials Advisory Board study for the Federal Emergency Management Agency and Commerce was completed. This study determined priorities for detailed quality assessment of the NDS nonfuel materials and concluded that chromium metal is in the high-priority assessment category.[2]

An American Society for Metals (ASM) assessment of chromium metal in the NDS for Commerce was completed. The ASM study found that NDS chromium metal (1) is not suitable for uses that have stringent purity requirements; (2) has no substitute in vacuum melted superalloys for hot corrosion and oxidation resistance; (3) is usable for air melted alloys; and (5) is disqualified principally as a result of excessive amounts of undesirable residuals.[3]

The U.S. Geological Survey (USGS) studied chromite occurrences in California, Montana, and North Carolina. The USGS studied the Emma Bell chromite deposit, Siskiyou County, CA, in cooperation with the Bureau of Mines.[4] By surface examination and drilling, the study delineated 5 million tons of dunite averaging 4% chromic oxide (Cr_2O_3). The fine grain nature and high iron content of accessory chromite reduced prospects for mine development. However, the large size of the deposit may offset these negative factors.

The U.S. Department of Defense, under Executive Order 11440 and 10 U.S.C. 2 304(a)(16), required that domestically produced high-carbon ferrochromium be used in defense items procured from domestic sources except when adequate supplies of domestically produced high-carbon ferrochromium are not available and when memorandums of understanding or offset agreements exist with North Atlantic Treaty Organization (NATO) countries. Executive Order 11490 assigned the Secretary of Defense responsibility for developing plans to fulfill military requirements and maintenance of the mobilization base.

The Environmental Protection Agency (EPA) completed a health assessment on chromium. The assessment contains sources and concentrations of important trivalent and hexavalent chromium compounds, measurement methods, pharmacokinetics and essentiality, toxic effects, and carcinogenic risks. This scientific assessment was prepared to provide a data base for EPA regulatory decision making.[5]

The U.S. Congress, Office of Technology Assessment (OTA), summarized a study on technologies to reduce U.S. import vulnerability to chromium. Based on criticality and extent of use, and vulnerability of supply, OTA found chromium to be 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 in each category.[6] OTA also reported on domestic chromite minerals access to transportation. Air, rail, road, and water transportation in Alaska were compared with those in the continental United States.[7]

Table 2.—U.S. Government stockpile goals and yearend inventories for chromium in 1984

(Thousand short tons, gross weight)

Material	Stockpile goals	Physical inventory		
		Stockpile-grade	Nonstock-pile-grade	Total
Chromite, metallurgical	3,200	1,957	406	[1]2,362
Chromite, chemical	675	242	--	242
Chromite, refractory	850	391	--	391
High-carbon ferrochromium	185	402	1	403
Low-carbon ferrochromium	75	300	19	319
Ferrochromium-silicon	90	57	1	58
Chromium metal	20	4	--	4

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

DOMESTIC PRODUCTION

The major marketplace products of chromium are chromium ore, alloys, chemicals, and metal. In 1984, the United States produced chromium alloys, chemicals, and metal from imported chromium ore. No chromium ore was mined domestically.

Domestic production of ferrochromium increased greatly over that of 1983. The major contribution to that increase was production for the NDS. (See "Legislation and Government Programs" section of this chapter.)

Diamond Shamrock Corp. increased its sodium dichromate production capacity from 85,000 to 100,000 tons in 1983. Through further engineering and process improvements, that capacity has been increased to 110,000 tons of sodium bichromate.

CIBA-GEIGY Corp. announced the start-up of a lead chromate pigments plant. The plant at Glens Falls, NY, has an annual capacity of 30 million pounds.

Ni-Cal Technology Corp. filed an application to build and operate a laterite processing demonstration plant in Del Norte County, CA. Chromium ore concentrate was proposed to be obtained by gravity separation preceding recovery of other minerals. The proposed plant was to process 85 tons per day of laterite ore. The plant was to be on California Nickel Corp.'s Gasque Mountain Mine property. California Nickel and Ni-Cal Technology are subsidiaries of Ni-Cal Developments Ltd. of Vancouver, Canada.

The United Auto Workers' strike against SKW Alloys Inc. continued throughout 1984. Macalloy Inc. recalled 150 of its employees to carry out its contract with GSA to produce ferrochromium for the NDS. In September, Macalloy's creditors approved a reorganization plan under chapter 11 of the Federal Bankruptcy Code. The reorganization plan provided $0.35 on the dollar for creditors that wanted immediate payment with the balance of debentures paid out annually during a 5-year period between 1984 and 1989.

Chromasco Ltd. of Toronto, Canada, announced the permanent closing of its U.S. ferrochromium production facilities at Woodstock, TN. The Woodstock plant had a production capacity of 82,000 tons per year of high-carbon ferrochromium divided among four furnaces and 16,000 tons per year of low-carbon ferrochromium supplied by one furnace. The plant had been producing chromium concentrates from slag since its furnaces were idled in 1980. The Globe Metallurgical Div. of Interlake Inc. was sold in 1984 to Pickands Mather & Co., a subsidiary of Moore McCormack Resources Inc., for about $33 million in preferred stock, notes, and cash. Globe had an annual production capacity of about 45,000 tons of ferrochromium at its Beverly, OH, plant. Globe's ferrochromium products included high- and low-carbon ferrochromium, low-nitrogen ferrochromium, and ferrochromium-silicon.

Closure of the General Refractories Co., Baltimore, MD, plant was completed. Closure of the plant was announced in 1981 after which production ceased in 1982. Since then, stocks and usable material have been transferred within the company or have been sold. At one time, the plant employed about 300 people. Declining market demand for the plant's products was the reason for closure.

Table 3.—Principal producers of chromium products in 1984, 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	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	Castle Haynes, NC.

Table 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in the United States

(Short tons)

	Net production		Net shipments	Producer stocks, Dec. 31
	Gross weight	Chromium content		
1983:				
Low-carbon ferrochromium; High-carbon ferrochromium	19,928	12,964	39,510	W
Ferrochromium-silicon; Other[1]	16,471	6,368	13,696	50,104
Total	36,399	19,332	53,206	50,104
1984:				
Low-carbon ferrochromium; High-carbon ferrochromium; Chromium concentrate	79,515	50,919	110,389	16,256
Ferrochromium-silicon; Chromium metal; Other[2]	15,885	8,324	10,383	8,282
Total	95,400	59,243	120,772	24,538

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

[1]Includes chromium metal, chromium concentrate, exothermic chromium additives, and other miscellaneous chromium alloys.

[2]Includes exothermic chromium additives and other miscellaneous chromium alloys.

CONSUMPTION AND USES

Domestic consumption of chromite ore and concentrate was 512,156 tons in 1984. Of the total chromite consumed, the metallurgical industry used 44%; the refractory industry, 19%; and the chemical industry, 37%. The metallurgical industry consumed 225,727 tons of chromite in the process of producing 95,400 tons of chromium ferroalloy, metal, and other chromium-containing materials. 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 1984 was in stainless steel. Of the 401,057 tons of chromium ferroalloys, metal, and other chromium-containing materials reported consumed, stainless steel accounted for 78%; full-alloy steel, 10%; superalloys, 3%; and other end uses accounted for the remainder. Chromium ferroalloys, metal, and other chromium material consumption increased 2% compared with that of 1983.

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 increased 35% compared with that of 1983.

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 consumed by the chemical industry increased 3% compared with that of 1983.

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)
1980	576,623	35.9	160,208	35.8	239,941	45.8	976,772	38.4
1981	503,051	35.7	147,853	37.3	238,465	42.6	889,369	37.9
1982	r283,481	r35.2	79,760	36.4	194,935	44.9	r558,176	r38.9
1983	64,310	39.3	72,050	36.9	r183,611	r44.9	r319,971	r42.0
1984	225,727	43.5	97,469	37.4	188,960	44.8	512,156	42.8

rRevised.

Table 6.—U.S. consumption of chromium ferroalloys and metal in 1984, by end use

(Short tons, gross weight)

End use	Low-carbon ferrochromium	High-carbon ferrochromium	Ferrochromium silicon	Other	Total
Steel:					
Carbon	3,664	4,814	743	W	9,221
Stainless and heat-resisting	9,996	292,787	9,693	594	313,070
Full-alloy	8,458	28,356	1,933	99	38,846
High-strength, low-alloy and electric	3,333	2,866	3,472	W	9,671
Tool	357	4,482	138	W	4,977
Cast irons	544	5,913	1,143	W	7,600
Superalloys	4,358	4,081	52	3,038	11,529
Welding materials (structural and hard-facing)	487	749	W	111	1,347
Other alloys[1]	684	712	W	1,054	2,450
Miscellaneous and unspecified	1,081	87	14	1,164	2,346
Total	32,962	344,847	17,188	[2]6,060	401,057
Chromium content	22,048	198,538	6,139	5,234	231,959
Stocks, Dec. 31	3,375	19,946	1,422	[3]1,559	26,302

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Includes magnetic and nonferrous alloys.
[2]Includes 4,275 tons of chromium metal.
[3]Includes 841 tons of chromium metal.

STOCKS

Reported consumer stocks of chromite declined from 455,576 tons in 1983 to 327,321 tons in 1984. Metallurgical, refractory, and chemical industry stocks declined. Producer stocks of chromium ferroalloys, metal, and other materials declined from 50,104 tons in 1983 to 24,538 tons in 1984. Consumer stocks declined from 26,670 tons in 1983 to 26,302 tons. At the 1984 annual rate of chromium ferroalloy and metal consumption, producer plus consumer stocks represented a 1.5-month supply.

Table 7.—U.S. consumer stocks of chromite, December 31, by industry

(Short tons, gross weight)

Industry	1980	1981	1982	1983	1984
Metallurgical	218,942	229,800	119,540	140,324	24,442
Refractory	r134,749	128,210	r113,233	75,832	69,619
Chemical	321,557	370,463	312,808	r239,420	233,260
Total	675,248	728,473	r545,581	r455,576	327,321

rRevised.

Table 8.—U.S. consumer stocks of chromium ferroalloys and metal, December 31, by product

(Short tons, gross weight)

Product	1980	1981	1982	1983	1984
Low-carbon ferrochromium	5,432	5,198	3,459	3,474	3,375
High-carbon ferrochromium	50,258	46,601	21,793	20,948	19,946
Ferrochromium-silicon	2,578	1,801	1,237	1,294	1,422
Other[1]	1,935	2,468	2,593	954	1,559
Total	60,203	56,068	29,082	26,670	26,302

[1]Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

PRICES

The price of South African and Turkish chromite remained unchanged. The published price of South African Transvaal chromite, 44% Cr_2O_3, no specific chromium-to-iron ratio, was $48 to $52 per metric ton, f.o.b. South African ports. The price of Turkish chromite, 48% Cr_2O_3, 3:1 chromium-to-iron ratio, was $110 per metric ton, f.o.b. Turkish ports.

The price of high-carbon ferrochromium, imported low-carbon ferrochromium, and ferrochromium-silicon varied, whereas the price of domestic low-carbon ferrochromium remained unchanged. The price of imported 50% to 55% high-carbon ferrochromium increased from $0.39 to $0.40 per pound to $0.40 to $0.42 during the first week of January. The price rose to $0.41 to $0.43 in March, then $0.43 to $0.45 in April where it remained until yearend. The price of domestic 50% to 55% high-carbon ferrochromium remained at $0.40 to $0.43 per pound until August, when the price was suspended for the remainder of the year. The price of imported 60% to 65% high-carbon ferrochromium rose from $0.41 to $0.42 per pound to $0.41 to $0.425 during the first week of January. The price rose to $0.435 to $0.45 in March, then to $0.45 to $0.46 in May, where it remained until yearend. The price of domestic 66% to 70% high-carbon ferrochromium rose from a range of $0.42 to $0.54 per pound to $0.54 per pound in August, where it remained until yearend. Chromium ferroalloy and metal prices are those published in Metals Week.

Table 9.—Price quotations for chromium materials at beginning and end of 1984

Material	January	December
	Cents per pound of chromium	
U.S. charge chromium (50% to 55% chromium)	40- 43	Suspended.
Imported charge chromium (50% to 55% chromium)	39- 40	43- 45
Imported charge chromium (60% to 65% chromium)	41- 42	45- 46
U.S. charge chromium (66% to 70% chromium)	42- 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	89- 95
Simplex (low-carbon ferrochromium)	100	100
	Cents per pound of product	
Electrolytic chromium metal	375	375
Ferrochromium-silicon	34.5	36.6

FOREIGN TRADE

Exports of chromium materials from the United States included chromite ore, ferrochromium, chromium metal, chromium chemicals, and chromium pigments.

Exports of chromite ores and concentrates totaled 54,928 tons valued at $2,956,982. The Federal Republic of Germany (44%), Sweden (30%), and Mexico (21%) were the major recipients of these exports.

Exports of chromium ferroalloy totaled 15,388 tons, contained 9,996 tons of chromium, and were valued at $10,542,286. The Federal Republic of Germany (56%), Canada (27%), and Spain (11%) were the major recipients of these exports.

Exports of chromium metal, wrought and unwrought, waste and scrap, totaled 259 tons, valued at $3,626,593. Canada (32%), Japan (20%), and Mexico (19%) were the major recipients of these exports.

Exports of potassium chromate and dichromate totaled 77 tons, valued at $74,617. Canada (58%) and Mexico (23%) were the major recipients of these exports.

Exports of sodium chromate and dichromate totaled 18,321 tons, valued at $10,382,766. Canada (26%) and China (26%) were the major recipients of these exports.

Exports of chromic acid totaled 5,672 tons, valued at $8,478,571. The major recipient of these exports was China (30%).

Exports of pigments containing chromium totaled 2,062 tons, valued at $7,213,880. Canada (27%) was the major recipient of these exports.

Imports of ferrochromium-silicon totaled 7,942 tons, contained 3,032 tons of chromium, and were valued at $3,736,336. These imports came from Zimbabwe.

Imports of chromium metal, wrought and unwrought, waste and scrap totaled 4,677 tons, and were valued at $24,073,109. These imports came primarily from the United Kingdom (41%) and Japan (31%).

Imports of potassium chromate and dichromate totaled 554 tons, valued at $507,331. These imports were supplied primarily by the United Kingdom (62%).

Imports of sodium chromate and dichromate totaled 4,617 tons, valued at $2,919,757. These imports were supplied primarily by the U.S.S.R. (22%) and the Republic of South Africa (20%).

Imports of chromium carbide totaled 181 tons, valued at $1,242,407. These imports were supplied primarily by the Federal Republic of Germany (69%).

Imports of chromic acid totaled 2,456 tons, valued at $3,500,149. These imports were supplied primarily by Italy (39%).

Imports of pigments included 53 tons of chrome green, valued at $130,260; 2,560 tons of chrome yellow, valued at $4,223,082; 1,999 tons of chromium oxide green, valued at $4,116,365; 18 tons of hydrated chromium oxide green, valued at $68,894; 1,013 tons of molybdenum orange, valued at $2,366,754; 197 tons of strontium chromate, valued at $424,883; and 1,186 tons of zinc yellow, valued at $1,529,624.

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)
1980	5,911	$1,447	43,696	$8,544
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

Table 11.—U.S. import duties for chromium-containing materials

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
Ore:				
Chrome ore and concentrate	601.15	Free	No target duty	Free.
Metal and alloys:				
Low-carbon ferrochromium	606.22	3.6% 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 (wrought, unwrought, waste and scrap)	632.18	4.2% 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	2.6% ad valorem	2.4% ad valorem	8.5% ad valorem.
Chromium carbide	422.92	4.9% ad valorem	4.2% ad valorem	25% ad valorem.
Chromic acid	423.0092	4.2% ad valorem	3.7% ad valorem	Do.
Pigments:				
Chrome green	473.10	4.4% 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.

Table 12.—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)
1983:												
Albania	6,274	2,336	$422	--	--	--	--	--	--	6,274	2,336	$422
Canada	5,697	2,164	327	--	--	--	--	--	--	5,697	2,164	327
Madagascar	--	--	--	--	--	--	21,272	10,423	$1,362	21,272	10,423	1,362
Philippines	12,899	4,160	1,328	--	--	--	--	--	--	12,899	4,160	1,328
South Africa, Republic of	7,796	3,087	541	63,244	29,860	$3,193	73,167	34,098	3,210	144,207	67,045	6,944
U.S.S.R	--	--	--	--	--	--	72	40	7	72	40	7
Total[1]	32,667	11,747	2,619	63,244	29,860	3,193	94,511	44,561	4,578	190,422	86,168	10,390
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

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Table 13.—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)
1983:						
Albania	--	--	--	3,881	2,445	$1,424
Belgium	--	--	--	1	1	(1)
Brazil	--	--	--	7,606	4,147	2,329
Canada	--	--	--	153	91	63
France	19	14	$25	--	--	--
Germany, Federal Republic of	827	585	744	827	546	468
Italy	135	104	164	--	--	--
Japan	1,565	1,044	1,687	--	--	--
Korea, Republic of	--	--	--	1,047	553	332
Norway	701	446	647	--	--	--
South Africa, Republic of	992	602	746	151,085	79,358	48,074
Spain	--	--	--	168	113	78
Sweden	7,598	5,534	7,186	3,307	2,135	1,358
Turkey	772	525	588	14,165	9,062	5,809
United Kingdom	36	25	40	--	--	--
Yugoslavia	--	--	--	32,562	21,046	13,038
Zimbabwe	4,113	2,833	3,448	48,744	31,788	20,766
Total[2]	16,757	11,713	15,274	263,546	151,285	93,738
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[2]	25,132	17,236	23,397	400,677	225,487	160,054

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

World chromite production increased to 10.5 million tons, from 9.4 million tons in 1983. Ferrochromium production increased to 3,231,000 from 1,814,000 tons in 1983.

Increased world production of stainless steel in 1984 resulted in strong demand for chromium. Market economy country stainless steel production reached a record high of about 9 million tons. Japan achieved a record-high production of 3 million tons. U.S. stainless steel production remained about the same as that of 1983. However, U.S. imports increased from 190,000 to 260,000 tons, showing that domestic demand was increasingly satisfied by imports owing to the strong dollar.

In the Republic of South Africa, the major market economy country producer of chromite and ferrochromium, chromite and ferrochromium production exceeded that of 1983, and ferrochromium production reached a record high. The Republic of South Africa produced about 1 million tons of ferrochromium by full production capacity use, delay of servicing, and conversion of idle furnace capacity.

Chromium ferroalloy production capacity continues to move from traditional consumer countries to chromium ore producing countries. This was highlighted in 1984 when Japan announced plans to reduce its ferrochromium production capacity, and a plant in the United States was permanently closed. On the other hand, ferrochromium plant construction or expansion was in progress in Finland, India, the Philippines, Sweden, and Turkey. Plant construction or expansion was under consideration in Madagascar and Greece.

Argentina.—Geologists participating in the Northwest Argentina Plan, a Government minerals evaluation program started in 1969 for Santiago del Estero, Tucumán, and Catamarca Provinces, reported promising chromium resources at Fiambala in Catamarca in 1984.

Brazil.—Cia. de Ferro-Ligas da Bahia S.A. (FERBASA) reportedly planned to expand its ferrochromium production capacity from its current 144,000 tons per year to 230,000 tons per year. Expansion was to be completed by mid-1986. FERBASA planned to expand because of increased domestic consumption.

Cyprus.—Chromite resource investigation has been carried out in Cyprus by the Bureau de Recherches Géologiques et Minières (BRGM) since mining ceased in 1982. In 1984, borehole drilling was carried out at the Kokkinorotsos and Hadjipavolou Mines and the Kannoures mining lease to prove reserves. The Cyprus Geological Survey Department in conjunction with BRGM has investigated chromite occurrences in the Akapnou Forest located in the Vasa-Layia area.

European Economic Community (EEC).—The EEC revised its ferrochromium quotas twice in 1984, once in May, then again in November. The revision occurred because of higher than anticipated demand. The EEC levied a duty on sodium dichromate from Romania in February when imports of that material reached a preset ceiling value of $209,230.

Finland.—Finland was continuing work to double ferrochromium production capacity at Tornio by adding a 36-megawatt furnace. Target capacity of 120,000 tons per year was scheduled for completion in 1985.

France.—The Chromium Association was formed, with headquarters in Paris, and is composed of producers and traders from Finland, Greece, India, Italy, Madagascar, the Philippines, the Republic of South Africa, Spain, Sweden, and the United States. The association's objectives are to collect and evaluate chromium production and consumption statistics, collect information on chromium industry-related matters, disseminate those statistics and information to further technical cooperation, provide a forum for the discussion of chromium industry-related problems, effect and maintain liaison with chromium-related organizations, promote chromium use, and encourage and sponsor chromium research and development.

Greece.—Greece started commercial shipments of high-carbon ferrochromium from Hellenic Ferroalloy S.A. The plant started production in 1983, with a capacity of 40,000 to 45,000 tons per year, with one 20-megavolt ampere furnace.

To protect 5,000 jobs, the Minister for National Economy brought the Scalistiris Group, a chromite refractories producer, under state control.

India.—To improve the competitiveness of chromite ore on the international market, the Indian Government abolished export duties on that ore.

Two high-carbon ferrochromium plants were under construction, the OMC Alloys Co. plant at Bamnipal, Orissa, and the Indian Metals & Ferro Alloys Ltd. (IMFA) plant at Chouduar, Cuttack District, Orissa. Both plants were scheduled to start operations in 1985.

Ferro Alloys Corp. Ltd. (FACOR), a high-carbon ferrochromium producer that started production in 1984 at Randia, Balasore District, Orissa, commissioned a chromium ore concentrator plant. The concentrator plant was built at its Boula Mine, which adjoins the ferrochromium production plant. The concentrator produces 50% Cr_2O_3 chromium ore concentrate from 20% Cr_2O_3 feedstock by gravity separation. The concentrator was supplied by Larsen & Toubro Ltd. in cooperation with Sala International AB, Sweden. The concentrator is expected to produce about 30,000 tons per year of concentrate, which is to be briquetted. The briquets could account for 30% of the chromium material feedstock.

Japan.—The system of advance allotment of duty-free ferrochromium imports, started in fiscal year 1983, was continued in 1984.

The tariff rate on ferrochromium-silicon was reduced to 3.7% from 3.8%. This duty reduction was agreed upon at the Tokyo Round of the General Agreement on Tariffs and Trade talks in 1977. Implementation was in effect 2 years ahead of schedule. The ferrochromium rate remained at 8%.

Preparations were made to expand the national rare metal stockpile by a 4.8-day supply during fiscal year 1984. Ferrochromium purchases were estimated at about 7,000 tons. The 4.8-day supply was to be distributed as follows: 2 days supply to the national stockpile, 2 days supply to the joint Government-private stockpile, and 0.8 day supply to the private stockpile.

The Ministry of International Trade and Industry (MITI) held talks with ferrochromium producers and announced plans to bring the ferroalloy industry under the Temporary Law for Structural Improvement of Specific Industries. MITI planned a ferrochromium production capacity reduction of 10%, from 500,000 to 450,000 tons per year. The reduction was planned for fiscal year 1987.

Madagascar.—A pilot plant for the production of ferrochromium was being planned by the Government.

Oman.—A stockpile of chromite was developed based on production from two sites, which started operation in 1982 near Nakhal. The Oman Mining Co. was considering the development of port facilities at Fujeirah or Khor Kakhan for the storage and shipment of chromite ore because there are no chromite storage facilities at Mina Qaboos, the port currently used.

Pakistan.—The Baluchistan Development Authority (BDA) was involved in three chromium-related development projects: one in mining, one in refractory brick production, and one in chromium chemicals production. A reorganized Pakistan Chrome Mines Ltd. could produce 9,000 tons per year under an agreement with BDA, the mineral rights owner, according to a new plan. BDA also proposed construction of a refractory brick plant. The plant, to be at Quetta, would produce chrome-magnesite and magnesite-chrome bricks. In addition, BDA proposed a chromium chemicals plant. The plant, to be at Quetta, would produce about 20,000 tons per year of sodium dichromate.

Papua New Guinea.—Nord Resources Corp. (NRC) of the United States continued development of the Ramu River lateritic deposit for its chromium content. NRC, in a joint venture with Carpentaria Exploration Co., was exploring the property and developing mining plans. NRC set proven reserves at 78 million tons in the Canga zone and 50 million in the Limonite zone, each grading at 4.0% chromium. The material can be concentrated to a 45%-Cr_2O_3 concentrate with a chromium-to-iron ratio of 1.6:1. High-carbon, low-chromium ferrochromium of 52%-chromium content has been produced by submerged arc and by plasma arc furnaces. Several mining plans were being evaluated.

Philippines.—Ferrochrome Philippines Inc. (FPI) modified its production facilities. FPI introduced the use of a water-cooled furnace cover and a gas cooling system to its process. The water-cooled furnace cover increases the time between cover maintenance from 2 to 5 years. The gas cooling system recovers dust for reuse, permitting higher temperature furnace operation.

Sierra Leone.—Rickelson Oil and Gas Co. (United States) reported reduction in its area of interest to 1,893 square miles. That area contains all known chromium resources in Sierra Leone. Surface samples were assayed 44.5% to 46.7% Cr_2O_3 and chromium-to-iron ratio of about 3:1.

South Africa, Republic of.—The Waterkloof Mine was sold by Metallurg Inc. of the United States to General Mining Union Corp. Ltd. (Gencor). Waterkloof chromite ore was not usable by Metallurg's European chromium ferroalloy production facilities at Weiswiller, Federal Republic of Germany, and Trollhattan, Sweden.

The Tweefontein Mine started production in 1982 at an annual capacity of 650,000 tons. In 1984, Gencor planned to expand this mine to an annual capacity of 1 million tons by expanding preparation facilities and extending the mine's belt conveyor.

South African Manganese Amcor Ltd. (Samancor) converted three of its small electric furnaces at Meyerton to ferrochromium production with an annual capacity of 40,000 tons. With this temporary change, Samancor took advantage of the simultaneous high demand for ferrochromium and low demand for ferromanganese.

Middelburg Steel & Alloys (Pty.) Ltd. (MSA) started operation of a 20,000-kilovolt ampere (kV•A) plasma furnace at 16,000 kV•A. The furnace has an annual production capacity of 17,000 tons of ferrochromium. MSA planned to increase that capacity to 30,000 tons by preheating the furnace feed.

Gencor started production capacity expansion studies for its Tubatse ferrochromium plant at Steelpoort, Transvaal. Tubatse operates three 30,000-kV•A electric furnaces. Expansion completion was projected for 1987.

The state-run South African Railway raised freight and port services charges. The increases averaged 14.7%.

Sweden.—Scan Dust AB completed construction and started operation of its recycling plant at Landskrona. The plant recovers chromium from iron and steel mill baghouse dust, processing up to 80,000 tons per year.

The Government approved construction of an 86,000-ton-per-year-capacity ferrochromium plant at Malmo. The plant was to be completed in 1986 and operated under the name of Swedechrome. The plant was designed by and expected to be built by SKF Engineering AB utilizing SKF's 6-megawatt plasma arc generator. The plant was expected to cost about $62 million and employ about 100 people. The new plant was to sell excess energy to the local district heating authority.

Togo.—The National Bureau of Mines and Minerals announced a 5-year plan to develop Togo's mineral resources. The first stage of this program was to be a national minerals inventory. Chromium ore is thought to be in the Haito and Farenda areas.

Turkey.—Elazig Ferrochrome Works' modernization continued. Upon completion in 1985, the Elazig Ferrochrome Works will have increased its high-carbon ferrochromium production capacity from 60,000 to 170,000 tons.

Kromsan Bilesikleri Sanayi ve Ticaret (Chromium Compounds Industry and Trade) started operation at Mersin. The chemical plant's annual capacity is 22,000 tons of sodium dichromate, 8,500 tons of sodium sulfate, and 3,200 tons of chromium sulfate. This plant is Turkey's first chromium chemicals plant. The plant is owned by Turkiye Sise Cam Fabrikalari (Turkish Glass Works).

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

(Thousand short tons, gross weight)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Albania[e]	[r]840	[r]960	[r]960	990	960
Brazil[3]	345	[r]261	304	304	310
Cuba[4]	[r]31	23	30	37	[5]41
Cyprus	18	11	3	(6)	--
Finland[4]	399	454	380	271	280
Greece[7]	[r]46	[r]32	34	30	30
India	[r]352	369	374	465	485
Iran[e]	90	35	45	55	55
Japan	15	12	12	9	[5]7
Madagascar	198	110	49	50	[5]66
New Caledonia	2	[r]5	55	96	[5]93
Pakistan	3	[r]2	3	6	7
Philippines	547	484	355	294	300
South Africa, Republic of[4]	3,763	3,164	2,385	2,460	[5]3,314
Sudan	28	[r]28	[e]21	[r e]22	30
Turkey	[r]411	466	449	564	[5]670
U.S.S.R.[e 8]	[r]3,200	[r]3,200	[r]3,240	[r]3,240	3,300
Vietnam[e]	17	17	18	[r]18	20
Yugoslavia	(9)	(9)	--	--	--
Zimbabwe	[r]610	591	476	476	500
Total	[r]10,915	[r]10,224	9,193	9,387	10,468

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 2, 1985.
[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. Data for 1980 may include 45,000 to 55,000 short tons of run-of-mine ore that required beneficiation. Total run-of-mine crude ore production (not comparable to data for other countries) was as follows, in thousand short tons: 1980—919; 1981—1,021; 1982—736; 1983—517; and 1984—550 (estimated).
[4]Production of marketable product (direct-shipping lump ore plus concentrates and foundry sand).
[5]Reported figure.
[6]Revised to zero.
[7]Exports of direct-shipping ore plus production of concentrates.
[8]Estimates for 1980 and 1981 are based in part on output reported in Soviet sources as follows, in thousand short tons: 1980—3,700; and 1981—3,600.
[9]Less than 1/2 unit.

U.S.S.R.—Operation of a beneficiation and concentrating plant started at the Donskoye complex in western Kazakhstan. The plant had a capacity to process 2 million tons of ore per year.

United Kingdom.—The Department of Trade and Industry announced that the national strategic chromium stockpile was to be sold. Material was stocked in 1982 and 1983. Contents of the stockpile are unknown.

The British Geological Survey and British Open University reported results of a survey of chromitiferous rocks in Shetland

Isles. Two zones of chromite concentration were located on Unst Island and two pods on Feltar Island. The areas have accounted for small and intermittent chromite production since 1817.

Zimbabwe.—Zimbabwe Alloys Ltd. purchased the Zshivani chromium mine from Inyala Chrome Co. The mine was to be brought into production in 1985 at a capacity of 2,000 tons per month of ore and concentrate.

Zimbabwe Mining and Smelting Co. (Pvt.) Ltd. (ZIMASCO) brought its fifth furnace into production. ZIMASCO has six furnaces, but did not have chromite capacity to supply all six furnaces.

WORLD RESERVES

The Bureau of Mines completed a chromium mineral availability study for market economy countries. Eighty chromite operations in 10 countries were analyzed to determine the long-range cost of producing chromite ore or high-carbon ferrochromium from that ore. The analysis included categorizing resources by economic, physical, geologic, geographic, and production characteristics; estimation of mining costs including labor, material and supply, and equipment operation costs; estimation of operating costs including depreciation, taxes, royalties, and interest and reinvestment costs; and aggregation of cost-resource data into material availability versus cost representatives. The resource base analyzed in this report includes 1.3 billion tons of demonstrated resources.[8]

The Bureau of Mines published a directory of 43 domestic and 83 foreign chromium deposits that are part of its minerals availability system.[9] These deposits are the major market economy country contributors to world production. They are subject to the Bureau's systematic engineering-cost evaluation.

The USGS studied low-grade chromium resources. Because only two-thirds of 1% of chromite is outside of the Republic of South Africa (66%), Zimbabwe (33%), and the U.S.S.R. (0.3%), there exists a potential for severe supply disruption. Because of this potential, this study examined possible unconventional, low-grade chromium resources. The study found no unconventional minerals to have potential as a chromium source. Of five unconventional geological settings considered, three were found to have mining potential. Chromite from laterite deposits was found to have the greatest potential because that chromite could be a byproduct of current economic nickel mining operations.[10]

The USGS completed a study of the world's major chromite deposits. The study was carried out as part of the International Strategic Minerals Inventory program, a collective effort by Australia, Canada, the Federal Republic of Germany, the Republic of South Africa, and the United States. For 51 major deposits and districts in 14 countries, this study details location, geologic characteristics, resource characteristics, production, and production capacity. The distribution of chromite resources and production among countries and economic classes of countries were reported.[11]

TECHNOLOGY

The Bureau of Mines has principal responsibility for conducting chromium mineral-related research and for collecting, interpreting, and analyzing chromium mineral information. The Bureau conducts mining research to improve chromium mineral extraction technology, and mineral and material research to improve chromium mineral processing, use, and disposal technology.[12]

The Bureau of Mines conducted resource identification and beneficiation studies as part of its domestic mineral assessment program. The Bureau surveyed black sand deposits on the Pacific coast;[13] 2.5% chromic oxide was found at the Uba Goldfield, one of three areas surveyed. The Bureau evaluated the chromium mineral development potential of the Chugach National Forest, south-central Alaska.[14] The chromium mineral development potential was found to be low. The Bureau investigated chromite occurrences in the Kaiyuh Hills area of west-central Alaska,[15] analyzing 32 samples from 4 chromite deposits in the area. The Bureau reported field reconnaissance results for chromium at Mount Hurst Ultramafics, west-central Alaska. Geologic conditions, samples, and current infrastructure suggest economic chromite mining of the area to be unlikely. The Bureau upgraded high-iron domestic chromite concentrate to high-chromium concentrate by a laboratory carbonyl process.[16] Chromium-to-iron ratios were increased from 1.6:1 to 3:1 by converting iron oxides to iron pentacarbonyl and removing it in a carbon monoxide flow.

The Bureau studied stainless steel pickling solutions, dichromate etching solution, and superalloy and stainless steel scrap as part of its resource recovery program, and studied chromium-bearing slags for the purpose of preventing chromium leaching. The pickling of stainless steel was reviewed.[17] After annealing, stainless steel is pickled in a mixed acid. Pickling removes annealing scale and a thin surface oxide layer. A better understanding of the pickling process could lead to more efficient pickling; to reduced acid consumption, metal loss to the pickling bath, and pickling process time. Chromium and acid recovery processes were reviewed.[18] A Bureau waste chromic acid regeneration process was evaluated.[19] The electrolyte membrane cell technology was applied to the regeneration of aluminum surface preparation acids. The regeneration system performed successfully.

The Bureau developed a low-cost method to identify and sort stainless steel and superalloy scrap.[20] The method uses a thermoelectric instrument to sort into four categories. The contents of those categories are then further sorted using a hand-held optical emission spectroscope. This sequence can be repeated to segregate scrap by alloy classes. The Bureau also developed a quick economical process to dissolve superalloy scrap.[21] This process may remove a major obstacle to the recovery of chromium from superalloy scrap. The Bureau studied chromium leach rates of stainless steel and other alloy slags subject to acid precipitation conditions.[22] Conditions for maximum chromium leachability were established and methods to change those conditions were identified.

The Bureau of Mines has studied the potential for reducing the chromium content of stainless and alloy steels as part of its chromium substitution program. Aluminum and silicon were studied as partial substitutes for chromium in type 304 stainless steel.[23] These substitutes are used to retain oxidation resistance and fabrication properties. Specific chemical formulations were selected and tested for oxidation resistance, stress rupture, and tensil properties. Silicon was found to have potential as a partial substitute for chromium in stainless steel used for heat-resisting applications. Molybdenum, copper, and vanadium were studied as partial substitutes for chromium in type 304 stainless steel.[24] These substitutes are used to retain corrosion resistance. Specific chemical formulations were developed and tested. Two were found to be comparable to type 304 stainless steel with respect to welding properties, tensil properties, and corrosion resistance. The Bureau studied specially strengthened, low-chromium steel as a potential substitute for type 304 stainless steel used in heat-resisting applications.[25] The specially strengthened alloy had stress rupture properties similar to type 304 stainless steel. However, this alloy possessed brittleness during stress rupture and tensil testing, and it had higher than expected oxidation rates. The Bureau also studied nitriding of alloy and stainless steels as a potential method for reducing chromium content in steels while retaining or improving corrosion resistance.[26] The method of nitriding and the corrosion environment affected corrosion rates significantly. In addition, various chromium substitution options were assessed.[27] It was found that chromium substitutes useful for room temperature corrosion resistance were of little use for high-temperature oxidation resistance application and vice versa.

The National Bureau of Standards (NBS) patented and made available for leasing a process for electroplating nickel-chromium alloys on carbon steel, aluminum, and other cathodic substrates.[28] NBS reported thick adherent coatings of controllable chromium content between 0.1 and 60 weight percent. The coatings are produced by pulsed current deposition from electrolyte containing trivalent chromium salt.

The U.S. Department of Energy studied black chromium coatings for industrial solar collectors.[29] A comparison of experimental data and theoretical calculations have led to the selection of a model for optical reflectance calculation.

The National Aeronautics and Space Administration licensed its iron-chromium battery technology to the Standard Oil Co. of Ohio.[30] The battery's chemical reactions occur in solution, so it is possible to store charged reactants outside of the reaction cell. The battery uses iron chloride and chromium chloride dissolved in hydrochloric acid to make 1.15-volt cells. At a chromium consumption rate of 15 pounds per kilowatt, a 10-kilowatt prototype battery would require 150 pounds of chromium.

The U.S. Department of Defense studied chromium plating and the heat treatment of chromium-plated steel.[31] The U.S. Army studied erosion of chromium-coated steel. The erosion resistance of chromium coatings under the conditions studied was found to depend on the substrate material. The Army also reviewed chromium erosion and its control in large caliber weapons. Such erosion was found to be generally attributed to bore temperature and thermal, chemical, and mechanical effects. The Army studied the effects of heat treatment on chromium-plated steel.

Some processes associated with ferrochromium production are fine ore agglomeration, melting, slag chemistry, and the beneficiation of chromite by prereduction of iron followed by leaching. Plasma processing was found to offer many advantages in the electrical power-intensive ferrochromium production process. Site specific cost analyses were found to be necessary to determine plasma melting utility, with electric power playing a significant role. The Republic of South Africa was identified as the leading plasma technology user for ferroalloy production with a capacity of over 70 megawatts.[32] The South African Council for Mineral Technology described the installation of its 100-kV•A plasma furnaces.[33] The U.S.S.R. studied the potential for smelting from natural ores.[34] Typically, a smelter is designed to recover one component of an ore with secondary recovery of remaining components. An alloyed pig iron for production of alloy cast iron was produced while conserving the natural components of ore.

A copper-chromium alloy was developed using unconventional production techniques. The development of chromium use in iron-based alloys was primarily in types 409 and 3CR12 steels. The use of chromium resulted from savings owing to reduced corrosion and oxidation over that of alloy or carbon steel. Improved fabrication characteristics of type 409 has extended its use. The toughness and weldability of type 3CR12 improved over previous 12% chromium steels resulting in expanded potential for use of this material in structural plates.

Canada developed a chromic acid recovery system for chromium plating processes. Chromic acid recovery was accomplished via a closed loop system using filtration and ion exchange beds. Japan reported development of a steel pickling acid recovery system.

Israel identified the azolla plant, a water plant indigenous to the Far East, Africa, and Asia, as an effective biological filter for chromium. Two processes using azolla were developed; one uses it as a filter, the other grows it in industrial sewage ponds. Along somewhat related lines, General Electric Co. developed a continuous process to extract chromium from waste water using hollow fiber technology.

Water insoluble chromates (lead and barium chromate) were found to produce no significant incidence of lung cancer, while water soluble chromates (strontium, calcium, and zinc chromate) exerted carcinogenic effects under the test conditions.[35]

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[1]Physical scientist, Division of Ferrous Metals.

[2]National Materials Advisory Board. Priorities for Detailed Quality Assessments of the National Defense Stockpile Nonfuel Materials. Natl. Acad. Sci., NMAB-440, 1984, 66 pp.

[3]American Society for Metals Panel. Quality Assessment of Chromium Metals for the National Defense Stockpile Inventory. Off. Strategic Resour., U.S. Dep. Commerce, Washington, DC, 1984, 35 pp.

[4]Lipin, B. R., N. Wetzel, and S. M. Heinrick. The Emma Bell Deposit, Siskiyou Co., California: A Possible Low-Grade Source of Chromite. U.S. Geol. Surv. Open File Rep. 83-0816, 1984, 16 pp.

[5]U.S. Environmental Protection Agency. Health Assessment Document for Chromium—Final Report. EPA-600/8-83-014F, Aug. 1984, 300 pp.

[6]Office of Technology Assessment. Strategic Materials: Technology to Reduce U.S. Import Vulnerability—Summary. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, 1984, GPO Stock No. 052-003-00979-0, 56 pp.

[7]———. Comparative Access of Selected Minerals to Transport in Alaska and Continental United States. OTA-C-166, 34 pp.

[8]Thomas, P. R., and E. H. Boyle, Jr. Chromium Availability—Market Economy Countries. A Minerals Availability Program Appraisal. BuMines IC 8977, 1984, 86 pp.

[9]Coppa, L. V., and C. A. Difrancesco. Minerals Availability Directory of Mineral Deposits for 23 Strategic Mineral Commodities. BuMines OFR 152-84, 1984, 216 pp.

[10]Lipin, B. R. Low-Grade Chromium Resources. Ch. in Cameron volume on unconventional mineral deposits, ed. by W. C. Shanks. Am. Inst. Min., Metall. and Pet. Eng., 1983, pp. 47-60.

[11]DeYoung, J. H., M. P. Lee, and B. R. Lipin. International Strategic Minerals Inventory Summary Report—Chromium. U.S. Geol. Surv. Circ. 930-B, 1984, 41 pp.

[12]Peterson, J. R. (comp. and ed.). Bureau of Mines Research 1984. A Summary of Significant Results in Mineral Technology and Economics. BuMines Spec. Publ. SP 2-84, 1984, 138 pp.

[13]Gomes, J. Black Sand Survey Along the Pacific Coast. Paper in Fifth Annual Conference on Alaskan Placer Mining (Univ. Alaska, Fairbanks, AK, Mar. 30-31, 1983), comp. and ed. by B. W. Campbell, J. Madonna, and M. S. Husted. Miner. Ind. Res. Lab. MIRL Rep. No. 68, 1983, pp. 49-52.

[14]Hoekzema, R. B. Strategic and Critical Mineral Development Potential of the Chugach National Forest, South-Central Alaska. BuMines OFR 215-84, 1984, 64 pp.

[15]Foley, J. Y., T. Hinderman, D. E. Kirby, and C. L. Mardock. Chromite Occurrences in the Kaiyuh Hills, West-Central Alaska. BuMines OFR 178-84, 1984, 27 pp.

[16]Visnapuu, A., and W. M. Dressel. Upgrading High-Iron Chromite Concentrates by Carbonyl Processing. Ch. in Process Mineralogy III. Applications in Metallurgy, Coal, Concrete, Smelting and Exploration (SME-AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983), ed. by W. Petruk. Soc. Min. Eng. AIME, New York, 1984, pp. 259-274.

[17]Covino, B. S., J. V. Scalera, and P. M. Fabis. Pickling of Stainless Steels—A Review. BuMines IC 8985, 1984, 15 pp.

[18]Stephenson, J. B., J. C. Hogan, and R. S. Kaplan. Recycling and Metal Recovery Technology for Stainless Steel Pickling Liquors. Environ. Prog., v. 3, No. 1, 1984, pp. 50-53.

[19]George, L. C., N. L. Rogers, and G. L. Horter. Recovery and Recycling of Chromium Bearing Solutions. Paper in Proc. of the 29th Natl. Soc. for the Advancement of Mater. and Process Eng. (SAMPE) Symp. (Reno, NV, Apr. 3-5, 1984). V. 29, Apr. 1984, pp. 853-858.

[20]Brown, R. D., W. D. Riley, and C. A. Zieb. Rapid Identification of Stainless Steel and Superalloy Scrap. BuMines RI 8858, 1984, 23 pp.

[21]Atkinson, G. B. Increasing the Leaching Rate of Bulk Superalloy Scrap by Melting With Aluminum. BuMines RI 8833, 1983, 11 pp.

[22]Kilau, H. W., and I. D. Shah. Preventing Chromium Leaching From Waste Slag Exposed to Simulated Acid Precipitation: A Laboratory Study. BuMines RI 8878, 1984, 21 pp.

[23]Glenn, M. L., and D. E. Larson. Reduced-Chromium Stainless Steel Substitutes Containing Silicon and Aluminum. BuMines RI 8918, 1984, 13 pp.

[24]Rhoads, S. C., S. J. Bullard, and M. L. Glenn. Partial Replacement of Chromium in Austenitic Stainless Steels by Molybdenum, Copper, and Vanadium. BuMines RI 8900, 1984, 13 pp.

[25]Glenn, M. L., and J. S. Dunning. Low-Chromium Heat-Resisting Ferritic Alloys Strengthened by the Chi Phase. BuMines RI 8860, 1984, 18 pp.

[26]Scalera, J. V. Corrosion Resistance of Nitrided Low-Alloy Steels. BuMines RI 8894, 1984, 20 pp.

[27]Dunning, J. S., M. L. Glen, and H. W. Leavenworth. Substitutes for Chromium in Stainless Steel. Met. Prog., Oct. 1984, pp. 19-24.

[28]U.S. Department of Commerce, National Technical Information Service. Plating Process To Improve Use of Chromium Has Been Developed. NTIS Tech Note, Dec. 1984, 1 p.

[29]Sweet, J. N., R. B. Pettit, and M. B. Chamberlain. Optical Modeling and Aging Characteristics of Thermally Stable Black Chrome Solar.

[30]Chemical Engineering. V. 91, No. 18, 1984, p. 14.

[31]Lakshminarayanan, G. R., and W. T. Ebihara. An Evaluation of the Endurance of Chromized and Plated Chromium Coatings in a Hot Gas Erosion Atmosphere. Thin Solid Films, v. 107, 1983, pp. 437-442.

[32]American Metal Market. V. 92, No. 95. pp. 14-15. Metal Progress. V. 126, No. 8, p. 15.

[33]Curr, T. R. The Installation of a 100-kV•A A. C. Plasma Furnace at MINTEK. Coun. Miner. Tech., Randburg, Republic of South Africa, Mintek Rep. No. M135, May 1984, 12 pp.

[34]Machikin, V. I., A. M. Zborshchick, A. E. Burochkin, P. E. Vlasov, and V. P. Moiseev. Naturally Alloyed Ores—A Reserve for Conserving Ferroalloys. Metallurgist (U.S.S.R.), v. 27, Nos. 11-12, Nov.-Dec. 1983, pp. 399-400.

[35]Polymers Paint Colour Journal. The European Manufacturers of Lead Chromate and Lead Molybdate Pigments e.v. Lead Chromates in the Paint Industry—A Risk for the Environment. Aug. 22, 1984, pp. 574, 577.

Clays

By Sarkis G. Ampian[1]

Total quantity of clays sold or used by domestic producers increased 8% in tonnage and 11% in value. Clays in 1 or more of 6 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 1984. Clay production, as in 1983, 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, Mississippi, Wyoming, North Carolina, California, and Alabama. Continued unpredictable shortages of natural gas and the cost of fuels were still major concerns to clay producers and manufacturers. Industrywide, efforts, again, to both economize and to obtain standby fuels persisted. 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. Increases in production of the specialty clays, ball clay, bentonite, fire clay, and kaolin, were caused largely by an improvement in the overall economy. Production of fuller's earth decreased.

Kaolin accounted for 18% of the clay production but 61% of clay value.

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 1,167 operations covered by the survey, 1,097 responded, representing 94% 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)

	1980	1981	1982	1983	1984
Domestic clays sold or used by producers:					
Quantity	48,790	44,379	35,345	40,858	44,236
Value	$898,947	$988,845	$825,064	$931,092	$1,037,233
Exports:[2]					
Quantity	3,214	3,151	2,619	2,484	2,699
Value	$263,147	$292,914	$267,700	$254,237	$295,733
Imports for consumption:[2]					
Quantity	34	33	24	21	32
Value	$6,688	$7,895	$4,514	$3,488	$4,868
Clay refractories shipments:[2] Value	$557,386	$609,949	$559,655	$595,299	$782,308
Clay construction products shipments:[2] Value	$1,061,507	$971,824	$923,459	$1,160,543	$1,342,196

[1]Excludes Puerto Rico.
[2]U.S. Department of Commerce.

Table 2.—Clays sold or used by producers in the United States in 1984, 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	1,523,073	144,267	--	238,520	[2]1,905,860	[2]$30,499,956
Arizona	--	20,494	117,134	--	--	--	137,628	818,593
Arkansas	--	--	933,420	--	--	85,898	1,019,318	7,838,122
California	246	94,543	1,945,840	W	--	59,705	[3]2,100,334	[3]23,868,369
Colorado	--	150	293,347	14,795	--	--	308,292	2,111,009
Connecticut	--	--	99,078	--	--	--	99,078	564,620
Florida	--	--	279,947	--	459,502	33,004	772,453	34,048,157
Georgia	--	--	1,601,268	--	569,083	6,508,319	8,678,670	600,029,223
Idaho	--	W	--	W	--	1,464	[2 3]1,464	243,429
Illinois	--	--	253,381	--	W	--	[4]253,381	[4]939,966
Indiana	--	--	653,135	W	--	--	[3]653,135	[3]2,085,427
Iowa	--	--	623,169	--	--	--	623,169	2,694,651
Kansas	--	20,000	897,722	--	--	--	917,722	5,536,598
Kentucky	W	--	661,644	W	--	--	802,233	7,277,490
Louisiana	--	7,679	539,472	--	--	--	547,151	[2]10,858,373
Maine	--	--	43,488	--	--	--	43,488	96,522
Maryland	W	--	346,963	--	--	--	[5]346,963	[5]1,483,631
Massachusetts	--	--	239,929	--	--	--	239,929	1,211,614
Michigan	--	--	1,320,774	--	--	--	1,320,774	5,051,586
Minnesota	--	--	W	--	--	W	W	W
Mississippi	W	207,553	1,870,938	--	W	--	2,397,660	30,565,340
Missouri	--	--	1,079,094	427,681	W	68,137	[4]1,574,912	[4]14,665,696
Montana	--	380,561	16,422	--	--	--	396,983	15,260,001
Nebraska	--	--	179,946	--	--	--	179,946	555,818
Nevada	--	20,092	--	--	W	W	[4 6]20,092	[4 6]1,191,011
New Hampshire	--	--	W	--	--	--	W	W
New Jersey	--	--	50,000	12,018	--	--	62,018	611,000
New Mexico	--	--	64,784	1,813	--	--	66,597	143,306
New York	W	--	543,368	--	--	--	[5]543,368	[5]2,434,776
North Carolina	--	--	2,280,634	--	--	46,787	2,327,421	8,986,641
North Dakota	--	--	W	--	--	--	W	W
Ohio	--	--	1,656,686	303,327	--	--	1,960,013	10,472,960
Oklahoma	--	--	979,291	--	--	--	979,291	2,498,178
Oregon	--	--	189,167	--	--	--	189,167	288,443
Pennsylvania	--	--	902,448	60,507	--	W	[6]962,955	[6]4,050,275
Puerto Rico	--	--	127,966	--	--	--	127,966	266,435
South Carolina	--	--	1,057,061	--	W	776,567	[4]1,833,628	[4]36,809,446
South Dakota	--	W	119,149	--	--	--	[2]119,149	[2]343,149
Tennessee	606,870	W	560,278	--	W	--	1,266,785	30,207,029
Texas	24,515	62,345	3,406,593	24,251	W	W	3,593,812	23,050,952
Utah	--	3,994	310,439	411	W	--	[4]314,844	[4]2,222,596
Virginia	--	--	687,968	--	24,000	--	711,968	6,003,785
Washington	--	--	285,961	6,000	--	--	291,961	[3]1,646,120
West Virginia	--	--	283,328	98,064	--	--	381,392	3,409,908
Wyoming	--	2,183,706	213,350	--	--	--	2,397,056	67,290,102
Undistributed	227,942	153,347	115,492	51,840	846,560	134,268	[7]893,946	[7]37,269,564
Total	859,573	3,154,464	29,353,147	1,144,974	1,899,145	7,952,669	44,363,972	1,037,499,867

W Withheld to avoid disclosing company proprietary data; included with "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 from which producers sold or used clays in the United States in 1984, by State[1]

State	Ball clay	Bentonite	Common clay and shale	Fire clay	Fuller's earth	Kaolin	Total
Alabama	--	1	25	6	--	11	43
Arizona	--	4	5	--	--	--	9
Arkansas	--	--	18	--	--	3	21
California	1	5	56	1	--	5	68
Colorado	--	14	29	8	--	--	51
Connecticut	--	--	2	--	--	--	2
Florida	--	--	3	--	4	1	8
Georgia	--	--	18	--	10	83	111
Idaho	--	1	2	1	--	1	5
Illinois	--	--	9	--	2	--	11
Indiana	--	--	20	2	--	--	22
Iowa	--	--	11	--	--	--	11
Kansas	--	1	21	--	--	--	22
Kentucky	6	--	11	2	--	--	19
Louisiana	--	1	8	--	--	--	9
Maine	--	--	4	--	--	--	4
Maryland	1	--	7	--	--	--	8
Massachusetts	--	--	3	--	--	--	3
Michigan	--	--	7	--	--	--	7
Minnesota	--	--	1	--	--	1	2
Mississippi	1	4	23	--	2	--	30
Missouri	--	--	11	54	2	1	68
Montana	--	16	5	--	--	--	21
Nebraska	--	--	5	--	--	--	5
Nevada	--	6	--	--	1	2	9
New Hampshire	--	--	1	--	--	--	1
New Jersey	--	--	2	1	--	--	3
New Mexico	--	--	4	2	--	--	6
New York	1	--	11	--	--	--	12
North Carolina	--	--	51	--	--	2	53
North Dakota	--	--	3	--	--	--	3
Ohio	--	--	52	15	--	--	67
Oklahoma	--	--	16	--	--	--	16
Oregon	--	--	6	--	--	--	6
Pennsylvania	--	--	35	20	--	1	56
Puerto Rico	--	--	2	--	--	--	2
South Carolina	--	--	26	--	1	19	46
South Dakota	--	1	1	--	--	--	2
Tennessee	23	--	10	--	1	--	34
Texas	1	10	64	2	2	1	80
Utah	--	2	15	1	1	--	19
Virginia	--	--	14	--	1	--	15
Washington	--	--	9	2	--	--	11
West Virginia	--	--	3	1	--	--	4
Wyoming	--	87	2	--	--	--	89
Total	34	153	631	118	27	131	1,094

[1]Includes both active and idle operations.

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Domestic production of kaolin increased 10% to nearly 8.0 million short tons. The average unit value of all grades of kaolin decreased 2% to $79.77 per ton. Kaolin was produced in 13 States. Two States, Georgia and South Carolina, again accounted for 92% of total production. Alabama ranked third, and Arkansas, fourth. Output in all States, except for Arkansas, Idaho, and Missouri, increased. Kaolin producers reported major end uses for their clay as follows: paper coating, 31%; paper filling, 12%; refractories, 5%; chemicals, common and face brick, rubber, and fiberglass and other insulation, 4% each; and catalysts, 3%.

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.

Kaolin production was buoyed by the continued growth of the economy, particularly in the record high level of paper production. Capacity increases in both water-washed and calcined grades that occurred during the early 1980's continued to cause some downward pressure on prices because of the remaining overhang. No price increases, except for certain calcined grades, have been advanced for the past 4 years, causing lower profit margins for the producers. Kaolin sales for refractory use increased slightly. The refractory industry was still undergoing long-range modifications brought about by changes in technology and imports. The trend from lower quality fire clays to higher alumina refractories, such as made from kaolin, should bode well for the kaolin producers. Production of paper-grade kaolins, low-temperature calcined, water-washed, and delaminated, increased 15%, 7%, and 6%, respectively.

All Georgia water-washed kaolin producers and South Carolina air-float producers continued to modernize, instead of expanding, to reduce drying and other energy or nonenergy related costs. Particular emphasis continued to be placed on heat recovery, improved filtration, and increased high-solids slurry shipments. Notable exceptions to the above were the activities of J. M. Huber Corp., Engelhard Corp.'s Specialty Chemicals Div., and Anglo-American Clays Corp. Huber's Clay Div. announced the opening of a large, new calcined clay-processing facility in Huber, GA. The new production facility will provide an additional 40,000 tons per year of paper-, plastic-, and paint-grade clays. Engelhard announced multimillion-dollar expansion projects for its calcined paper grades at McIntyre, GA, and at its catalyst plant in Attapulgus, GA. Both expansions were scheduled for completion in 1985. Anglo-American, in another calcined clay project, began installing a new $8 million calciner and ancilliary equipment at its Sandersville, GA, operation.

In a major kaolin acquisition, Engelhard agreed in principle to purchase Freeport Kaolin Co. from Freeport-McMoRan Inc. for $100 million. Engelhard, with kaolin operations at Sandersville, Irwinton, McIntyre, and Gardner (all in Georgia) will be joined by Freeport's Georgia operations at Sandersville and Gordon. In another acquisition, United Catalysts Inc. of Louisville, KY, bought the kaolin mining and processing facilities of the Albion Kaolin Co. at Hephzibah, GA, from McDermott Corp.'s Babcock and Wilcox Inc. of Augusta, GA. Albion planned to expand its new facilities and diversify its product line to include both air-floated and water-washed clays. Sud-Chemie AG of Munich, Federal Republic of Germany, a major shareholder in United Catalysts, also produces clay products and catalysts. Another acquisition showed Union Carbide Corp. purchasing Katalistiks International BV of the Netherlands for over $100 million. The previous owners of Katalistiks were English China Clays PLC (ECC) in the United Kingdom, EKA in Sweden, and CRI International Inc. in Baltimore, MD. Katalistiks manufactures a fluid-cracking catalyst for crude oil from Georgia kaolin at its 50,000-ton-per-year plant in Savannah, GA.

A comprehensive economic study on the contribution of the Georgia kaolin industry to the State's economy was published.[2] This work, prepared by an independent consultant, provides a rare opportunity for the public to receive information about an industry and its economic impact on individual counties and a State, in particular.

Exports of kaolin, as reported by the U.S. Department of Commerce, increased 6% to 1.4 million tons valued at $170 million, despite a strong U.S. dollar. Kaolin, including calcined material, was exported to 68 countries. The major recipients were Japan, 33%; Canada, 19%; the Netherlands, 13%; Italy, 8%; and Mexico, 6%. Kaolin producers reported end uses for their exports as follows: paper coating, 65%; paper filling, 15%; refractories, 10%; rubber, 3%; paint, 2%; and other, including ceramics and plastics, the remaining 5%.

Kaolin imports increased 43% to 10,700 tons valued at $838,000. The United Kingdom supplied 95%. The unit price of kaolin imported from the United Kingdom decreased 21% to $77.68.

Kaolin prices quoted in the trade journals remained unchanged. Chemical Marketing Reporter, December 31, 1984, 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 4.—Kaolin sold or used by producers in the United States, by State

State	1983		1984	
	Short tons	Value	Short tons	Value
Alabama	101,269	$8,673,861	238,520	$18,631,800
Arizona	(1)	(1)	--	--
Arkansas	109,476	8,393,582	85,898	5,681,092
California	44,367	1,163,999	59,705	1,838,393
Florida	28,943	2,165,080	33,004	2,438,372
Georgia	5,885,746	523,406,722	6,508,319	562,696,774
Idaho	W	W	1,464	W
Missouri	103,118	2,652,195	68,137	1,946,674
North Carolina	W	W	46,787	1,075,548
South Carolina	742,178	31,409,140	776,567	33,404,087
Other[2]	187,606	6,887,309	134,268	6,674,390
Total	7,202,704	584,751,888	7,952,669	634,387,130

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Less than 1/2 unit.
[2]Includes Minnesota, Nevada, Pennsylvania, Tennessee (1983), Texas, and data indicated by symbol W.

Table 5.—Kaolin sold or used by producers in the United States, by kind

Kind	1983		1984	
	Short tons	Value	Short tons	Value
Air-float	965,055	$54,678,774	1,153,291	$62,401,704
Calcined[1]	1,006,616	138,276,614	1,204,117	157,909,403
Delaminated	722,128	68,527,254	764,566	72,529,476
Unprocessed	843,071	11,710,948	891,645	16,734,107
Water-washed	3,665,834	311,558,298	3,939,050	324,812,440
Total	7,202,704	584,751,888	7,952,669	634,387,130

[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
1983				
Georgia and Alabama	423,682	$40,677,908	[2]448,143	[1]$86,765,361
Other	[2]89,541	[2]7,861,746	[3]45,250	[3]2,971,599
Total	513,223	48,539,654	493,393	89,736,960
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

[1]Excludes Alabama.
[2]Includes Arkansas, California, and Idaho.
[3]Includes Pennsylvania, South Carolina, and Texas.

Table 7.—Georgia kaolin sold or used by producers, by kind

Kind	1983		1984	
	Short tons	Value	Short tons	Value
Air-float	395,422	$21,359,864	591,869	$27,989,083
Calcined[1]	770,556	118,769,408	850,372	129,410,496
Delaminated	722,128	68,527,254	764,566	72,529,476
Unprocessed	360,942	4,699,555	395,094	9,799,483
Water-washed	3,636,698	310,050,641	3,906,418	322,968,236
Total	5,885,746	523,406,722	6,508,319	562,696,774

[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	1983 Air-float	1983 Unprocessed[1]	1983 Water-washed[2]	1983 Total	1984 Air-float	1984 Unprocessed[1]	1984 Water-washed[2]	1984 Total
Domestic:								
Adhesives	14,983	--	55,967	70,950	9,556	--	63,276	72,832
Aluminum sulfate and other chemicals	8,931	219,890	937	229,758	--	250,000	8,819	258,819
Animal feed	--	242	509	751	17	--	142	159
Asphalt tile and linoleum	3,635	--	--	3,635	3,635	--	--	3,635
Catalysts (oil-refining)	56,776	--	113,392	170,168	54,839	--	115,854	170,693
Electrical porcelain	8,462	7,263	--	15,725	16,393	--	--	16,393
Face brick	45	19,801	--	19,846	--	20,700	--	20,700
Fiberglass and mineral wool	70,351	11,477	47,301	129,129	117,520	--	51,123	168,643
Fine china and dinnerware; crockery and earthenware	14,570	3,740	--	18,310	37,813	1,399	--	39,212
Firebrick, blocks and shapes	408	10,900	--	11,308	2,567	4,643	--	7,210
Floor and wall tile, ceramic	19,931	--	--	19,931	20,866	--	--	20,866
Flue linings and high-alumina brick, specialties, glazes, glass, enamels	29,042	--	--	29,042	20,000	3,030	--	23,030
Foundry sand	--	--	685	685	--	--	41	41
Grogs and calcines, refractory	1,245	215,043	--	216,288	--	245,000	--	245,000
Ink	W	--	--	W	W	--	W	W
Kiln furniture, mortar, cement	W	W	--	W	W	W	--	W
Medical, pharmaceutical, cosmetic	--	--	1,611	1,611	--	--	1,894	1,894
Paint	5,285	--	107,667	112,952	14,314	--	187,473	201,787
Paper coating	--	--	2,321,663	2,321,663	8,827	--	2,465,748	2,474,575
Paper filling	11,533	4,035	979,012	994,580	89,484	--	890,799	980,283
Plastics	499	26	38,088	38,613	2,400	--	44,160	46,560
Portland cement	--	--	--	--	--	72,700	--	72,700
Pottery	7,981	699	--	8,680	271	699	--	970
Roofing granules	6,308	7,316	--	13,624	17,944	--	--	17,944
Rubber	24,943	--	52,275	77,218	24,803	--	60,487	85,290
Sanitary ware	25,259	41,225	33	66,517	108,579	11,891	51	120,521
Miscellaneous, air-float:								
Common brick, fertilizers, gypsum products, pesticides and related products, roofing and structural tile, uses not specified	20,509	--	--	20,509	11,190	--	--	11,190
Miscellaneous, unprocessed:								
Fertilizers, pesticides and related products, uses not specified	--	11,086	--	11,086	--	--	--	--
Miscellaneous, water-washed:								
Gypsum products, pesticides and related products, waterproofing and sealing, fertilizers, uses not specified	--	--	81,663	81,663	--	--	57,127	57,127
Undistributed	8,715	23,855	--	32,570	19,873	30,032	220	50,125
Total	339,411	576,598	3,800,803	4,716,812	580,891	640,094	3,947,214	5,168,199

Exports:								
Paint	4,352	--	29,403	33,755	126	--	33,480	33,606
Paper coating	41,543	--	840,559	882,102	--	--	941,417	941,417
Paper filling	887	--	106,974	107,861	134	--	217,242	217,376
Plastics	--	--	21,116	21,116	21	--	22,935	22,956
Refractories	8,535	106,757	--	115,292	110	95,000	823	95,933
Rubber	188	--	595	783	24	--	785	809
Undistributed	506	--	7,519	8,025	10,563	--	17,460	28,023
Total	56,011	106,757	1,006,166	1,168,934	10,978	95,000	1,234,142	1,340,120
Grand total	395,422	683,355	4,806,969	5,885,746	591,869	735,094	5,181,356	6,508,319

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	1983		1984	
	Short tons	Value	Short tons	Value
Air-float[1]	510,189	$29,976,858	530,208	$32,188,917
Unprocessed	231,989	1,432,282	246,359	1,215,170
Total	742,178	31,409,140	776,567	33,404,087

[1]Includes water-washed.

Table 10.—South Carolina kaolin sold or used by producers, by kind and use

(Short tons)

Kind and use	1983	1984
Air-float:[1]		
Adhesives	17,693	16,751
Animal feed and pet waste absorbent	1,269	6,844
Ceramics[2]	5,453	5,843
Fertilizers and pesticides and related products	21,281	19,300
Fiberglass	100,099	82,149
Paint	1,671	365
Paper coating and filling	2,980	1,488
Plastics	14,804	12,351
Rubber	196,452	204,627
Other refractories[3]	4,157	9,318
Other uses[4]	106,914	108,514
Exports[5]	37,416	62,658
Total	510,189	530,208
Unprocessed: Face brick and uses not specified	231,989	246,359
Grand total	742,178	776,567

[1]Includes water-washed.
[2]Includes floor and wall tile, pottery, and roofing granules.
[3]Includes refractory grogs and calcines; 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 uses not specified.
[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	1983 Air-float	1983 Unprocessed[1]	1983 Water-washed[2]	1983 Total	1984 Air-float	1984 Unprocessed[1]	1984 Water-washed[2]	1984 Total
Domestic:								
Adhesives	33,804	--	57,967	91,771	26,307	--	66,733	93,040
Aluminum sulfate and other chemicals	24,913	329,826	4,122	358,861	--	327,497	10,544	338,041
Animal feed	1,326	242	4,552	6,120	6,861	--	5,526	12,387
Brick, common and face	229	305,750	--	305,979	5,213	319,340	--	324,553
Catalysts (oil- and gas-refining)	124,744	--	113,392	238,136	114,799	30,000	115,854	260,653
Cement, portland	--	46,507	--	46,507	--	134,240	1,336	135,576
Crockery and other earthenware	W	W	--	W	W	--	W	W
Electrical porcelain	20,083	7,263	366	27,712	26,871	--	--	26,871
Fertilizers[3]	7,011	6,015	2,818	15,844	11,300	--	2,986	14,286
Fiberglass; mineral wool and other insulation	183,209	11,477	61,538	256,224	212,174	--	66,607	278,781
Fine china and dinnerware	20,104	1,399	855	22,358	31,767	1,399	1,240	34,406
Firebrick, blocks and shapes	1,951	10,900	--	12,851	7,814	4,643	--	12,457
Floor and wall tile; ceramic glazes, glass, enamel	32,253	2,826	3,974	39,053	30,477	2,820	--	33,297
Flue linings; high-alumina brick and specialties	29,564	81,254	--	110,818	20,000	47,818	--	67,818
Foundry sand	--	--	685	685	869	--	41	910
Grogs and calcines, refractory	4,884	324,599	--	329,483	4,886	417,062	--	421,948
Gypsum products and wallboard	4,544	--	12,634	17,178	8,324	7,249	2,759	18,332
Ink	W	--	--	W	W	--	W	W
Kiln furniture and refractory mortar and cement	9,234	23,855	2,000	35,089	17,662	30,032	--	47,694
Linoleum and asphalt tile	3,635	--	--	3,635	14,098	--	7,000	21,098
Medical, pharmaceutical, cosmetic	W	--	W	2,674	1,244	--	1,894	3,138
Paint	6,956	903	130,742	138,601	14,679	849	214,475	230,003
Paper coating	--	--	2,321,663	2,321,663	8,827	--	2,465,748	2,474,575
Paper filling	15,466	4,035	981,012	1,000,513	90,972	--	893,799	984,771
Pesticides and related products	16,069	171	1,438	17,678	8,073	31,750	2,458	42,281
Plastics	15,346	--	39,114	54,460	14,751	--	44,160	58,911
Pottery	11,632	699	1,658	13,989	4,568	699	1,712	6,979
Roofing granules	8,925	7,316	--	16,241	19,288	--	4,152	23,440
Roofing and structural tile	850	--	1,000	1,850	353	--	--	353
Rubber	223,857	--	55,232	279,089	229,430	--	65,139	294,569
Sanitary ware	33,299	41,225	33	74,557	109,912	11,891	51	121,854
Waterproofing and sealing	--	--	W	W	W	--	W	W
Miscellaneous	35,229	43,275	77,056	[4]152,886	36,361	16,131	60,713	113,205
Total	869,117	1,249,537	3,873,851	5,992,505	1,077,880	1,383,420	4,034,927	6,496,227

See footnotes at end of table.

Table 11.—Kaolin sold or used by producers in the United States, by use —Continued

(Short tons)

Use	1983 Air-float	1983 Unprocessed[1]	1983 Water-washed[2]	1983 Total	1984 Air-float	1984 Unprocessed[1]	1984 Water-washed[2]	1984 Total
Exports:								
Ceramics	2,985	--	959	3,944	3,551	--	--	3,551
Foundry sand; grogs and calcines; other refractories	9,570	106,757	--	116,327	--	145,000	--	145,000
Paint	4,352	--	29,403	33,755	126	--	33,480	33,606
Paper coating	41,543	--	840,559	882,102	--	--	941,417	941,417
Paper filling	959	--	106,974	107,933	371	--	217,242	217,613
Plastics	--	--	21,116	21,116	21	--	22,935	22,956
Rubber	35,775	--	595	36,370	47,968	--	785	48,753
Miscellaneous	754	--	7,898	8,652	23,374	--	20,172	43,546
Total	95,938	106,757	1,007,504	1,210,199	75,411	145,000	1,236,031	1,456,442
Grand total	965,055	1,356,294	4,881,355	7,202,704	1,153,291	1,528,420	5,270,958	7,952,669

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.
[4]Incomplete total; remainder included with totals for specific uses.

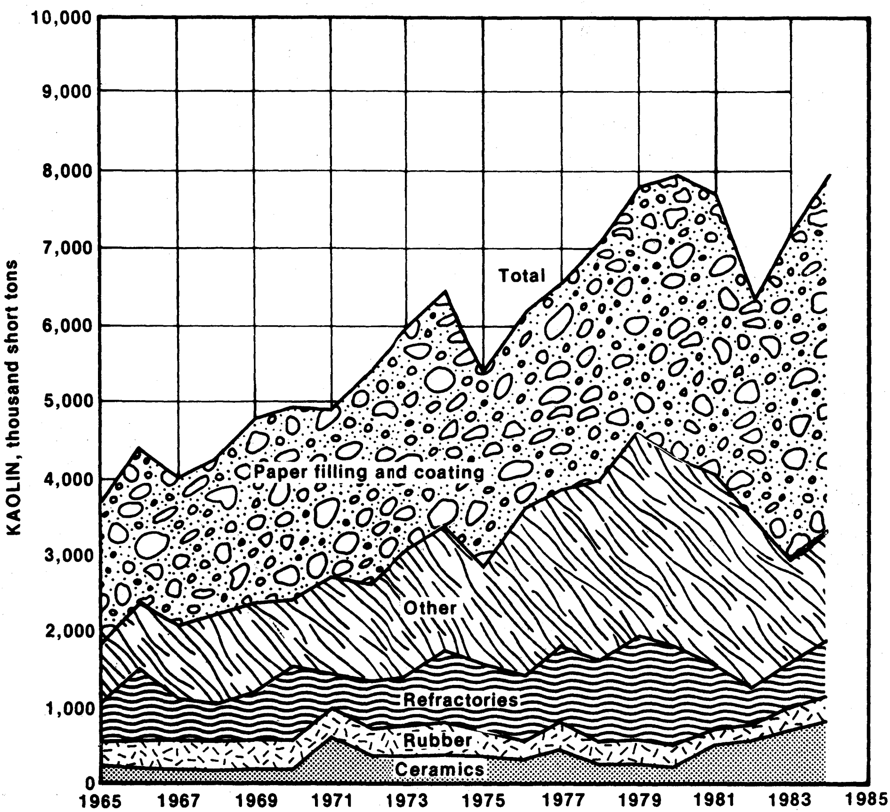

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

BALL CLAY

Reported production of domestic ball clay increased 15% to nearly 860,000 tons valued at $31 million. Tennessee provided 71% of the Nation's output, followed, in order of production, by Kentucky, Mississippi, Texas, and Maryland.[3] Production either increased or remained unchanged in all States. The principal ball clay markets continued to be ceramics, chiefly dinnerware, pottery, sanitary ware, and wall tile. Continued recovery of the construction industry and the overall economy during the year again triggered impressive ball clay production gains.

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.

Increased production capacities, modernizations, and/or new plant construction again continued cautiously during the year. Ball clay producers were also cautiously increasing their capabilities to produce, store, and ship (mostly by rail slurry-tank-car) water-slurried ball clay for ceramics markets or adopting this capability. In a major expansion, H. C. Spinks Clay Co. completed two new storage silos for air-floated clays. The new silos were installed at Spinks' drying and grinding plant in Gleason, TN, to facilitate rail and truck shipments.

The average unit value for ball clay reported by domestic producers increased slightly to $36.17. Chemical Marketing Reporter, December 31, 1984, 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 13% to 165,000 tons valued at $6.5 million. Unit value increased 19% to $39.37 per ton. Shipments were made to 30 countries, or 6 more than in 1983. The major recipients were Mexico, 58%, and Canada, 25%. The large Mexican ceramic market continued to be partially supplied by its domestic clay because of international financial difficulties, and its exports are fabricated with U.S. and domestic clays.

Ball clay imports, again almost entirely from the United Kingdom, decreased 50% to 1,979 tons valued at $200,000. The unit value of these imports increased 43% to $101.06 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
1983						
Tennessee	[1]315,937	[1]$11,826,934	191,807	$5,128,676	507,744	$16,955,610
Other	[2]226,140	[2]8,917,738	[3]12,927	[3]327,931	239,067	9,245,669
Total	542,077	20,744,672	204,734	5,456,607	746,811	26,201,279
1984						
California	--	--	246	2,958	246	2,958
Tennessee	406,287	15,656,579	[1]200,583	[1]5,592,451	606,870	21,249,030
Texas	24,515	612,875	--	--	24,515	612,875
Other	[2]215,186	[2]8,900,320	[3]12,756	[3]322,314	227,942	9,222,634
Total	645,988	25,169,774	213,585	5,917,723	859,573	31,087,497

[1]Includes water-slurried.
[2]Includes Kentucky, Maryland, Mississippi, and Texas (1983).
[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	1983			1984		
	Air-float[1]	Unprocessed	Total	Air-float[1]	Unprocessed	Total
Adhesives	W	--	W	W	--	W
Animal feed	W	W	9,550	W	W	9,116
Crockery and other earthenware	W	--	W	W	--	W
Drilling mud	W	--	W	W	--	W
Electrical porcelain	12,545	6,908	19,453	18,847	6,908	25,755
Fiberglass and catalysts (oil-refining)	W	--	W	W	--	W
Fine china and dinnerware	34,779	--	34,779	35,355	--	35,355
Firebrick, blocks and shapes	W	W	W	W	W	W
Glazes, glass, enamels	2,446	245	2,691	2,426	273	2,699
Grogs and calcines, high-alumina, mortar and cement, other refractories	81,175	8,207	89,382	81,815	12,207	94,022
Kiln furniture	1,786	--	1,786	1,780	--	1,780
Paper coating and filling	11,329	--	11,329	11,062	--	11,062
Pesticides and related products	--	W	W	W	--	W
Pottery	179,059	17,113	196,172	180,709	17,359	198,068
Rubber	--	W	W	W	--	W
Sanitary ware	43,584	93,627	137,211	53,774	84,288	138,062
Tile:						
Floor and wall	63,581	37,029	100,610	92,115	35,981	128,096
Other	--	1,607	1,607	--	--	--
Miscellaneous	54,389	13,019	[2]57,858	84,955	51,386	[2]127,225
Exports	57,404	26,979	84,383	83,150	5,183	88,333
Total	542,077	204,734	746,811	645,988	213,585	859,573

W Withheld to avoid disclosing company proprietary data; included with "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 increased 10% to 1.1 million tons valued at $21.1 million. Fire clay is defined as detrital material, either plastic or rocklike, 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. Some fire clay was previously reported in other end uses in this report.

Industrywide expansions, modernizations, acquisitions, and/or mergers were kept to a minimum during the year. Most plants were again closed for part of the year or placed on minimal production schedules. The refractory clay industry has entered a period of low production, reflecting lower demand by major consumers—aluminum, cement, foundry, steel, and the structural clay industries. In addition, these industries were continuing to switch to higher alumina-based refractories, either direct-fired or specialties, which contain less fire clay. A notable exception to the industry retrenchments was the A. P. Green Refractories Co.'s Mexico, MO, plans for an expansion project to add new production facilities to its Sulphur Springs, TX, plant. The enlargement included a 40,000-square-foot addition to manufacture a line of clay-alumina mortars, plastic refractory products, and high-alumina firebrick. In a final move to divest itself of its refractory holdings, Kaiser Aluminum & Chemical Corp., Oakland, CA, announced plans to sell off its North American refractory operations to a company organized by the management of its Kaiser Refractories Div. and Kelso and Co., an investment banker. Kaiser Refractories has manufacturing, research, and administrative facilities in California, Indiana, Missouri, Ohio, and Ontario, Canada.

Fire clay production was reported from mines in 15 States. Six States, Missouri, Ohio, Alabama, West Virginia, Pennsylvania, and Texas, in order of volume, accounted for 92% of the total domestic output. Production increased significantly in Alabama, Missouri, and Ohio and decreased significantly in Texas.

Exports of fire clay increased 39% to 229,000 tons valued at $17.3 million. The unit value of exported fire clay decreased 7% to $75.59 per ton, indicating, despite larger percentages of higher quality material shipped, increased worldwide competition was depressing prices. Fire clay was exported to 31 countries, an increase of 9 over that of 1983. Belgium-Luxembourg received 31%, while Mexico, Japan, and Canada received 18%, 16%, and 15%, respectively. No imports, as in the past, were reported for fire clay.

Unit value for fire clay, reported by producers, ranged from $2.00 to $28.50 per ton. The average unit value increased 17% to $18.46 per ton.

Table 14.—Fire clay sold or used by producers in the United States, by State[1]

State	1983		1984	
	Short tons	Value	Short tons	Value
Alabama	137,232	$3,595,800	144,267	$3,488,675
Colorado	12,110	114,516	14,795	169,403
Kentucky[2]	167,467	1,912,388	W	W
Missouri	310,675	5,479,963	427,681	8,540,260
Montana	188	940	--	--
New Jersey	12,018	211,000	12,018	211,000
New Mexico	2,251	20,282	1,813	11,080
Ohio	248,055	3,421,330	303,327	5,004,394
Pennsylvania	61,537	853,104	60,507	305,196
South Carolina	18,302	303,083	--	--
Texas	43,508	287,601	24,251	189,894
Utah	622	4,980	411	3,289
Washington	7,000	W	6,000	W
West Virginia	(2)	(2)	98,064	2,794,824
Other[3]	22,109	198,943	51,840	422,871
Total	1,043,074	16,403,930	1,144,974	21,140,886

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Refractory uses only.
[2]Data for West Virginia included with Kentucky for 1983.
[3]Includes California, Idaho, Indiana, and data indicated by symbol W.

BENTONITE

Bentonite production increased 9% to 3.2 million tons valued at $102.8 million. A 13% increase in production of swelling bentonite in Wyoming, the largest producing State, accounted for most of this increase. Domestic consumption rose for drilling mud, foundry sand, and pelletizing iron ore.

Bentonite was again produced in 15 States. The high-swelling or sodium bentonites continued to be produced chiefly, in descending order, in Wyoming, Montana, and California. The calcium or low-swelling bentonites continued to be produced in the other States.

The major Western and Southern bentonite producers continued to either cancel or defer ongoing expansions or modernizations. Most plants were again shut down intermittently during the year or were on reduced production schedules. The industry slowdown continues to be caused by low levels of oil and gas well-drilling activities during the year, exacerbated by the low level of production in the steel and foundry industries. These three industries traditionally consume about 90% of domestic output. The major and captive producers of bentonite were also attempting to diversify their product lines to compete in other marketing areas.

Exceptions to the bentonite industry's malaise were the activities of some of the calcium bentonite producers. The Harshaw-Filtrol Partnership, which combined the assets of Gulf Oil Corp.'s Harshaw Chemical Co. and Kaiser's subsidiary, Filtrol Corp., launched a program to double desiccant production capacity at its Jackson, MS, plant. The plant also produces acid-activated clays. United Desiccant, a division of United Catalysts, and a member of the Süd-Chemie Group of Munich, Federal Republic of Germany, opened a new facility at Belen, NM, about 20 miles from Albuquerque, to produce desiccant clay products from Cheto, Apache County, AZ, bentonites. American Colloid Co., Skokie, IL, began pilot production of acid-activated clays at a new 15,000-ton-per-year plant in Aberdeen, MS, scheduled for startup by mid-1985. Acid-activated clay is used to bleach and decolorize vegetable oils and animal fats and to refine mineral oils.

In sodium bentonite activities, IMCO Services of Houston, TX, a division of Halliburton Co., and Aurora Industries Inc., a subsidiary of Panhandle Eastern Corp., signed a letter of intent in April for IMCO to purchase Aurora's Federal Bentonite Div. The sale would include three bentonite mines in northeastern Wyoming and four processing plants in Minnesota, Montana, and Wyoming. The facilities have the capacity to produce and process 500,000 tons of bentonite per year.

On December 31, 1984, 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 15% to $32.57 per ton. Per-ton values reported in the various producing States ranged from $14.00 to $70.79, but the average value reported by the larger producers was near the Montana average figure of $40.03.

Bentonite exports increased 2% to 563,000 tons valued at $45.4 million. The unit value of exported bentonite increased 5% to $80.60 per ton; this was attributed to a higher percentage of the higher cost drilling-mud and foundry-sand grades shipped. Domestic bentonite producers were continuing to face increased worldwide competition caused in part by the strength of the U.S. dollar.

Bentonite was exported to 71 countries. The major recipients were Canada, 43%; Japan, 12%; the Netherlands, 8%; and Australia, Singapore, and the United Kingdom, 5% each. Domestic bentonite producers reported that the end uses of their exports were drilling mud, 61%; foundry sand, 10%; and other, 29%.

Bentonite imports, consisting largely of both clay and chemically activated material, more than doubled to nearly 17,000 tons. The chemically activated category, slowly increasing in quantity for the past several years, increased over 50% to 10,723 tons valued at $2.8 million, primarily because of increased shipments from Mexico. The chemically activated bentonite was imported from seven countries, with Mexico supplying 61%; Canada, 37%; the Federal Republic of Germany, 1%; and Australia, France, Japan, and the United Kingdom, the remaining 1%.

Table 15.—Bentonite sold or used by producers in the United States, by State

State	Nonswelling Short tons	Nonswelling Value	Swelling Short tons	Swelling Value	Total Short tons	Total Value
1983						
Arizona	32,316	$934,145	--	--	32,316	$934,145
California	65,789	4,655,802	22,303	$1,239,437	88,092	5,895,239
Colorado	4,000	56,000	300	6,000	4,300	62,000
Kansas	--	--	15,000	300,000	15,000	300,000
Mississippi	240,944	5,952,304	--	--	240,944	5,952,304
Montana	--	--	179,068	6,170,500	179,068	6,170,500
Nevada	--	--	20,151	1,191,425	20,151	1,191,425
Texas	W	W	W	W	74,756	2,875,965
Utah	--	--	6,230	187,000	6,230	187,000
Wyoming	--	--	1,938,499	48,046,760	1,938,499	48,046,760
Other	[1]160,361	[1]4,874,387	[2]201,909	[2]8,092,366	[3]287,514	[3]10,090,788
Total	503,410	16,472,638	2,383,460	65,233,488	2,886,870	81,706,126
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
Kansas	--	--	20,000	750,000	20,000	750,000
Mississippi	207,553	6,304,186	--	--	207,553	6,304,186
Montana	--	--	380,561	15,234,258	380,561	15,234,258
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	--	--	2,183,706	66,055,721	2,183,706	66,055,721
Other	[1]158,310	[1]5,593,694	[2]2,866	[2]490,887	161,176	[3]5,158,887
Total	491,277	17,298,271	2,663,187	85,455,539	3,154,464	102,753,810

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Alabama, Colorado, and Louisiana.
[2]Includes Colorado (1984), Idaho, South Dakota, and Tennessee.
[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	1983 Non-swelling	1983 Swelling	1983 Total	1984 Non-swelling	1984 Swelling	1984 Total
Domestic:						
Adhesives	--	6,688	6,688	--	6,665	6,665
Animal feed	38,737	98,220	136,957	36,322	89,513	125,835
Catalysts (oil-refining)	10,329	178	10,507	7,099	11	7,110
Cement, portland	--	W	W	--	W	W
Drilling mud	580	1,155,189	1,155,769	14,861	1,405,405	1,420,266
Filtering, clarifying, decolorizing:						
Animal oils, mineral oils, greases and desiccants	81,781	4,260	86,041	614	4,058	4,672
Vegetable oils	21,250	4,203	25,453	--	--	--
Foundry sand	207,224	372,726	579,950	222,253	428,673	650,926
Glazes, glass, enamels	--	W	W	--	W	W
Medical, pharmaceutical, cosmetic	--	4,437	4,437	--	4,653	4,653
Oil and grease absorbents	--	--	--	100,951	13	100,964
Paint	--	9,223	9,223	--	10,171	10,171
Pelletizing iron ore	--	301,357	301,357	--	381,900	381,900
Pesticides and related products	506	7,282	7,788	425	6,377	6,802
Waterproofing and sealing	20,079	73,534	93,613	4,393	52,448	56,841
Miscellaneous[1]	120,488	74,116	194,604	102,670	57,190	159,860
Total	500,974	2,111,413	2,612,387	489,588	2,447,077	2,936,665
Exports:						
Drilling mud	--	178,037	178,037	--	132,579	132,579
Foundry sand	126	34,943	35,069	--	21,265	21,265
Other[2]	2,310	59,067	61,377	1,689	62,266	63,955
Total	2,436	272,047	274,483	1,689	216,110	217,799
Grand total	503,410	2,383,460	2,886,870	491,277	2,663,187	3,154,464

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.

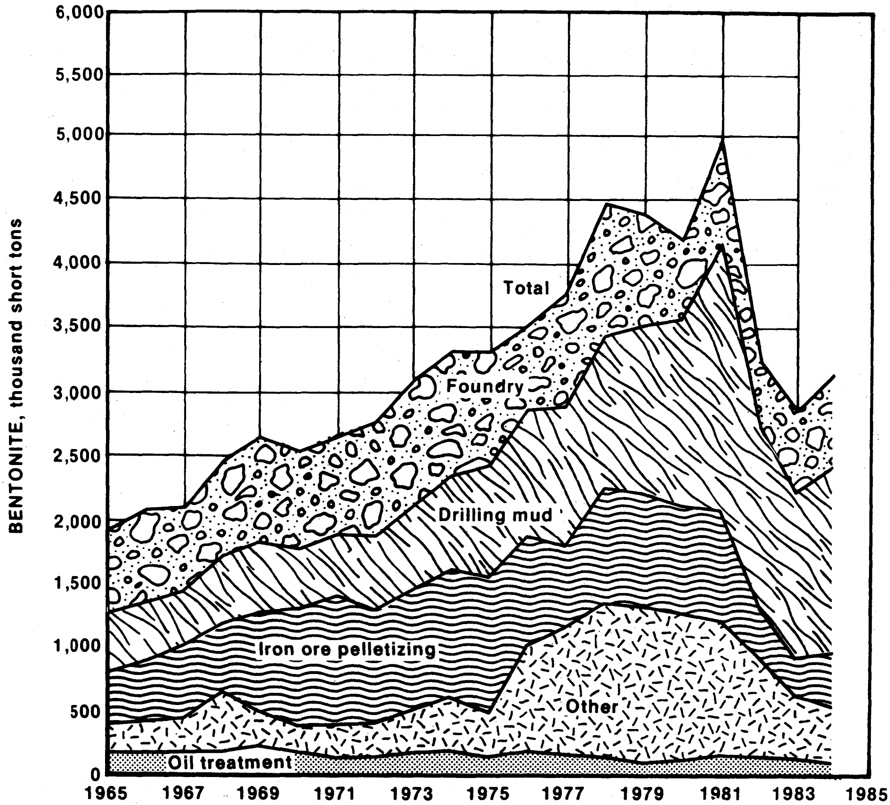

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

FULLER'S EARTH

Production of fuller's earth decreased slightly to 1.90 million tons valued at $118 million. This decrease in production was the first reported by industry in over 10 years. Most of the decrease was caused by a 9% decrease in attapulgite-gelling clay production in Florida. The average unit value increased 12% to $62.34 per ton. Production was reported from operations in 11 States. The two top producing States, Florida and Georgia, accounted for 54% of domestic production. All States, except Georgia, Texas, and Virginia, showed gains in production, while Illinois was unchanged.

Decreases in consumption occurred in oil and grease absorbents and pet waste absorbents.

Fuller's earth is defined as a nonplastic clay or claylike material, usually high in magnesia, which has adequate absorbing, decolorizing, and purifying properties.

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 mergers, which were either canceled or deferred until economic conditions improved, were starting to be acted upon again. In this regard, Oil-Dri Corp., Chicago, IL, was exploring the possibility of acquiring the property formerly owned and operated by the Anschutz Mining Corp. adjacent to its facility in Ochlocknee, GA. The acquisition included both mines and an adjacent plant.

Attapulgite, a fuller's earth-type clay, finds wide application in both absorbent and gelling or thickening areas. The thixotropic properties of attapulgite clay 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 polishes.

Prices for attapulgite reported by producers ranged from $49.50 to $67.24 per ton; montmorillonite prices ranged from $20.91 to $100.00.

Fuller's earth exports to 31 countries increased 14% to 116,000 tons valued at $9.3 million. The unit value of exported fuller's earth decreased 6% to $79.90 per ton; this was attributed to the smaller percentage of the higher cost drilling-mud grades shipped. The major recipients were Canada, 72%; the Netherlands, 19%; and Ecuador and the United Kingdom, 2% each. A minor amount of fuller's earth was imported from France.

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
1983						
Florida	423,986	$28,727,128	--	--	423,986	$28,727,128
Georgia	497,191	23,571,143	195,240	$9,254,469	692,431	32,825,612
Texas	21,689	1,415,440	W	W	W	W
Virginia	--	--	40,000	2,000,000	40,000	2,000,000
Other	[1]86,370	[1]4,476,993	[2]647,158	[2]37,245,322	[3]755,217	[3]43,137,755
Total	1,029,236	58,190,704	882,398	48,499,791	1,911,634	106,690,495
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

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Illinois, Nevada, and Texas (1984).
[2]Includes Arizona (1983), Illinois, Mississippi, Missouri, South Carolina, Tennessee, and Utah.
[3]Incomplete total; difference included with individual States.

Table 18.—Fuller's earth sold or used by producers in the United States, by use

(Short tons)

Use	1983			1984		
	Attapulgite	Montmorillonite	Total	Attapulgite	Montmorillonite	Total
Domestic:						
Adhesives	1,865	--	1,865	1,798	--	1,798
Animal feed	--	--	--	12,139	--	12,139
Drilling mud	81,406	--	81,406	105,716	--	105,716
Fertilizers	47,257	13,331	60,588	52,291	10,576	62,867
Filtering, clarifying, decolorizing mineral oils and greases	21,185	1,576	22,761	18,017	784	18,801
Medical, pharmaceutical, cosmetic	111	2	113	105	--	105
Oil and grease absorbents	269,688	193,946	463,634	209,831	220,878	430,709
Paint	8,238	--	8,238	6,606	--	6,606
Pesticides and related products	69,731	83,858	153,589	96,200	120,223	216,423
Pet waste absorbents	320,587	485,844	806,431	291,943	506,279	798,222
Other[1]	22,971	10,126	33,097	25,872	19,841	45,713
Miscellaneous[2]	66,945	40,879	107,824	28,710	30,911	59,621
Total	909,984	829,562	1,739,546	849,228	909,492	1,758,720
Exports:						
Drilling mud	865	--	865	1,246	--	1,246
Oil and grease absorbents	91,911	36,469	128,380	41,020	38,138	79,158
Pesticides and related products	7,437	458	7,895	9,135	373	9,508
Pet waste absorbents	12,805	12,898	25,703	27,642	12,295	39,937
Miscellaneous[3]	6,234	3,011	9,245	10,090	486	10,576
Total	119,252	52,836	172,088	89,133	51,292	140,425
Grand total	1,029,236	882,398	1,911,634	938,361	960,784	1,899,145

[1]Includes paper filling and roofing granules.
[2]Includes common brick; catalyst oil refining; chemical manufacturing; glazes, glasses, and enamel; gypsum products; mortar and cement refractories; plastics; pottery; and sanitary ware.
[3]Includes paint and uses not specified.

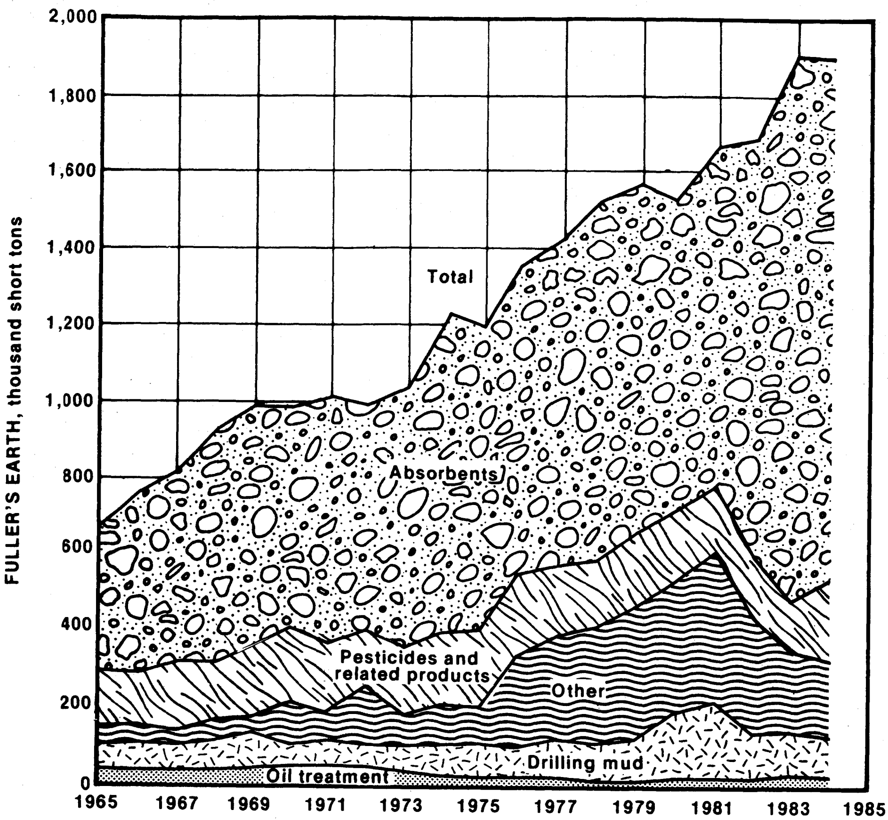

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

COMMON CLAY

Domestic sales or use of common clay and shale increased 8% to 29.4 million tons valued at $130 million. Output rose markedly in California, Georgia, and North Carolina, and decreased in Texas, the major producing State. Common clay and shale represented 66% of the quantity and 13% of the value of total domestic clay production. Domestic clay and shale is 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 increased 4% to $4.42 per ton. The unit value ranged from $2 to over $20.

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 have been both laminated and indurated while buried under other sediments. Clay and shale is 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, and acquisitions and/or mergers proceeded slowly during the year. The construction industry, the largest consumer of heavy clay products such as brick, lightweight aggregate, portland cement, sewer pipe, and tiles, was rapidly recovering from its depressed state. The large inventories that resulted from this were being reduced by increased sales and plant activity at midyear.

Three exceptions were noted to the slowdown in industry mergers. Buildex Inc., Ottawa, KS, a manufacturer of lightweight aggregate, was purchased by the Lightweight Aggregate Div. of Carter-Waters Corp., a Kansas City, MO, construction materials producer. Crescent Brick Co. Inc., based in western Virginia, bought the mines and plants of Cedar Heights Clays Co. of Oak Hill, OH. Cedar Heights is the largest producer of prepared clay in the State. Continental Clay Products Co., Martinsburg, WV, was sold to a group headed by Imperial Coal Sales, Lynchburg, VA, which also owns Locher Brick Co. in Lynchburg. Imperial Coal was also planning to convert Continental's two gas-fired kilns to coal. Another conversion unit was being advanced by National Synfuels Inc., Jacksonville, FL, at Elgin-Butler Brick Co.'s plant near Elgin, TX. National Synfuels was designing a traveling-bed gasifier to produce natural gas from lignite associated with Elgin-Butler's clay mining operation. Elgin-Butler hoped to produce a competitive low-British thermal unit gas in its $1.6 million project. These conversions are in-line with the heavy clay products industry's efforts to reduce operating costs, in general, and firing costs, in particular. In a west coast expansion, Gladding, McBean and Co., a division of Pacific Coast Building Products Inc., revealed plans for an $8 million addition to its 108-year-old Lincoln, CA, plant. The addition was to occur in two stages. The first stage, of a 5-year plan, called for producing a new line of split-tiles and then adding a modern, fuel-efficient brick-manufacturing plant in the second stage. A capacity of 4 million square feet was targeted for the tile operation, although the planned capacity of the brick plant was to be 40 million bricks per year.

A preliminary determination was made by the International Trade Administration (ITA) that manufacturers, producers, or exporters of Mexican bricks were receiving certain benefits that constituted bounties or grants within the meaning of the countervailing duty law. The ITA estimated the net bounty or grant to be 5.13% ad valorem and directed the U.S. Customs Service to require either a cash deposit or bond on these products in an amount equal to the estimated net bounty or grant.[4]

Table 19.—Common clay and shale sold or used by producers in the United States, by State[1]

State	1983		1984	
	Short tons	Value	Short tons	Value
Alabama	1,624,734	$8,487,924	1,523,073	$8,379,481
Arizona	118,815	490,290	117,134	517,140
Arkansas	769,217	1,562,063	933,420	2,157,030
California	1,683,153	11,196,177	1,945,840	15,334,228
Colorado	442,807	2,473,005	293,347	1,939,506
Connecticut	86,034	514,910	99,078	564,620
Florida	231,416	674,043	279,947	824,512
Georgia	1,280,809	3,773,157	1,601,268	4,917,857
Illinois	716,580	3,359,537	253,381	939,966
Indiana	557,698	1,421,142	653,135	2,085,427
Iowa	576,251	3,257,649	623,169	2,694,651
Kansas	703,234	3,620,604	897,722	4,786,598
Kentucky	669,300	2,142,337	661,644	2,532,769
Louisiana	505,054	10,573,640	539,472	10,858,373
Maine	43,488	92,522	43,488	96,522
Maryland	483,741	1,746,874	346,963	1,483,631
Massachusetts	236,993	1,298,295	239,929	1,211,614
Michigan	1,198,900	5,693,416	1,320,774	5,051,586
Mississippi	943,089	2,694,071	1,870,938	5,631,311
Missouri	1,003,755	3,716,105	1,079,094	4,178,762
Montana	15,226	33,854	16,422	25,743
Nebraska	163,651	500,951	179,946	555,818
New Jersey	50,000	385,000	50,000	400,000
New Mexico	47,609	94,224	64,784	132,226
New York	371,060	868,551	543,368	2,434,776
North Carolina	2,067,947	6,680,959	2,280,634	7,911,093
Ohio	1,468,285	4,639,527	1,656,686	5,468,566
Oklahoma	861,531	2,287,746	979,291	2,498,178
Oregon	188,222	275,397	189,167	288,443
Pennsylvania	854,687	3,457,825	902,448	3,745,079
Puerto Rico	125,259	251,204	127,966	266,435
South Carolina	1,052,666	3,118,251	1,057,061	3,405,359
South Dakota	122,576	353,105	119,149	343,149
Tennessee	433,221	955,685	560,278	1,165,263
Texas	3,714,421	14,426,690	3,406,593	15,362,396
Utah	220,222	1,376,665	310,439	2,079,497
Virginia	744,291	3,466,950	687,968	3,603,785
Washington	275,285	1,714,671	285,961	1,598,120
West Virginia	248,571	531,990	283,328	615,084
Wyoming	201,263	1,011,916	213,350	1,234,381
Other[2]	90,934	367,358	115,492	422,688
Total	27,191,995	115,586,280	29,353,147	129,741,663

[1]Includes Puerto Rico.
[2]Includes Minnesota, New Hampshire, and North Dakota.

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 37%, 19%, 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 of heavy clay products increased 16% to $1.34 billion. The million standard brick count for building or common face brick increased 12%. Vitrified clay sewer pipe and fittings shipped increased 6%, and shipments of clay floor and wall tile increased slightly more than 2%. Increases in common clay and shale used in building brick production occurred in most States. Increases above 30% were noted in Arkansas, California, Georgia, Kansas, Mississippi, New Hampshire, New Mexico, North Dakota, Oklahoma, Tennessee, Utah, and Wyoming.

Lightweight Aggregates.—Consumption of clay and shale in the manufacture of lightweight aggregate remained relatively unchanged at 4.4 million tons. The upturn in construction, which increased the demand for lightweight aggregates, offset the decline in the new markets, such as golf courses, horticulture, and running tracks, which in prior years were growing modestly each year.

Refractories.—All types of clay were used in manufacturing refractories. Fire clay, bentonite, and kaolin accounted for 41%, 25%, and 21%, respectively, of total clays used for this purpose. The remainder, ball clay, common clay and shale, and fuller's earth, were used primarily as bonding agents. Bentonite was used chiefly as a bonding agent in proprietary foundry formulations.

The tonnage of clays used for refractories increased slightly and constituted 6% of total clays produced. The modest recovery, which continued for the depressed major refractory consuming industries, cement, foundry, glass, and steel, was responsible for the increased consumption. These increases continued expansion in refractory aggregate production and manufacture of the more conventional brick refractories. Refractory aggregates were used mostly in specialty plastics, gunning, ramming, castable mixes, and/or as a substitute for refractory bauxite. The major refractory consuming industries, mentioned above, were continuing to undergo major changes in technology and production levels for their products.

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 was used in the manufacture of paper, rubber, paint, and plastics. Fuller's earth was used primarily in pesticides and fertilizers. Clays were in pesticides and fertilizers as carriers, diluents, or prilling agents. Bentonites were used mainly in animal feeds.

Of total clay produced, 11% was used in filler applications; of this, kaolin accounted for 89%; fuller's earth, 6%; bentonite, 3%; and ball clay, common clay and shale, and fire clay, the remaining 2%. Kaolin consumed as fillers increased 8% to 4.3 million tons. Increases occurred in all the major filler categories for kaolin. Except for increases of 8% in plastics, 4% in paper coating and filling, and 1% in adhesives, all other categories increased over 20% each. The total quantity of fuller's earth used in insecticides and fungicides increased over 25%.

Absorbent Uses.—Absorbent uses for clays accounted for over 1.5 million tons, or 3% of total clay consumption. Demand for absorbents increased 5%. Fuller's earth was the principal clay used for absorbent purposes, and this application accounted for 81% of its entire output. Bentonite was also used. Demand for clays in pet waste absorbents, representing 63% of absorbent use, remained unchanged. Use in floor absorbents, chiefly to absorb hazardous oily substances, representing the remaining 37% of absorbent demand, increased 13%. An upturn in the smokestack industries, large consumers of floor absorbents, and the economy in general were largely responsible for the increased demand.

Drilling Mud.—Demand for clays in rotary-drilling muds increased 23% to 1.53 million tons and accounted for 3% of total clay production. This increase reverses a downward trend begun in 1982 when a combination of an oil glut and economic uncertainties resulted in lower oil and gas well-drilling activities, which depressed bentonite demand. Swelling-type bentonite remained the principal clay used in drilling mud mixes, although fuller's earth and nonswelling bentonite were also used to a limited extent. Bentonite and fuller's earth accounted for nearly 100% of the total amount of clay used for this purpose. Small amounts of ball clay and kaolin were used in specialized formulations.

Table 20.—Clays sold or used by producers in the United States[1] in 1984, 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	--	100,964	W	--	430,709	--	531,673
Pet waste	--	W	W	3,887	798,222	--	802,109
Other[2]	--	50,038	130,424	--	--	--	180,462
Ceramics and glass:							
Catalysts (oil-refining)	W	7,110	--	--	W	260,653	267,763
Crockery and earthenware	W	--	2,028	--	--	1,610	3,638
Electrical porcelain	25,755	--	40	--	--	26,871	52,666
Fine china and dinnerware	35,355	--	--	--	--	34,406	69,761
Glazes, glass, enamels	2,699	W	--	--	W	444	3,143
Mineral wool and insulation, fiberglass	W	W	--	--	--	278,781	278,781
Pottery	198,068	--	22,938	550	W	6,979	228,535
Roofing granules	W	--	99,800	--	W	23,440	123,240
Sanitary ware	138,062	--	--	--	W	121,854	259,916
Other[2]	98,609	1,609	--	10,665	20,423	11,042	142,348
Chemical manufacturing	--	2,893	--	--	--	338,041	340,934
Civil engineering and sealing	--	56,841	12,888	--	--	7,413	77,142
Drilling mud	127	1,420,266	--	--	105,716	1,503	1,527,612
Fillers, extenders, binders:							
Adhesives	W	6,665	1,000	W	1,798	93,040	102,503
Animal feed	9,116	125,835	200	W	W	12,387	147,538
Fertilizers	--	--	--	--	62,867	14,286	77,153
Gypsum products and wallboard	--	--	--	--	W	18,332	18,332
Ink	--	W	--	--	--	W	W
Linoleum and asphalt tile	W	--	--	--	--	21,098	21,098
Medical, pharmaceutical, cosmetic	W	4,653	--	--	105	3,138	7,896
Paint	W	10,171	50	--	6,606	230,003	246,830
Paper coating	W	W	--	--	--	2,474,575	2,474,575
Paper filling	W	W	--	--	3,265	984,771	988,036
Pesticides and related products	W	6,802	9,320	--	216,423	42,281	274,826
Plastics	--	W	--	W	W	58,911	58,911
Rubber	W	W	4,731	W	--	294,569	299,300
Other[2]	23,040	3,193	--	1,866	17,615	22,548	68,262
Filtering, clarifying, decolorizing:							
Animal oils	--	1,537	--	--	--	729	2,266
Desiccants	--	614	--	--	--	--	614
Mineral oils and greases	--	2,521	--	--	18,801	--	21,322

See footnotes at end of table.

Table 20.—Clays sold or used by producers in the United States[1] in 1984, 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	128,096	--	88,343	384	--	18,796	235,619
Quarry tile	--	--	199,132	--	--	--	199,132
Other[2]	--	--	--	--	--	14,057	14,057
Heavy clay products:							
Brick, common	2,242	1,565	2,194,874	--	--	15,771	2,214,452
Brick, face	--	93	13,168,554	12,533	--	308,782	13,489,962
Drain tile	--	--	44,420	--	--	--	44,420
Flower pots	--	--	27,641	--	--	--	27,641
Flue linings	--	--	49,455	9,121	--	3,030	61,606
Portland and other cements	--	505	8,112,248	513	--	135,576	8,248,842
Roofing tile	--	--	37,575	--	--	--	37,575
Sewer pipe, vitrified	--	--	430,379	--	--	9,836	440,215
Structural tile	--	--	70,163	--	--	353	70,516
Terra cotta	--	--	800	--	--	--	800
Other[2]	--	--	8,609	--	--	--	8,609
Lightweight aggregate:							
Concrete block	--	--	2,671,210	--	--	--	2,671,210
Highway surfacing	--	--	447,774	--	--	--	447,774
Structural concrete	--	--	1,194,245	--	--	--	1,194,245
Other[2]	--	--	64,709	--	--	--	64,709
Pelletizing iron ore	--	381,900	--	--	--	--	381,900
Refractories:							
Firebrick, blocks and shapes	W	2,079	32,568	534,331	--	12,457	581,435
Foundry sand	--	650,926	--	108,848	--	910	760,684
Grogs and calcines	W	--	--	59,755	--	420,703	480,458
High-alumina brick and specialties	8,712	--	--	147,263	--	64,788	220,763
Kiln furniture	1,780	--	--	--	--	1,244	3,024
Mortar and cement, refractory	W	--	166,999	144,000	30,097	46,450	387,546
Other[2]	96,922	9,221	--	80,109	5,309	1,245	192,806
Other[3]	2,657	88,664	3,600	20,684	40,764	58,524	214,893
Exports	88,333	217,799	56,430	10,465	140,425	1,456,442	1,969,894
Total	859,573	3,154,464	29,353,147	1,144,974	1,899,145	7,952,669	44,363,972

W Withheld to avoid disclosing company proprietary data; included with "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	1980	1981	1982	1983	1984
Unglazed common and face brick:					
Quantity million standard brick	6,513	5,202	4,407	5,792	6,510
Value millions	$625	$540	$504	$704	$836
Unglazed structural tile:					
Quantity thousand short tons	102	92	49	30	32
Value millions	$7	$8	$6	$5	$7
Vitrified clay and sewer pipe fittings:					
Quantity thousand short tons	654	463	325	375	397
Value millions	$109	$73	$52	$64	$79
Unglazed, salt-glazed, ceramic-glazed structural facing tile including glazed brick:					
Quantity million equivalent brick	46	35	11	W	W
Value millions	$11	$10	$8	W	W
Clay floor and wall tile including quarry tile:					
Quantity million square feet	323	288	296	333	340
Value millions	$310	$341	$354	$388	$421
Total value[1] do	$1,062	$972	$923	$1,161	$1,342

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	1983		1984	
	Short tons	Value	Short tons	Value
Alabama	888,072	$3,627,864	721,338	$2,924,014
Arizona and New Mexico	125,413	331,746	143,866	380,227
Arkansas	364,840	840,369	493,325	1,269,049
California	233,035	837,755	378,644	1,527,701
Colorado	441,007	2,470,391	291,547	1,937,112
Connecticut and New Jersey	136,034	899,910	149,078	1,314,620
Georgia	1,026,196	2,949,605	1,356,003	3,782,607
Illinois	566,145	2,739,175	106,740	402,342
Indiana and Iowa	337,512	1,133,137	361,865	926,670
Kansas	147,083	430,877	193,022	535,701
Kentucky	268,496	1,058,766	292,800	1,354,941
Louisiana	90,398	207,162	117,404	306,673
Maine, Massachusetts, New Hampshire	158,015	884,239	166,451	860,538
Maryland and West Virginia	306,914	1,187,226	375,013	1,515,289
Michigan and Minnesota	83,282	658,875	51,641	128,111
Mississippi	790,471	2,235,428	1,744,621	5,255,238
Missouri	82,183	323,846	84,373	358,183
Nebraska and North Dakota	145,812	410,601	180,927	490,011
New York	128,994	177,828	88,397	90,248
North Carolina	1,889,706	6,230,024	2,067,546	7,398,557
Ohio	838,689	2,670,674	919,971	3,205,889
Oklahoma	313,092	961,143	518,107	1,661,852
Oregon	18,898	26,914	18,874	41,001
Pennsylvania	750,578	2,875,034	765,237	2,857,355
South Carolina	642,380	2,027,300	660,974	2,540,845
Tennessee	278,790	538,740	394,182	685,569
Texas	1,635,777	6,889,517	1,725,337	7,331,347
Utah	83,512	594,781	217,914	1,645,138
Virginia	646,719	1,807,945	583,405	1,634,348
Washington	153,453	575,502	150,115	415,315
Wyoming	30,738	295,392	44,711	553,079
Total	13,602,234	48,897,766	15,363,428	55,329,570

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	
1983						
Alabama and Arkansas	495,128	134,143	--	13,981	643,252	$3,442,788
California	136,401	200,849	--	19,114	356,364	2,761,916
Florida, Indiana, Iowa	182,159	47,239	--	8,416	237,814	957,493
Kansas, Kentucky, Louisiana	513,357	175,791	48,542	12,990	750,680	13,201,640
Massachusetts, Mississippi, Missouri	277,587	81,856	26,231	--	385,674	1,922,309
Montana and New York	64,214	19,352	--	--	83,566	340,530
North Carolina and North Dakota	106,288	68,635	--	31	174,954	539,188
Ohio, Oklahoma, Pennsylvania	193,025	36,829	50	6,500	236,404	532,254
Utah and Virginia	137,118	32,791	--	7,860	177,769	1,966,037
Texas	375,509	524,582	213,453	235,724	1,349,268	4,755,477
Total	2,480,786	1,322,067	288,276	304,616	4,395,745	30,419,632
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

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 1% of the total clay production. Demand for tile increased 11% to 449,000 tons. The upturn in the housing industry was largely responsible for the increased demand.

Pelletizing Iron Ore.—Bentonite continued to be used as a binder in forming hard iron ore pellets. Demand increased 27% to 381,900 tons. This increase in taconite pellet production reverses the downward trend for steel demand noted for the past 2 years. The inroads of cheaper and lower quality foreign bentonites into this traditional U.S. clay marketing area appear to be waning.

Ceramics.—Total demand for clays in the manufacture of pottery, sanitary ware, china and dinnerware, and related products (excluding clay flower pots) accounted for 3% of the total clay output. This demand, principally for ball and kaolin clays, increased 15% to 1.43 million tons.

Table 24.—Shipments of refractories in the United States, by product

Product	Unit of quantity	1983 Quantity	1983 Value (thousands)	1984 Quantity	1984 Value (thousands)
CLAY REFRACTORIES					
Superduty fireclay brick and shapes	1,000 9-inch equivalent.	29,716	$36,023	34,422	$41,887
Other fire clay including semisilica brick and shapes, glasshouse pots, tank blocks, feeder parts, upper structure parts used only for glass tanks.	do	60,522	40,830	66,368	44,742
High-alumina (50% to 60% Al_2O_3) brick and shapes made of calcined diaspore or bauxite.[1]	do	70,402	130,773	81,957	151,578
Insulating firebrick and shapes	do	25,328	25,419	29,296	29,677
Ladle brick	do	77,134	24,615	66,763	22,622
Sleeves, nozzles, runner brick, tuyeres	do	20,768	26,998	20,665	30,475
Hot-top refractories	Short tons	W	W	W	W
Kiln furniture, radiant heater elements, potter's supplies, other miscellaneous-shaped refractory items.	do	26,524	24,495	28,769	26,526
Refractory bonding mortars	do	56,286	24,103	80,317	36,589
Plastic refractories and ramming mixes, containing up to 87.5% Al_2O_3.[2]	do	182,584	99,409	95,968	48,362
Castable refractories	do	204,154	77,937	219,939	88,637
Gunning mixes	do	77,825	31,868	85,551	31,121
Other clay refractory materials sold in lump or ground form.[3 4]	do	474,563	52,829	505,525	230,092
Total clay refractories		XX	595,299	XX	782,308
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent.	6,718	14,513	7,095	15,025
Magnesite and magnesite-chrome brick and shapes.	do	21,864	88,526	25,754	112,129
Chrome and chrome-magnesite brick and shapes.	do	29,286	109,455	38,656	154,045
Shaped refractories containing natural graphite.	Short tons	16,386	31,973	17,461	33,308
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.	1,289	22,922	5,043	36,762
Other mullite, kyanite, sillimanite, or andalusite brick and shapes.	do	2,366	11,628	3,734	16,100
Other extra-high-alumina (over 60%) brick and fused bauxite, fused alumina, dense-sintered alumina shapes.[6]	do	4,036	36,230	3,677	46,611
Silicon carbide brick, shapes, kiln furniture	do	3,241	9,939	1,674	34,845
Refractory bonding mortar	Short tons	12,731	9,194	14,223	9,792
Hydraulic-setting nonclay refractory castables	do	18,402	19,503	23,742	23,973
Plastic refractories and ramming mixes	do	123,824	71,217	130,966	87,041
Gunning mixes	do	235,916	73,997	233,331	86,709
Dead-burned magnesia or magnesite[3 7]	do	300,907	71,523	376,029	102,160
Dead-burned dolomite	do	120,661	7,675	309,291	18,002
Other nonclay refractory material sold in lump or ground form.[3]	do	237,948	44,104	213,433	47,834
Total nonclay refractories		XX	622,399	XX	824,336
Grand total refractories		XX	1,217,698	XX	1,606,644

W Withheld to avoid disclosing company proprietary data. XX Not applicable.

[1]Heated 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 which, 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 1984, by country

(Thousand short tons and thousand dollars)

Country	Ball clay		Bentonite		Fire clay		Fuller's earth		Kaolin		Clays, n.e.c.		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	(2)	1	(2)	37	(2)	6	(2)	26	3	544	1	894	4	1,508
Australia	6	22	29	2,738	15	1,052	(2)	27	18	3,018	4	1,428	72	8,285
Belgium-Luxembourg	--	--	(2)	29	71	5,297	1	141	4	405	1	1,062	77	6,934
Brazil	(2)	8	7	1,744	--	--	--	--	2	889	13	9,971	22	12,612
Canada	42	1,530	240	14,507	34	1,946	83	6,534	263	25,039	30	2,730	692	52,286
Chile	(2)	24	4	641	--	--	--	--	1	280	(2)	49	5	994
Colombia	--	--	6	519	--	--	(2)	6	11	1,656	5	4,419	22	6,600
Ecuador	(2)	9	2	230	--	--	2	185	3	520	(2)	69	7	1,013
Finland	--	--	3	172	(2)	16	--	--	16	2,077	(2)	1	19	2,266
France	(2)	58	(2)	204	1	169	1	122	13	2,752	2	673	17	3,978
Germany, Federal Republic of	(2)	10	8	679	1	58	(2)	22	46	5,136	27	2,296	82	8,201
Hong Kong	--	--	1	189	(2)	5	--	--	1	111	(2)	50	2	355
Italy	(2)	1	(2)	4	3	272	1	98	115	12,516	(2)	239	119	13,130
Japan	12	286	65	6,990	37	3,365	(2)	17	468	61,707	69	11,702	651	84,067
Korea, Republic of	(2)	19	3	1,256	(2)	27	--	--	40	8,216	2	321	45	9,839
Mexico	95	3,367	4	525	42	2,776	(2)	3	88	8,468	15	1,907	244	17,046
Netherlands	(2)	2	44	2,467	1	128	22	1,287	182	14,833	3	917	252	19,634
Peru	(2)	2	3	423	--	--	--	--	3	324	1	75	7	824
Philippines	1	108	3	605	--	--	(2)	121	3	448	1	147	8	1,429
Saudi Arabia	--	--	13	783	(2)	1	(2)	13	(2)	38	(2)	10	13	845
Singapore	--	--	29	1,725	(2)	1	(2)	23	2	434	(2)	158	31	2,341
South Africa, Republic of	1	57	1	253	(2)	39	1	155	16	2,286	(2)	224	19	3,014
Spain	--	--	(2)	214	(2)	20	--	--	11	1,453	(2)	63	11	1,750
Sweden	(2)	16	(2)	3	8	878	(2)	2	15	1,623	4	658	27	3,181
Switzerland	--	--	(2)	5	(2)	1	(2)	7	1	226	1	62	2	301
Taiwan	(2)	10	14	1,784	2	157	--	--	37	4,704	(2)	58	53	6,713
Thailand	(2)	1	5	625	(2)	2	--	--	1	247	1	349	9	1,224
United Arab Emirates	--	--	2	206	--	--	(2)	16	--	--	(2)	173	2	395
United Kingdom	1	25	30	1,866	9	903	2	231	15	3,308	11	2,997	68	9,330
Venezuela	1	83	22	1,554	--	--	(2)	28	18	2,581	2	595	43	4,841
Other	6	857	25	2,399	5	192	3	204	22	4,297	15	2,850	76	10,799
Total[1]	165	6,496	563	45,375	229	17,309	116	9,268	1,418	170,137	208	47,148	2,699	295,733

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Source: U.S. Department of Commerce.

Table 26.—U.S. imports for consumption of clays in 1984, by kind

Kind	Quantity (short tons)	Value (thousands)
China clay or kaolin, whether or not beneficiated:		
Canada	246	$19
France	92	13
Germany, Federal Republic of	28	3
Mexico	140	8
United Kingdom	10,106	785
Other[1]	46	10
Total	10,658	838
Fuller's earth, not beneficiated: France	8	3
Bentonite:		
Canada	932	154
Germany, Federal Republic of	13	5
Mexico	3,724	120
United Kingdom	1,176	227
Other[1]	21	9
Total	5,866	[2]516
Common blue and other ball clay, not beneficiated:		
Canada	49	8
United Kingdom	452	23
Other	10	1
Total	511	32
Common blue and other ball clay, wholly or partly beneficiated:		
United Kingdom	1,447	165
Other[1]	21	3
Total	1,468	168
Other clay, not beneficiated:		
Canada	180	15
Japan	35	9
Poland	84	23
United Kingdom	4	6
Other[1]	22	6
Total	325	59
Clay, n.e.c., wholly or partly beneficiated:		
Brazil	16	15
Canada	336	87
France	114	11
Germany, Federal Republic of	127	25
Italy	16	3
Japan	10	13
Mexico	3	2
United Kingdom	1,396	275
Other[1]	8	2
Total	2,026	[2]434
Artificially activated clay:		
Canada	3,932	1,023
Germany, Federal Republic of	197	169
Japan	42	36
Mexico	6,513	1,549
United Kingdom	20	27
Other[1]	19	14
Total	10,723	2,818
Grand total	31,585	4,868

[1]Includes countries with imports of quantities less than 1 short ton and/or values of less than $1,000.
[2]Data do not add to total shown because of independent rounding.

Source: U.S. Department of Commerce.

WORLD REVIEW

Estimated world production of all grades of kaolin, bentonite, and fuller's earth increased 12%, 5%, and 2%, respectively. Kaolin production during the year was 24.3 million tons, and U.S. output was 33% of the world total. World bentonite production was 6.0 million tons, with the United States accounting for 53% of the total. Fuller's earth production was 2.5 million tons, and U.S. output accounted for 75% of the total.

Australia.—Comalco Pty. Ltd. was planning to spend about $60 million on a kaolin plant at its Weipa bauxite operation in northern Queensland.[5] The company planned to bring the 100,000-ton-per-year plant, largely targeted for export, on-stream by July 1986 with a further expansion to 500,000 tons per year within 10 years, if warranted. The kaolin, under the bauxite deposit, is considered of paper-coating quality. In another kaolin event, Zanex Ltd. of Melbourne was exploring the possibilities of developing a kaolin deposit, of unknown quality, at the Elaine exploration lease in Victoria. The property is owned 50-50 by Zanex and Bass Strait Oil and Gas (Holdings) Ltd.

The United Kingdom-based refractories, aggregates, and construction materials group, Steetley PLC, sold off its Australian interests to the Anglo American Corp. of South Africa Ltd. for $19 million.[6] Steetley Industries Ltd. (Australia) controls mining and mineral processing operations throughout Australia, including major flint clay deposits in New South Wales.

Bolivia.—The reserves of bentonite deposits, currently mined by NL Baroid/NL Industries Inc. and Mosamar (Bolivia) were as follows: actual measured, 35,000 tons; indicated, 130,000 tons; and inferred, 175,000 tons.[7]

Bulgaria.—The Institute of Physical Chemistry of the Bulgarian Academy of Sciences has reportedly developed a new energy conserving method for producing finely dispersed kaolin.[8] The new process is said to require 80% to 90% less energy per unit of production and eliminates the need for dust collectors.

China.—A large deposit containing bentonite, perlite, and zeolite was discovered in Xinyeng County in Henan Province.[9] No further details about the deposit were released.

Denmark.—A/S Aalborg Portland-Cement Fabrik, a member of the F. L. Smidth Group, announced plans to close its Dania sintered grog facility near Mariager.[10]

Egypt.—The Eastern Desert has been the focus of a high level of exploratory activity for clay, metallic, and other nonmetallic minerals.[11] The clay minerals of highest priority were bentonite and kaolin.

Germany, Federal Republic of.—A new PEM magnetic separator was scheduled for delivery to Kick Kaolin in Schnaittenbach.[12] The new separator and accompanying flowsheet modifications will allow the company to produce coating-quality kaolins.

Hungary.—Vast reserves of clay minerals, principally calcium, magnesium, and sodium bentonites, were reportedly present in Tojaj Mount in the northeastern part of the country.[13] Twelve open pit clay mines were operating in the area.

Indonesia.—Production of kaolin from the Belitung operation began at midyear with a rated capacity of about 30,000 tons per year.[14] The kaolin project, operated through P.T. Tambang Timah's subsidiary, P.T. Kaolin Indonesia, was intended largely for domestic consumption.

Iraq.—A new company was established by the Government to handle bricks and other construction materials.[15] The company is part of the State Organization for Construction Industries and will be known as the State Establishment for Marketing Building Materials.

Malaysia.—Laporte Industries Ltd., a leading world producer of activated earths, has been granted permission by the Government to manufacture acid-activated bentonitic clays at Pasir Gudang in the State of Johore.[16] Work was to begin on the first stage of a 50,000-ton-per-year production unit based on the company's advanced technology used at its Widnes plant in the United Kingdom. The new venture by Laporte (Malaysia) Sdn. Berhad, a recently formed wholly owned subsidiary of Laporte Industries (Holdings), is an extension of Laporte's United Kingdom operations to other Asian countries and the Indian subcontinent. The activated clays are used throughout the region for decolorizing locally produced palm oils.

Morocco.—Important reserves of bentonite in the Nador area and kaolin in the Taghjijit region were reported.[17] The Bureau de Recherches et de Participations Minières was attempting to develop the bentonite deposits. Samples from the kaolin deposits were sent to Czechoslovakia for testing.

Saudi Arabia.—New finds of bentonite, of unknown type and quality, were located at Khulays, north of Jidda.[18]

Sri Lanka.—Sizable deposits of ball clay were discovered in the southern Kalutara area.[19] The Government's Ceylon Ceramic Corp., currently producing a ceramic-quality kaolin from Boralesgamuwa and Mettiyagoda, was planning to use both clays in meeting the increased domestic demand for ceramic products.

Swaziland.—The Langa National Brickworks Ltd.'s new manufacturing facility in Mpaka went into production during the year with a capability of nearly 50,000 bricks per year.[20] The new plant was targeted to produce about 50 million bricks per year with some of its production being exported to neighboring Natal and Transvaal.

Sweden.—The Overseas Clay Div. of ECC acquired SPH Chemicals AB, which was previously owned by a major part of the Swedish paper industry.[21] The newly purchased company was merged with AB CDM, another Swedish agency acquired in the early 1980's to expand the use of ECC clays in Scandinavia.

Togo.—The National Bureau of Mines and Mineral Reserves unveiled a 5-year mineral resources development plan.[22] The first stage of the program will involve a countrywide inventory of areas where industrial mineral deposits, including attapulgite and bentonite, have already been identified.

U.S.S.R.—Bentonite production from the Oganly deposit in Turkmenia was reportedly in excess of 100,000 tons.[23] Future plans call for modernization and expansions to permit production of nearly 1 million tons by the 1990's.

United Kingdom.—A new $10 million factory was to be built by Blockleys Ltd. adjacent to its brickworks at Telford, Shropshire.[24] The factory will initially produce simulated hand-thrown bricks and have the capability of being expanded to over 15 million bricks per year. The company currently produces only conventional facing bricks and shapes. In another heavy clay event, Redland PLC announced its acquisition of the Staffordshire-based Rosemary Brick and Tile Co. from Thomas Wragg and Sons.[25] The acquisition is in-line with Redland's worldwide expansions into heavy clay products, following the takeover of an Australian tilemaker in 1982. The new company also gives Redland access to the Midlands markets.

A new line of coated mineral fillers, for use in manufacturing wire cable insulation, was introduced by ECC International.[26] The coated fillers are manufactured from a high-purity calcined kaolin for use either as a sole filler or in combination with other fiber additives.

Table 27.—Kaolin: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Algeria	9	[e]21	[e]17	[e]19	[3]9
Argentina	101	74	80	160	155
Australia	241	188	168	[r] [e]220	275
Austria (marketable)	92	87	85	92	92
Bangladesh[4]	12	11	6	3	[3]4
Belgium	67	60	58	66	60
Brazil (beneficiated)	452	518	544	463	495
Bulgaria	229	244	261	267	265
Burundi[e]	2	2	2	[3]4	4
Chile	66	63	23	45	44
Colombia	867	893	943	840	880
Costa Rica	1	1	1	[e]1	1
Czechoslovakia	[r]565	560	581	730	660
Denmark[e]	22	22	22	22	22
Ecuador	4	3	5	1	1
Egypt	45	35	55	110	132
Ethiopia (including Eritrea)	61	10	[e]10	[e]10	10
France[5]	373	365	358	380	385
German Democratic Republic (marketable)[e]	220	220	230	220	190
Germany, Federal Republic of (marketable)	553	523	500	448	495
Greece	47	47	[e]47	67	67
Hong Kong	1	9	(6)	1	(6)
Hungary	57	58	50	41	42
India:					
Salable, crude	391	432	585	610	[3]687
Processed	116	126	[e]110	[e]110	110
Indonesia	83	89	85	66	77
Iran[e]	165	110	121	110	110
Israel	10	41	13	30	30
Italy:					
Crude	98	82	59	58	55
Kaolinitic earth	30	34	32	28	28
Japan	252	232	218	254	[3]248
Kenya	2	[e]2	1	1	1
Korea, Republic of	[r]637	[r]766	690	754	716
Madagascar	3	2	3	[r] [e]3	3
Malaysia	51	49	49	63	80
Mexico	299	229	190	179	180
Mozambique	(7)	(7)	(7)	(7)	--
New Zealand	51	54	26	26	28
Nigeria	1	1	[e]1	[e]1	1
Pakistan	30	42	46	26	28
Paraguay	55	77	[e]61	50	48
Peru[e]	[3]6	7	7	7	7
Poland	56	47	51	54	55
Portugal	[r]92	58	56	63	66
Romania[e]	[3]444	452	452	452	452
South Africa, Republic of	119	165	141	143	[3]149
Spain (marketable)[8]	709	[r]872	763	[r] [e]753	772
Sri Lanka	7	8	9	9	9
Suriname	(7)	(7)	(7)	(7)	--
Taiwan	88	100	96	113	[3]88
Tanzania[e]	1	1	1	[3]1	1
Thailand	22	16	20	40	[3]65
Turkey	[e]55	49	[e]50	[e]60	[3]61
U.S.S.R.[e]	2,800	2,800	2,900	2,900	3,100
United Kingdom	4,370	4,189	3,922	3,000	4,500
United States[9]	7,879	7,660	6,362	7,203	[3]7,953
Venezuela[e]	24	[3]72	72	[r]12	25
Vietnam[e]	1	1	1	1	1
Yugoslavia	217	248	258	[e]265	275
Zimbabwe	5	5	3	1	1
Total	[r]23,256	[r]23,132	21,500	21,656	24,298

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

[1]Table includes data available through July 9, 1985.

[2]In addition to the countries listed, China, Lebanon, Mozambique, and Suriname also produced kaolin, but information is inadequate to make reliable estimates of output levels. Guatemala and Morocco each produced less than 500 short tons in each of the years covered by this table.

[3]Reported figure.

[4]Data for year ending June 30 of that stated.

[5]Includes kaolinitic clay.

[6]Less than 1/2 unit.

[7]Revised to zero; see footnote 2.

[8]Includes crude and washed kaolin and refractory clays not further described.

[9]Sold or used by producers.

Table 28.—Bentonite: World production, by country[1]

(Short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Algeria[3]	[4]38,162	38,600	38,600	33,100	27,000
Argentina	144,826	135,274	135,864	149,439	143,300
Australia[3]	12,112	[r]18,635	32,201	[r] [e]33,100	33,100
Brazil	273,322	183,356	180,845	141,857	148,800
Burma	1,485	2,554	1,613	783	[4]783
Cyprus[5]	[r]26,455	[r]51,809	14,330	33,069	[4]35,715
Egypt[e]	5,700	5,700	5,700	[r]2,800	3,300
France	[r]3,307	[r]3,307	3,627	3,407	[4]3,307
Greece	553,225	343,862	343,921	759,427	[4]771,617
Guatemala[e]	2,900	2,750	2,750	8,800	9,900
Hungary	85,633	88,770	93,624	87,972	[4]88,185
Iran[e]	22,000	11,000	12,100	[r]11,000	11,000
Israel (metabentonite)	20,195	13,868	13,228	NA	NA
Italy	[r]365,967	305,340	261,611	327,183	[4]343,131
Japan	604,427	564,141	533,993	486,034	[4]458,532
Mexico	194,037	243,009	203,837	188,649	192,900
Morocco	3,620	3,203	4,913	4,514	[4]2,012
Mozambique[e]	1,650	1,650	1,650	[r]550	550
New Zealand (processed)	3,307	2,078	6,856	2,158	2,205
Pakistan	1,658	1,246	1,022	1,178	1,900
Peru	20,062	33,620	[e]34,200	[e]34,200	35,300
Philippines	5,570	6,092	5,149	1,477	3,300
Poland[e]	55,000	55,000	[r]77,000	[r]77,000	77,000
Romania	194,558	[e]194,000	192,904	195,109	[4]198,416
South Africa, Republic of	54,912	48,912	33,981	43,573	[4]46,131
Spain	107,701	129,772	132,277	90,996	[4]88,185
Tanzania	[r]88	55	55	[e]83	83
Turkey[e]	22,000	[4]33,827	34,200	34,200	[4]30,967
United States[6]	4,184,619	4,947,000	3,244,800	2,886,870	[4]3,154,464
Zimbabwe	76,228	86,424	94,236	69,552	77,200
Total	[r]7,084,726	[r]7,554,854	5,741,087	5,708,080	5,988,283

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through July 9, 1985.
[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.
[6]Sold or used by producers.

Table 29.—Fuller's earth: World production, by country[1]

(Short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Algeria	--	--	--	--	[3]3,858
Argentina	5,205	5,783	13,002	7,431	7,200
Australia (attapulgite)	([4])	--	16,280	[r] [e]16,500	16,500
Italy	4,740	6,057	[e]6,000	[r] [e]5,500	5,500
Mexico	62,675	72,067	46,835	45,827	46,000
Morocco (smectite)	19,213	21,771	27,121	30,187	[3]36,824
Pakistan	26,966	22,661	15,557	19,272	19,300
Senegal (attapulgite)	4,385	55,116	109,128	110,644	[3]127,315
South Africa, Republic of	794	478	343	344	--
Spain (attapulgite)	52,933	52,059	47,318	45,916	44,000
United Kingdom	231,485	225,974	267,861	294,317	320,000
United States[5]	1,533,802	1,655,854	1,682,655	1,911,634	[3]1,899,145
Total	[r]1,942,198	2,117,820	2,232,100	2,487,572	2,525,642

[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 9, 1985.
[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]Revised to zero.
[5]Sold or used by producers.

TECHNOLOGY

The Bureau of Mines published the results of clay-related research at its facilities in Boulder City and Reno, NV, and Tuscaloosa, AL. Two Boulder City research reports concerned the alumina miniplant operations for the hydrochloric acid (HCl) extraction of alumina from calcined Georgia kaolin. One report, a bench-scale study, indicated that horizontal belt filtration was a highly practical method for separating the siliceous residue from the aluminum chloride liquor generated in the leaching step.[27] Miniplant-scale continuous testing evaluated the filter circuits and compared filtration response of different kaolin feed materials and of different agitator-baffle designs in the leaching reactors. Soluble alumina recovery with a single filter ranged from 94% to over 99.5% when a thickener and another filter was employed for optimized feeds. The other report showed that degradation of calcined kaolin particles during reactor leaching by the clay-HCl miniplant process and subsequent reduced alumina extraction was caused primarily by mechanical attrition.[28] Chemical degradation during leaching was minor. Installation of a Bureau of Mines-designed, custom-made impeller, improved baffling, and subsurface discharge of slurry from each reactor decreased the problems of coarse solids accumulation and formation of excessive fines, which reduced alumina extraction. The Reno study detailed the recovery of alumina, also from calcined Georgia kaolin, by an HCl sparging process.[29]

The study reports on a modification of a process that involves a double-leaching system. The first leach of the calcined clay is made with as high strength HCl as possible, so that the dissolution of the aluminum chloride hexahydrate is suppressed, thereby removing most of the impurities but leaving the aluminum, which is soluble in the strong acid. The second leach in a weaker acid is shown to be both technically feasible and practical by eliminating the need for solvent extraction to remove iron and the recrystallization steps in the standard double-leaching HCl-clay process. The work includes not only a flowsheet incorporating common elements of the new approach and the standard process but also a preliminary economic evaluation that proves favorable for the new modification.

The Tuscaloosa investigation, a part of the long-range Bureau of Mines effort to dewater fine-particle clay wastes, reports on the effect of ion exchange on the rheological properties of ion-exchanged montmorillonite clays.[30] Viscosity measurements on the clay slurries indicate that univalent ion-exchanged montmorillonites had significantly higher viscosities than multivalent exchanged clays. The magnitude of viscosity components was further found to be dependent upon the floc volume, a parameter controlled by the degree of particle interaction, and thickness of the individual montmorillonite platelets (tactoids). This type of research holds potential for improvements in quality, new physical properties, and even designed physical and chemical parameters of clays, which could lead to their successful beneficiation by conventional techniques.

The U.S. Geological Survey (USGS) reported the geological descriptions of kaolin, refractory clay, ball clay, and halloysite in North America, Hawaii, and the Caribbean regions.[31] This comprehensive geological study included mineralogical definitions, the types of clay deposits, and the history, production, and uses from the regions and 46 commercial sedimentary, underclay, and residual clay districts. The work also included X-ray crystallographic data, differential thermal analyses scans, chemical analyses, and electron micrographs for each of the different clay types. Maps locating the domestic deposits and selected generalized and/or geological sections were also included. Similar definitive studies were published by the USGS on the white clays of Pennsylvania,[32] and ball clay and bentonite deposits of the central and western Gulf of Mexico Coastal Plain, which are of commercial importance.[33] A detailed map pinpointing the active and inactive domestic bentonite and fuller's earth mines and accompanying plants was also released by the USGS.[34] A listing of the major clay producers by State, county, and major industrial application was provided. Another study by the USGS details a procedure for the routine identification of samples containing clay minerals.[35] The procedure using X-ray diffraction techniques in conjunction with centrifuges, ultrasonic generators, and porous tiles, for orientation purposes, and its accompanying chemical determination methods are innovatively detailed in a flowsheet resulting in positive clay mineral identification.

An overview of raw materials supply for ceramic whitewares was published.[36] The article highlighted the entire range of products in ceramics from structural clay products to high-tech ceramics and related them to the one common factor that binds them together, clays. The article also takes an indepth look at each of the ball clays and kaolins used in tableware, sanitaryware, and electrical porcelain manufacturing. Feature sections were also included on typical chemical, physical, and mineralogical analyses of these clays, as well as the principal producers in the United States, the United Kingdom, and to a lesser extent, the rest of the world. An analogous study restricted to the structural clay products industry within the United Kingdom was also released.[37] This work discusses the raw materials required in manufacturing, various technical aspects of production methods, major producers, and market trends for clay bricks, clay roofing tiles, and vitrified clay pipes. The report featured a diagrammatic flowsheet for a typical modern, fully automated, extruded clay-brick plant.

Comprehensive reports on the production, major operating companies, production flowsheets, mining methods, geology, and marketing of industrial minerals, emphasizing clays, were published for Canada,[38] Cyprus,[39] the Republic of Korea,[40] and the United Kingdom.[41] The Canadian article highlighted the recent industrial minerals developments in each of the producing Provinces, while the South Korean study dealt mainly with ceramic-quality clays. The article on Cyprus had a special technical section on the production of sodium-exchanged bentonite from its indigenous calcium bentonites. The publication on the United Kingdom featured the recent mining and processing developments by the major ball clay, kaolin, fuller's earth, structural clay, and refractory producers and/or manufacturers.

The planning and execution of a practical program of clay prospecting was described.[42] Included in the program are preliminary studies, surface exploration, subsurface examination, sampling, field tests, mapping, and reporting. Mention is also made of a seismic exploration method that appears to be promising. The economics of mining, producing, and marketing a high-quality Western sodium bentonite was presented in a brief report.[43] The report reveals that commercial deposits average 3 to 4 feet in thickness and 5 to 50 acres in area, with overburden limited to about 50 feet.

The use of direct oxygen injection into an eight-wide, continuous-push tunnel kiln to enhance carbon burnout was investigated.[44] Implementation of an oxygen enrichment system, which resulted in improved production and reduced brick losses, due to carbon contamination, was discussed from both technical and economic viewpoints. A dilatometer laboratory method for optimizing the firing temperatures for clay brick, without either melting or undesirable deformation, was developed.[45] The research showed that the length of alpha-to beta-quartz inversion coupled with the amount of residual shrinkage could be used to determine the original firing temperature of the bricks. It was suggested that this method be utilized to determine the firing temperature of the brick as an index for quality control purposes. Controlled additions of ceramic waste sludges from tile glazing lines was found to be effective in eliminating the formation of water-soluble efflorescent salts, on brick surfaces, prepared from calcareous clays.[46] The research, while showing the technical basis for the efflorescent problem and its solution, revealed that a small increase in operating costs was more than compensated for by the increased value of the products, especially when used in outside load-bearing walls.

A reformulation technique for ceramic whiteware bodies, containing significant amounts of kaolin and clay, was developed that permits the ready substitution of raw materials by simply matching predetermined physical, chemical, and mineralogical parameters.[47] Linear programming concepts were used in these computer-assisted calculations. The input for this technique consists of property specifications and characteristics of the pertinent raw materials. The program is particularly effective in selecting raw material quantities to minimize cost and to maintain or modify properties for consistently high-quality competitive products.

Results from an initial survey of plastic refractories made largely from calcined kaolin aggregates revealed that aggregate type and grain sizing, as well as bonding agents, either clay, sulfate, or phosphate, were directly responsible for product degradation during service.[48] Research of this type, relating and analyzing fracture properties of superior and poorly performing refractories, should result in upgrading the performance of plastic refractories. An article discusses and lists the chemical and physical characteristics of different materials, such as clay-bonded graphite and brown-fused alumina crucibles, for lining coreless furnaces used in melting nonferrous metals.[49] This report stresses both the monolithic refractories used in crucible manufacture and the optimum design of crucibles for selected nonferrous melting.

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[1]Physical scientist, Division of Industrial Minerals.

[2]Thompson, D. The Kaolin Industry: Its Economic Impact on the Georgia Economy. Jan. 1985, 17 pp.; available from Kaolin Information Office, 161 Spring St., Suite 812, Atlanta, GA, 30303.

[3]Albany slip clay is included with ball clay solely for statistical convenience.

[4]Federal Register. International Trade Administration (Dep. Commerce). Bricks From Mexico; Preliminary Affirmative Countervailing Duty Determination. V. 49, No. 38, Feb. 24, 1984, pp. 6958-6962.

[5]Industrial Minerals (London). World of Minerals: Australia—Paper Grade Kaolin for Comalco. No. 206, Nov. 1984, p. 9.

[6]———. World of Minerals: Australia—Exit Steetley, Enter Anglo American. No. 197, Feb. 1984, p. 9.

[7]U.S. Embassy, La Paz, Bolivia. State Dep. Airgram A-21, p. 62.

[8]Industrial Minerals (London). Company News and Minerals Notes. No. 198, Mar. 1984, p. 71.

[9]———. Company News and Mineral Notes. No. 200, May 1984, p. 189.

[10]———. World of Minerals: Denmark—Aalborg Closes Dania Refractory Plant. No. 196, Jan. 1984, p. 9.

[11]Notholt, A. Mining Annual Review. North Africa: Egypt. Min. J. (London), June 1984, pp. 415-417.

[12]Iannicelli, J. Kaolin. Eng. and Min. J., v. 186, No. 3, Mar. 1984, pp. 118-119.

[13]Page 187 of work cited in footnote 9.

[14]Prijono, A. Mining Annual Review. Far East: Indonesia. Min. J. (London), June 1984, pp. 360-363.

[15]Work cited in footnote 8.

[16]European Chemical News. ECN New Projects: Laporte To Make Activated Earth Products in Malaysia. V. 42, No. 1126, Apr. 9, 1984, p. 21.

[17]U.S. Embassy, Rabat, Morocco. State Dep. Airgram A-9, pp. 7-8.

[18]Mining Journal (London). Mining Annual Review. Middle East: Saudi Arabia. June 1984, pp. 430-433.

[19]Wyesekera, N. Mineral Exploration in Sri Lanka. Min. Mag. (London), v. 150, No. 5, May 1984, pp. 464-467.

[20]Industrial Minerals (London). Company News and Mineral Notes. No. 205, Oct. 1984, pp. 70-71.

[21]Industrial Minerals (London). Annual Report Highlights—English China Clays PLC. No. 200, May 1984, p. 27.

[22]———. Company News and Mineral Notes. No. 201, June 1984, p. 62.

[23]———. Company News and Mineral Notes. No. 203, Aug. 1984, p. 69.

[24]———. Company News and Mineral Notes. No. 204, Sept. 1984, p. 115.

[25]———. World of Minerals: United Kingdom—Redland Moves Into Clay Tile. No. 206, Nov. 1984, pp. 14-15.

[26]Work cited in footnote 23.

[27]Sorensen, R. T., and D. L. Sawyer, Jr. Alumina Miniplant Operations—Separation of Aluminum Chloride Liquor From Leach Residue by Horizontal Belt Filtration. BuMines RI 8831, 1984, 44 pp.

[28]Hunter, D. B., D. L. Sawyer Jr., and T. L. Turner. Alumina Miniplant Operations—Influence of Reactor Design on the Attrition of Calcined Kaolin During HCl Leaching. BuMines RI 8877, 1984, 21 pp.

[29]Bauer, D. J., D. E. Hanks, and J. A. Eisele. A Strong Acid-Weak Acid Method for Producing Aluminum Chloride Hexahydrate From Kaolinitic Clay. BuMines RI 8908, 1984, 7 pp.

[30]Stanley, D. A., S. W. Webb, and B. J. Scheiner. Rheology of Ion-Exchanged Montmorillonite Clays. BuMines RI 8895, 1984, 17 pp.

[31]Patterson, S. H., and H. H. Murray. Kaolin, Refractory Clay, Ball Clay, and Halloysite in North America, Hawaii, and the Caribbean Region. U.S. Geol. Surv. Prof. Paper 1306, 1984, 56 pp.

[32]Hosterman, J. W. White Clays of Pennsylvania. U.S. Geol. Surv. Bull. 1558-D, 1984, 38 pp.

[33]———. Ball Clay and Bentonite Deposits of the Central and Western Gulf of Mexico Coastal Plain, United States. U.S. Geol. Surv. Bull. 1558-C, 1984, 22 pp.

[34]———. Bentonite and Fuller's Earth Resources of the U.S. Mineral Resources Investigations Series. U.S. Geol. Surv. Map MR-92, 1984.

[35]Starkey, H. C., P. D. Blackman, and P. L. Hauff. The Routine Mineralogical Analysis of Clay-Bearing Samples. U.S. Geol. Surv. Bull. 1563, 1984, 32 pp.

[36]Robbing, J. Ceramic Whiteware—An Overview of Raw Materials Supply. Ind. Miner. (London), No. 204, Sept. 1984, pp. 31-63.

[37]———. United Kingdom Structural Clay Products—Building on Firmer Ground. Ind. Miner. (London), No. 196, Jan. 1984, pp. 19-35.

[38]Industrial Minerals (London). Industrial Minerals in Canada—A Review of Recent Developments. No. 200, May 1984, pp. 63-125.

[39]Griffiths, J. The Industrial Minerals of Cyprus. Ind. Miner. (London), No. 207, Dec. 1984, pp. 21-35.

[40]Dickson, T. Korean Industrial Minerals—A Brief Summary. Ind. Miner. (London), No. 202, July 1984, pp. 57-61.

[41]Clarke, G. Industrial Minerals in the United Kingdom—An Overview of Recent Developments. Ind. Miner. (London), No. 206, Nov. 1984, pp. 21-43.

[42]Talbott, P. Prospecting for Clay Bull. Am. Ceram. Soc., v. 63, No. 8, Aug. 1984, pp. 1047-1049.

[43]Fleshman, H. G. Economics of Producing and Marketing Western Sodium Bentonite. Soc. Min. Eng. AIME preprint 84-364, 1984, 2 pp.

[44]McMillin, J. A., K. Kiyonaga, and R. L. Chambers. Improved Brick Quality Through Oxygen Injection. Bull. Am. Ceram. Soc., v. 63, No. 8, Aug. 1984, pp. 1035-1038.

[45]Litvan, G. G. Determination of the Firing Temperature of Clay Brick. Bull. Am. Ceram. Soc., v. 63, No. 4, Apr. 1984, pp. 617-619.

[46]Ortelli, G., and P. Vincenzini. Reduction of Efflorescence in Brick Through Addition of Ceramic Sludges. Bull. Am. Ceram. Soc., v. 63, No. 8, Aug. 1984, pp. 1025-1030.

[47]Lehman, R. L., J. G. Weinstein, G. W. Phelps, and K. Mac G. Adams. Reformulation of Whiteware Bodies Using Characterization and Linear Programming Methods and Techniques. Bull. Am. Ceram. Soc., v. 63, No. 8, Aug. 1984, pp. 1039-1041.

[48]Krietz, L. P., and R. E. Fischer. Effect of Temperature on Fracture Behavior of Plastic Refractories. Bull. Am. Ceram. Soc., v. 62, No. 12, Dec. 1983, pp. 1351-1354.

[49]Turner, J. L., Jr. Nonferrous Refractory Practice for Coreless Industries Furnaces. Part I. Modern Casting, v. 74, No. 2, Feb. 1984, pp. 35-37.

Cobalt

By William S. Kirk[1]

Domestic cobalt consumption increased for the second consecutive year after 4 consecutive years of decline, approximately paralleling general economic conditions. Reported consumption rose to 12.9 million pounds, and calculated apparent consumption rose to 17.9 million pounds. The event that had the most impact on the cobalt market during the year was the steep rise in spot prices in March and the apparent subsequent price stability. The producer price remained at $12.50 per pound throughout the year. Although there was no domestic mine production of cobalt, one domestic refiner produced cobaltous hydroxide from imported nickel-copper-cobalt matte.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Consumption, reported	15,321	11,680	9,468	11,319	12,944
Imports for consumption	16,302	15,594	12,870	17,221	25,310
Stocks, Dec. 31:					
Consumer	2,540	1,411	1,327	1,441	1,368
Processor	1,696	1,519	1,161	1,366	1,781
Price: Metal, per pound	$25.00	[1]$14.58	[1]$8.56	[1]$5.76	[1]$10.40
World: Production[2]	[r]69,076	[r]67,790	53,508	[p]52,890	[e]68,490

[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 April, the Defense Production Act was extended through September 30, 1986, and was particularly important to cobalt because it provided a legislative basis for the development of alternative mineral supply measures. Partly as a result of this legislation, cobalt had been produced domestically, and production could be resumed under its provisions.

The General Services Administration (GSA) awarded a contract to Inco Ltd. of Canada to provide 500,000 pounds of cobalt to the National Defense Stockpile. At $11.70 per pound, Inco's bid was $0.70 higher than that of Metal Marketing Corp. of Zambia Ltd. However, under GSA's solicitation, Inco received priority consideration owing to Canada's status as a signatory of the General Agreement on Tariffs and Trade. The contract specified that the cobalt be delivered within 1 year of initiation of the contract (September 26, 1984), and be supplied in the form of electrolytic rounds.

The U.S. Geological Survey and the State of Hawaii formed a joint task force to consider the economic potential and environmental impact of mining the cobalt-containing manganese crusts in the 200-nautical-mile zone surrounding the Hawaiian Islands. The goal of the task force was to establish a working relationship between State and Federal authorities to permit the potential leasing, exploration, and development of the deep sea mineral deposits. In other Government actions concerning seafloor mining, (1) the United States joined seven other nations in signing a Seabed Mining Agreement, which established the framework of seabed mining claims for those countries; (2) the National Oceanic and Atmospheric Administration announced that exploration licenses had been issued to four firms pursuant to the Deep Seabed Hard Mineral Act; and (3) also in accordance with the act, the Environmental Protection Agency issued the final general discharge permit under the National Pollutant Discharge Elimination System for ships exploring or mining the deep-sea beds under the auspices of the Federal Water Pollution Control Act, in the 200-nautical-mile zone surrounding the Hawaiian Islands.

In passing the California Wilderness Act of 1984, the U.S. Congress specifically excluded from wilderness designation an area in which nickel-cobalt laterites were found in northern California. Instead, the law directed the U.S. Forest Service to manage the North Fork Smith roadless area in the Six Rivers National Forest for multiple use. The California Nickel Corp. deposits are located in the area.

DOMESTIC PRODUCTION

The AMAX Nickel Refining Co. Inc. nickel-cobalt refinery at Port Nickel, LA, closed for 5 weeks in midsummer. The facility was closed owing to the soft nickel market. Toward yearend, a Canadian cobalt producer opened negotiations aimed at obtaining the majority of the nickel-copper-cobalt matte produced by Bamangwato Concessions Ltd. (BCL) of Botswana. BCL provided some two-thirds of the AMAX refinery's feedstock.

Carolmet Inc., a producer of extra-fine cobalt powder near Laurinburg, NC, began producing cobalt nitrate and cobalt chloride. The Belgian-owned facility had a nominal capacity of 330,000 pounds per year of contained cobalt for each product. Carolmet processed cobalt of Zairian origin.

Small-scale exploratory work by California Nickel on the Gasquet Mountain nickel-cobalt laterite deposit in northern California was halted by the U.S. Forest Service. The company, in its 1984 operating plan, had proposed to remove about 25,000 short tons of ore from three test pits at the site, sort the ore, and truck it to a pilot plant. The Forest Service advised California Nickel that, to comply with the National Environmental Protection Act, the company had to revise and expand its environmental data concerning the impact of such testing. After submission of an environmental impact statement and a 45-day waiting period, the Forest Service approved the 1984 operating plan. However, a number of environmental groups requested an administrative review. At yearend, the plan was still under administrative appeal, and none of the proposed operations had been implemented. Reactivation of the full-scale mining proposal was awaiting submission of additional environmental data from California Nickel.

Interstrat Resources Inc., Vancouver, British Columbia, announced the results of new exploration surveys of the Pine Flat site in northern California. The surveys indicated a deposit of 25,000 tons of laterite, grading 0.78% nickel and 0.61% cobalt.

Table 2.—U.S. cobalt products[1] produced and shipped by refiners and processors

(Thousand pounds)

	1983				1984			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Driers (organic compounds)	NA	1,359	NA	1,428	NA	1,329	NA	1,300
Hydrate (hydroxide)	NA	1,000	NA	1,100	NA	1,228	NA	1,219
Metal	206	206	NA	NA	--	--	NA	NA
Salts[2] (inorganic compounds)	NA	667	NA	643	NA	942	NA	803
Total	206	3,232	NA	3,171	NA	3,499	NA	3,322

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

Reported cobalt consumption increased for the second consecutive year after 4 consecutive years of decline. As in 1983, the increased demand was largely the result of improved economic conditions.

Apparent consumption, calculated from net imports, secondary production, and changes in industry and Government stocks, increased to 17.9 million pounds, 14% more than that of 1983.

Table 3.—U.S. consumption of cobalt, by end use

(Thousand pounds of contained cobalt)

End use	1983	1984
Steel:		
Full-alloy	W	W
High-strength, low-alloy	W	W
Stainless and heat-resisting	54	74
Tool	248	353
Superalloys	4,034	4,766
Alloys (excludes alloy steels and superalloys):		
Cutting and wear-resistant materials[1]	666	831
Magnetic alloys	1,711	2,209
Nonferrous alloys	169	176
Welding materials (structural and hard-facing)	472	399
Other alloys	72	15
Mill products made from metal powder	W	W
Chemical and ceramic uses:		
Catalysts	1,064	1,296
Drier in paints or related usage	1,503	1,258
Feed or nutritive additive	51	58
Glass decolorizer	41	41
Ground coat frit	651	617
Pigments	366	417
Miscellaneous and unspecified	217	434
Total	11,319	12,944

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
[1]Cemented and sintered carbides and cast carbide dies or parts.

Table 4.—U.S. consumption of cobalt, by form

(Thousand pounds of contained cobalt)

Form	1980	1981	1982	1983	1984
Chemical compounds (organic and inorganic) other than oxide	2,475	2,421	1,643	2,297	2,226
Metal	10,825	7,450	6,055	7,165	8,746
Oxide	441	557	732	938	915
Purchased scrap	1,183	972	871	723	879
Other	397	280	167	196	178
Total	15,321	11,680	9,468	11,319	12,944

PRICES

The listed producer price for cobalt cathodes remained at $12.50 per pound since 1982 but is no longer a price standard. The spot price for cathodes began the year at $6.25 per pound and rose gradually until March, when it leaped from $7.10 per pound to $11.80 in the period of a week.

The sudden price increase was attributed to dealers who had sold cobalt, which was not in their inventory, to be delivered months later. These dealers had assumed that cobalt would continue to be available on the open market. Zaire and Zambia stopped allowing their cobalt to be sold on the open market, causing the supply of cobalt on the open market to begin to dry up. Dealers were forced to buy cobalt at higher prices to fill their orders, and prices began to creep up. In March, a temporary tightness in the cobalt supply caused a minor panic, and prices shot up. The price probably would have gone higher had Zaire and Zambia not set a uniform price of $11.70 per pound.

Later in the year, an official of Afrimet Indussa Inc. said that Zaire was strongly committed to a policy of preventing cobalt prices from falling below $11.70 per pound. Shortly thereafter, an official of La Générale des Carrières et des Mines du Zaire (Gécamines), the Zairian state-owned mining company and marketing agency, stated that Zaire was also strongly committed to a policy of keeping cobalt prices from rising above $11.70. The company official also mentioned some of the measures that Zaire was willing to institute to enforce this policy. Zaire seemed to have adopted at least an unofficial producer price.

Table 5.—Yearend published prices of cobalt materials[1]

(Dollars per pound)

Material	1982	1983	1984
Cobalt:			
Cathodes	$4.75	$6.03	$11.50
Fine powder	16.36	10.11	16.53
Powder	12.30	6.91	13.24
Cobalt oxide:			
Ceramic-grade (70% cobalt)	8.74	4.90	9.40
Ceramic-grade (72% cobalt)	8.99	5.04	9.66
Metallurgical-grade (76% cobalt)	9.29	5.21	9.86

[1]Metals Week.

FOREIGN TRADE

Afrimet Indussa and Mooney Chemicals Inc. entered into an agreement to provide for a joint effort in the production, distribution, and sales of cobalt salts in the United States. Afrimet Indussa was the exclusive sales agent in North America for Zairian and Belgian cobalt (Belgian cobalt originated in Zaire). The company was to supply cobalt salts from Métallurgie Hoboken-Overpelt SA (MHO), a Belgian metals processor, and from Carolmet in Laurinburg, NC. Mooney, based in Cleveland, OH, also produced cobalt salts. (See "World Review Belgium.")

Exports of unwrought cobalt metal and waste and scrap totaled 952,000 pounds, gross weight, with an estimated 671,000 pounds cobalt content, valued at $7.7 million. These exports were shipped to 37 countries, with the following, in descending order, receiving the largest quantities: Japan, Belgium-Luxembourg, the Netherlands, the United Kingdom, and the Federal Republic of Germany. Exports of wrought metal totaled 455,000 pounds, gross weight, valued at $5.1 million. Of the 34 countries to which wrought cobalt was shipped, the major recipients, in descending order, were the Netherlands, Canada, the United Kingdom, and Norway.

Cobalt imports originating in south-central Africa, that is, imports from Belgium-Luxembourg (Zairian origin), Botswana, the Republic of South Africa, Zaire, and Zambia, represented 71% of total cobalt imports compared with 68% from that area in 1983.

Table 6.—U.S. imports for consumption of cobalt, by class

(Thousand pounds and thousand dollars)

Class	1982	1983	1984
Metal:[1]			
Gross weight	11,610	15,853	23,316
Cobalt content[e]	11,610	15,853	23,316
Value	$137,652	$110,076	$202,954
Oxide:			
Gross weight	362	403	706
Cobalt content[e]	268	298	522
Value	$2,560	$1,813	$5,285
Salts and compounds:			
Gross weight	1,340	1,671	2,284
Cobalt content[e]	404	502	685
Value	$2,650	$2,244	$5,371
Other forms:[2]	588	568	787
Value	$4,552	$1,969	$4,793
Total content	12,870	17,221	25,310

[e]Estimated.
[1]Includes unwrought metal and waste and scrap.
[2]Contained cobalt in nickel-copper and nickel matte.

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]	
	1983		1984		1983		1984		1983		1984			
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value	Cobalt content	Value	Cobalt content	Value	1983	1984
Australia	--	--	15	82	--	--	([6])	([6])	168	[7]578	218	[7]1,341	168	233
Belgium-Luxembourg	816	5,469	903	9,137	187	789	466	3,578	168	1,043	201	2,405	1,123	1,449
Botswana	--	--	--	--	--	--	--	--	400	[7]1,391	569	[7]3,452	400	569
Canada	1,886	11,776	3,044	29,016	19	91	71	481	50	247	32	175	1,950	3,128
Finland	1,017	6,712	958	9,498	--	--	--	--	--	--	--	--	1,017	958
France	79	246	298	1,332	--	--	2	40	12	64	1	15	91	301
Germany, Federal Republic of	39	357	69	821	2	15	47	344	39	266	68	496	79	171
Japan	442	2,138	224	1,134	11	50	--	--	12	49	14	128	462	238
Netherlands	499	2,541	202	2,294	--	--	--	--	8	37	2	57	507	204
Norway	707	3,592	1,382	6,312	--	--	--	--	([6])	2	--	--	707	1,382
South Africa, Republic of	--	--	39	288	--	--	--	--	185	281	285	1,395	185	324
United Kingdom	237	606	439	2,948	144	677	74	565	23	213	68	547	367	563
Zaire	7,721	63,082	11,728	108,172	--	--	45	276	2	6	11	139	7,723	11,772
Zambia	2,347	13,226	3,796	29,662	--	--	--	--	--	--	--	--	2,347	3,796
Zimbabwe	32	143	--	--	--	--	--	--	--	--	--	--	32	--
Other	31	188	219	2,259	40	191	--	--	4	36	3	13	64	222
Total[5]	15,853	110,076	23,316	202,954	403	1,813	706	5,285	1,070	4,212	1,472	10,163	17,221	25,310

[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 contained 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 $5.76 per pound for 1983 and $10.40 per pound for 1984, multiplied by 0.6 (estimated factor for matte) for imports from Australia and Botswana.

Table 8.—U.S. import duties for cobalt

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
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	4.9% 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

Australia.—Production at the Greenvale nickel-cobalt mine in Queensland was increased from 50% to 70% of capacity. The mine, jointly owned by Metals Exploration Ltd. and Freeport Queensland Ltd. had been producing at one-half of its capacity since March 1983 owing to general softness in the world nickel market and the expiration of contracts with some of Greenvale's customers.

Belgium.—MHO and Gécamines restructured the terms under which MHO would process Zairian cobalt. Under the former, longstanding arrangement, MHO acted as a toll processor for Gécamines. The new arrangement, which was to become effective January 1, 1985, specified that MHO would purchase its cobalt outright for the production of cobalt salts, oxides, and powder. The 3-year contract also specified that MHO would receive roughly the same quantities as in the past. Reports indicated that the company would receive a discount on the cobalt it purchased from Zaire. For its part, Gécamines was reported to have ended the old agreement to improve its cash flow situation. Carolmet, which had formerly also been a toll processor for Gécamines, was to process cobalt owned by MHO.

Brazil.—Cia. Níquel Tocantins reportedly was planning to begin cobalt production in 1985. Significant concentrations of cobalt are found in several Brazilian States in nickel laterite deposits. Brazil was totally dependent on imported cobalt.

Canada.—Falconbridge Ltd. was seeking additional sources of feed for its smelter in Sudbury, Ontario, and its refinery at Kristiansand, Norway. Both facilities were operating below capacity. In Sudbury, Falconbridge produced its own nickel-copper-cobalt matte, which was sent to its refinery in Norway for treatment. However, the Kristiansand refinery could treat more matte than could be produced by Falconbridge's Canadian operations.

The company's first step in developing other sources of feedstock was to set up a new partnership called Falconbridge Trading Associates Inc., which was to be based in Stamford, CT. This was a joint venture between Falconbridge Metals Inc., a wholly owned U.S. subsidiary, and Alloys & Carbides Inc. of Stamford. The company's primary role was to secure raw materials for processing at either Falconbridge's Sudbury smelter or its Norwegian refinery. The raw materials were to consist primarily of scrap and residues containing cobalt, nickel, copper, and other metals. The company was to be able to trade on its own account, buying and selling materials that for economic or technical reasons might have been unsuitable for Falconbridge's plants.

Secondly, Falconbridge reportedly talked to the agents for the Nonoc Mining and Industrial Corp., formerly Marinduque Mining and Industrial Corp. (MMIC), smelter about acquiring feedstock from the Philippines. The Nonoc Mining feed had formerly been sent to Japan to be refined by Sumitomo Metal Mining Co. Ltd., which had ceased production. Thirdly, talks were held between Falconbridge and BCL of Botswana. BCL produced a nickel-copper-cobalt matte, which was sent to Braithwaite, LA, to be refined by AMAX. Fourthly, Falconbridge talked with the owners of the Greenvale Mine in Australia in regard to acquiring feed from them.

Cuba.—The ambitious nickel-cobalt expansion program that was being instituted was reported to provide for a complete overhaul of Cuba's two existing nickel plants at Nicaro and Moa Bay and the construction of three new improved plants. The program also involved the construction of several cobalt separation plants. The

Punta Gorda nickel-cobalt plant in the northwestern Moa region was reported to have opened its first production line late in the year. The line was expected to become fully operational in 1985. The initial output was to be nickel-cobalt oxide averaging 77% to 78% nickel and 0.8% to 1% cobalt. The foundations for the Las Camariocas plant were laid in October. Cuba and the U.S.S.R. signed an agreement in November that increased long-term investments in Cuban nickel-cobalt facilities.

Japan.—Sumitomo suspended cobalt production in April because of a shortage of feedstock. The Sumitomo refinery had depended entirely on the Philippine nickel-cobalt sulfide concentrates for raw material. The company had enough cobalt in its inventory to satisfy its customers' orders until June or July. Sumitomo had planned to resume production in August based on renewed availability of feedstock. When the feedstock failed to materialize, the company indefinitely postponed the restart of production.

Papua New Guinea.—Nord Resources Corp., Dayton, OH, had been planning to develop its Ramu River deposit, which was about 50 miles from the coastal city of Madang. However, the project was put on hold until metal prices improved. Plans called for the production of about 6 million pounds of cobalt per year.

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

(Short tons)

Country	Mine output, metal content[2]					Metal[3]				
	1980	1981	1982	1983[p]	1984[e]	1980	1981	1982	1983[p]	1984[e]
Albania[e]	360	380	380	390	400	--	--	--	--	--
Australia[4]	2,177	[r]1,616	1,631	1,500	1,400	--	--	--	--	--
Botswana	249	280	280	246	250	--	--	--	--	--
Brazil	NA	NA	NA	131	110	--	--	--	--	--
Canada[5]	1,767	2,293	1,548	1,747	2,200	763	1,003	1,148	1,460	2,080
Cuba	1,778	1,890	[e]1,650	[e]1,820	1,690	--	--	--	--	--
Finland	1,141	1,140	1,026	[e]1,000	1,000	1,269	1,355	1,604	1,709	1,540
France	--	--	--	--	--	745	493	545	--	--
Germany, Federal Republic of[e]	--	--	--	--	--	330	160	160	[r]110	110
Japan	--	--	--	--	--	3,160	2,669	2,141	1,512	[6]998
Morocco	924	870	[e]770	--	--	--	--	--	--	--
New Caledonia[7]	395	407	299	[e]300	280	--	--	--	--	--
Norway	--	--	--	--	--	1,405	1,592	1,094	996	990
Philippines	1,467	1,099	516	639	140	--	--	--	--	--
U.S.S.R.[e]	2,300	2,400	2,500	2,600	2,900	4,600	4,700	4,700	5,000	5,200
United Kingdom[e 8]	--	--	--	--	--	800	800	[r]400	([9])	--
United States	--	--	--	--	--	500	447	508	103	--
Zaire	[e]17,000	[e]17,000	[e]12,460	[e]12,460	18,700	15,964	12,262	6,143	5,800	9,400
Zambia	4,850	[r]4,410	3,584	3,527	5,090	3,649	2,833	2,697	2,654	[6]3,829
Zimbabwe	[e]130	[e]110	[e]110	[r e]85	85	127	[r]104	109	81	80
Total	[r]34,538	[r]33,895	[r]26,754	26,445	34,245	33,312	[r]28,418	[r]21,249	19,425	24,227

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

[1]Table includes data available through May 4, 1984.

[2]Figures represent recovered 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: 1980—4,083; 1981—3,199; 1982—3,911; 1983—3,091; and 1984—2,840.

[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: 1980—3,527; 1981—3,074; 1982—2,351; 1983—2,320 (estimated); and 1984—NA.

[8]Estimated recovery of elemental cobalt in refined cobalt oxides and salts from intermediate metallurgical products originating in Canada.

[9]Revised to zero.

Peru.—A study to determine the feasibility of producing a cobalt concentrate from the Marcona Mine was completed. The study showed that a positive rate of return could be expected from the production of 2 million pounds per year of cobalt carbonate concentrate. The mine was owned by Empresa Minera del Hierro del Perú, a Government mining company.

Philippines.—The MMIC Surigao nickel-cobalt complex on Nonoc Island remained closed during the first 5 months of the year owing to a lack of working capital and delays in receiving imported coal and spare parts. Early in the year, a major restructuring of the company was undertaken. This resulted in two Philippine Government-owned institutions, the Philippine National Bank (PNB) and the Development Bank of the Philippines (DBP), increasing their ownership of MMIC from 36% to 87%. MMIC reopened its Surigao complex in late June, operating at 25% capacity. In late August, MMIC's fixed assets were transferred to the Philippine Government. A new company, Nonoc Mining was established to operate the Surigao complex. Nonoc Mining was jointly owned by DBP (57%) and PNB (43%). In September, the Surigao complex was forced to cease operations owing to extensive damage from typhoons. Repair and rehabilitation work was completed in November, and operations were resumed.

South Africa, Republic of.—Western Platinum Ltd. was planning the construction of a copper-nickel-cobalt refinery at its mine near Rustenburg. The plant was expected to be in operation in 1986 and was to use the Sherritt Gordon acid leaching process to produce 30,000 pounds per year of cobalt contained in cobalt sulfate.

Zaire.—The Zairian Government dissolved Société Zairoise de Commercialisation de Minerais, the state-owned metals marketing agency. All cobalt marketing was to be handled by Gécamines, the Government mining company. Later in the year, Gécamines changed the terms under which a Belgian company processed Zairian cobalt.

For the third consecutive year, Zaire refined about one-half of the cobalt that it mined. Most of the unrefined cobalt was thought to be in an intermediate form, such as cobaltous hydroxide, which could easily and quickly be refined to cobalt metal.

Zambia.—Zambia received a loan of $148 million to modernize its copper and cobalt mining industry. The International Bank for Reconstruction and Development supplied $75 million with the remainder coming from the European Common Market and the African Development Bank.

TECHNOLOGY

A Bureau of Mines researcher developed a method for extracting cobalt from copper leach solutions.[2] About 18% of domestic copper production has depended on heap leaching. The heap leaching method consisted of spraying a dilute acid solution over a heap of crushed ore. The solution leached copper and other metals out of the ore and was collected to recover the copper. The method developed by the Bureau extracted cobalt from these spent copper leach solutions. The solution was passed through columns filled with an ion-exchange resin that absorbed the cobalt and other remaining metals. The resin was then washed with sulfuric acid, which extracted the cobalt and considerable quantities of nickel, iron, zinc, and aluminum. All the metals except cobalt and nickel were extracted during the first phase of the recovery, followed by recovery of nickel during the second phase. The remaining concentrate contained nearly 1 ounce of cobalt per liter. The Bureau estimated that 1.3 million pounds of cobalt per year could be recovered from the heap leach streams of two U.S. copper mines.

A paper was published on research conducted on the recovery of cobalt and nickel from lead smelter matte.[3] It was estimated that the Missouri lead ores mined annually contained about 2.5 million pounds of cobalt. The paper described the basis for selective oxidative leaching of the matte, followed by selective recovery of salable or usable products of cobalt, nickel, copper, and manganese from the resulting leach liquor.

As part of its continuing research on recovering cobalt and other strategic metals from domestic laterite deposits, the Bureau of Mines published the results of a study in which two techniques for solid-liquid separation, centrifugation and thickening, were investigated.[4] The report presented the results of laboratory and pilot plant studies to determine parameters for sizing centrifuges and thickeners and an economic study of the two techniques. This was based on the requirements of a commercial-size laterite processing plant capable of handling 5,000 tons of ore per day. Another followup report was published by the Bureau in 1984 in which an alternate method of recovering cobalt was investigated.[5] To reduce the cost and complexity of recovering cobalt by solvent extraction and electrowinning, a method for using lignite to extract cobalt was studied. It was found that Co^{3+} removal from ammoniacal solutions by lignite was technically difficult and economically unfeasible.

A Bureau report was published that described a new methodology for the rapid identification and sorting of superalloy scrap.[6] The method used two modern, portable instruments: a thermoelectric sorter and a hand-held emission spectroscope. Tested on a 27-sample stainless steel and superalloy array, the method made it possible to group and/or identify a typical mixture of high-value metal scrap in two or three steps. Normally, seven or eight steps are needed to perform the same separations using chemical spot tests.

Ni-Cal Technology Ltd., a wholly owned subsidiary of Ni-Cal Developments Ltd. based in Vancouver, British Columbia, developed and made available for licensing an acid leach process for extracting cobalt, nickel, and other metals from laterite ores.[7] The process was reported to require much less energy than other commercially proven laterite extraction processes as well as having higher cobalt and nickel recovery rates.

The U.S. Air Force, in conjunction with Pratt & Whitney Aircraft Group, United Technologies Corp., announced the development of two new cobalt-free superalloys.[8] It was stated that the new superalloys had extremely high oxidation and corrosion resistance. The superalloys were undergoing ground tests on gas turbine engines for possible application on a new generation of fighter jet engines.

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[1]Physical scientist, Division of Ferrous Metals.

[2]Jeffers, T. H. Separation and Recovery of Cobalt From Copper Leach Solutions. J. Met., v. 11, No. 1, Jan. 1985, pp. 47-50.

[3]Doerr, R. M., R. B. Prater, Jr., and E. R. Cole. Recovery of Cobalt and Nickel From Lead Smelter Matte. Pres. at Metall. Soc. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26-Mar. 1, 1984. Metall. Soc. AIME paper selection A84-59, 1984, 19 pp.

[4]Hundley, G. L., and R. E. Siemens. Solid-Liquid Separations in Processing Domestic Laterites. BuMines RI 8840, 1984, 30 pp.

[5]Slavens, G. J., D. E. Traut, L. R. Penner, and J. L. Henry. Lignite Recovery of Cobalt^{3+} From an Ammoniacal Ammonium Sulfate Solution. BuMines RI 8870, 1984, 12 pp.

[6]Brown, R. D., Jr., W. D. Riley, and C. A. Zieba. Rapid Identification of Stainless Steel and Superalloy Scrap. BuMines RI 8858, 1984, 23 pp.

[7]Mining Journal. Mining Week. Ni-Cal's Acid Leach Process for Surigao Nickel? V. 303, No. 7784, Oct. 26, 1984, p. 289.

[8]American Metal Market. Air Force Develops Engine Superalloys "X", "Y". V. 92, No. 201, Oct. 15, 1984, pp. 1, 35.

Columbium and Tantalum

By Larry D. Cunningham[1]

The United States continued to be dependent on imports since there was no domestic mine production of either columbium or tantalum minerals. However, a pilot mine operation was reportedly being assembled by Fansteel Inc. to produce tantalum materials at an undisclosed site believed to be in the Western United States. Imports for consumption of both columbium and tantalum mineral concentrates increased substantially and were at the highest levels since 1980. The General Services Administration (GSA) tantalum acquisition program, initiated in late 1983, was stopped in January with the award of the final contract for purchase of tantalum materials for the National Defense Stockpile (NDS).

Reported consumption of columbium in the form of ferrocolumbium and nickel columbium continued to rise with substantial gains being made in the stainless and heat-resisting and high-strength low-alloy (HSLA) segments of the steelmaking industry. Columbium demand in superalloys continued to show improvement, the first year since 1980 that consumption exceeded 1 million pounds. Reported shipments of tantalum products were at the highest level since 1980, and sales of tantalum capacitors were at an alltime high.

Columbium prices remained stable, and most tantalum prices continued virtually unchanged. Net trade for columbium and tantalum remained at a deficit, with overall trade volume and value up significantly for both exports and imports.

Greenbushes Tin Ltd. secured a loan to implement its tin-tantalite hard-rock project. A mining and processing operation is planned for operation by January 1986.

Domestic Data Coverage.—Domestic production data for ferrocolumbium are developed by the Bureau of Mines from the annual voluntary survey for ferroalloys. Of

Table 1.—Salient columbium statistics

(Thousand pounds of columbium content unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Mine production of columbium-tantalum concentrates	(1)	(1)	(1)	--	--
Releases from Government excesses	--	--	--	--	--
Consumption of raw materials	3,122	1,983	e1,900	e1,900	e2,600
Production of ferrocolumbium	2,028	1,145	W	W	W
Consumption of primary products: Ferrocolumbium and nickel columbium	6,503	6,244	3,679	4,318	5,399
Exports: Columbium metal, compounds, alloys (gross weight)e	120	150	100	100	100
Imports for consumption:					
Mineral concentratee	2,320	1,050	580	730	1,790
Columbium metal and columbium-bearing alloyse	73	(2)	9	2	10
Ferrocolumbiume	5,918	6,068	3,128	2,539	4,343
Tin slagse 3	1,417	842	636	W	W
World: Production of columbium-tantalum concentratese	r33,379	r32,651	23,334	19,055	27,922

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data.
1A small unreported quantity was produced.
2Less tnan 1/2 unit.
3Receipts 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)

	1980	1981	1982	1983	1984
United States:					
Mine production of columbium-tantalum concentrates	(1)	(1)	(1)	--	--
Releases from Government excesses	--	--	--	--	--
Consumption of raw materials	1,863	1,269	e800	e900	e1,300
Exports:					
Tantalum ore and concentrate (gross weight)[2]	468	99	235	121	156
Tantalum metal, compounds, alloys (gross weight)	524	205	382	211	352
Tantalum and tantalum alloy powder (gross weight)	251	97	115	123	151
Imports for consumption:					
Mineral concentrate[e]	860	650	440	180	680
Tantalum metal and tantalum-bearing alloys[3]	93	34	71	27	47
Tin slags[e 4]	1,327	896	576	W	W
World: Production of columbium-tantalum concentrates[e]	r1,199	r798	580	740	703

[e]Estimated. [r]Revised. 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, 1984

(Thousand pounds of columbium or tantalum content)

Material	Stockpile goals	National Defense Stockpile inventory		
		Stockpile-grade	Nonstockpile-grade	Total
Columbium:				
Concentrates	5,600	937	869	[1]1,806
Carbide powder	100	21	--	21
Ferrocolumbium	--	598	333	[1]931
Metal	--	45	--	[1]45
Total	(2)	1,601	1,202	2,803
Tantalum:				
Minerals	8,400	1,432	1,152	[3]2,584
Carbide powder	--	29	--	[3]29
Metal	--	201	(4)	[3]201
Total	(2)	1,662	1,152	2,814

[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.

the four domestic operations to which a survey was sent, all responded, representing 100% of total production. Ferrocolumbium production data are withheld for 1984 to avoid disclosing company proprietary data.

Legislation and Government Programs.—The NDS goals and inventories for columbium and tantalum materials did not change, and there were no sales of stockpile excess materials.

In January, GSA agreed to purchase tantalum materials containing 61,050 pounds of tantalum pentoxide (Ta_2O_5), equivalent to approximately 50,000 pounds of tantalum, for the NDS from Amalgamet Inc., New York City, at a price of $35.8911 per pound of contained Ta_2O_5. The material shall be grade 1 as defined in National Stockpile Purchase Specification P-113a, effective August 3, 1981, requiring a minimum Ta_2O_5 content of 25% and a minimum combined Ta_2O_5 plus columbium pentoxide (Cb_2O_5) content of 55%. A Federal judge had ordered a halt to GSA's late 1983 purchase of approximately 200,000 pounds of tantalum from three firms. This order was based on a General Accounting Office decision that

Amalgamet—the only bidder of tantalum materials from a country designated for special concessions under the International Trade Agreement Acts of 1979—should have been entitled to one of the contracts awarded. A clerical error in Amalgamet's bid had led GSA to find the company ineligible for preferential treatment. GSA subsequently received court permission to leave the 1983 contracts unchanged and awarded the above described contract to Amalgamet.

Bids solicited by GSA for offers to supply columbium concentrates containing 572,160 pounds of Cb_2O_5, equivalent to approximately 400,000 pounds of columbium, were rejected for being too high in price and not conforming to prevailing market conditions. Bid prices from two companies ranged from $7.24 to $12.00 per pound of contained Cb_2O_5 for one-half of the material required. In addition, a third bid was considered nonresponsive because the bidding company offered to supply the intermediate product Cb_2O_5 instead of the specified Cb_2O_5 contained in concentrates. The procurement action was the first for columbium since the U.S. Government-guaranteed purchase program was ended in the late 1950's.

The National Materials Advisory Board, under contract to the Federal Emergency Management Agency and the U.S. Department of Commerce, issued a report on priorities for quality assessment of nonfuel materials in the NDS.[2] Forty-four materials, or groups of materials, were examined to identify which material needed detailed investigation regarding its usability in the event of a national emergency. The report recommended that quality assessment of columbium and tantalum should receive special and immediate consideration owing to the critical use of tantalum for electronic applications and the use of both metals in superalloys. Joint assessment by experts on columbium and tantalum was to be considered essential. Initial assessment was undertaken by the Metal Properties Council Inc. (MPC), New York City, to review columbium and tantalum stockpile specifications. A key recommendation resulting from the MPC review was to revise the tantalum source material specification to include the three grades "tantalum natural mineral and concentrates, synthetic concentrates, and chemically processed materials and concentrates."

In the March 5, 1984, Federal Register, the Environmental Protection Agency (EPA) proposed effluent limitations guidelines and standards for nonferrous metals forming.[3] In the March 8, 1984, Federal Register, EPA also set final rules for new effluent limitations guidelines and standards for nonferrous metals manufacturing.[4] Both standards include columbium and tantalum and are based on best practicable technology, best available technology, and best conventional technology to handle industry's waste water discharges. The regulations 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 1984, but a pilot mill was reportedly being operated by American Aurum Inc., Spearfish, SD, to evaluate production of tantalum, tin, and mica.

Domestic production of ferrocolumbium, expressed as contained columbium, experienced little change from that of 1983. Value of ferrocolumbium production rose to $10.8 million. The regular grade remained 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 1.3 million pounds, up over 40% from that of 1983. In addition, consumption of purchased metal scrap was estimated at about 130,000 pounds.

A pilot mine operation was being assembled by Fansteel at an undisclosed site believed to be in the Western United States, to produce tantalum concentrates containing up to 45,000 pounds of tantalum pentoxide. The material would be tested at the company's Muskogee, OK, processing plant to determine the feasibility of domestic tantalum mining.[5]

A $1.8 million pilot plant was built by Cabot Corp., in Boyertown, PA, to further the company's ability to stay on the leading edge of capacitor powder technology. The new facility enables Cabot to move experimental powders into production more quickly, which gives the company the ability to develop tantalum powders with ever higher capacitance.[6]

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1984

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.:								
KBI Div	Boyertown, PA	X	X	--	--	X	X	--
Do	Revere, PA	--	--	--	--	--	--	X
Fansteel Inc	Muskogee, OK	X	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
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 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 H. C. Starck Berlin.

CONSUMPTION, USES, AND STOCKS

Overall reported consumption of columbium as ferrocolumbium and nickel columbium was up 25%. Consumption of columbium by the steelmaking industry increased 23%, influenced by a 9% rise in raw steel production, with over a 10% increase in the percent of columbium usage per ton of steel produced. Consumption in the carbon and the stainless and heat-resisting steels increased by 11% and 44%, respectively. Columbium usage per ton of stainless and heat-resisting steels produced was up over 40%. Columbium demand in HSLA steels rose by more than 25%, ending a 2-year decline for columbium consumption in this category of steelmaking. The increased demand for these grades of steels was due in part to the automotive industry's increased use of stainless steels for applications such as exhaust manifolds and the expanded usage of HSLA steels resulting from continued emphasis on weight reduction and fuel efficiency.

Demand for columbium in superalloys was up by more than 30% to over 1.2 million pounds. This was the first year since 1980 that consumption in this category was more than 1 million pounds. That portion used in the form of nickel columbium increased by over 60% to about 420,000 pounds.

Emerging applications for columbium included a columbium-titanium alloy selected for use as the core material of prototype superconducting magnets during development work for a proposed advanced atom smasher. Also, the Food and Drug Administration gave Federal approval to two companies to commercially market nuclear magnetic resonance imaging equipment systems, which use superconducting magnets containing wire usually of columbium-tin or columbium-titanium.

Tantalum consumption continued to rise, as reflected in the 26% increase in overall shipments reported by the Tantalum Producers Association. This was the highest level in tantalum shipments since 1980. The major segments of the tantalum market continued to show significant improvement; powder and anodes were up by 32% and mill products were up by 44%. Tantalum for cemented carbide was up nearly 13%, most of the demand occurring in the automotive and defense markets with minor gains in the farm and construction industries.

Factory sales of tantalum capacitors were up almost 35% as reported by the Electronic Industries Association. The record sales were accelerated by the continuing recovery in the electronics industry. The computer and automotive markets experienced steady growth and fostered a need for greater miniaturization without sacrificing capacitor performance. Mepco-Electra Inc. reportedly added a new plant in Jupiter, FL, totally dedicated to producing tantalum chip capacitors, and Mallory Capacitor Co. expanded its tantalum facility by an additional 25%.[7]

Data on aggregate stocks of columbium

and tantalum raw materials reported by processors for 1984 were incomplete at the time this chapter was prepared. Aggregate stocks of columbium and tantalum raw materials reported by processors for yearend 1983 were both down from yearend 1982, by more than 20% for columbium and by more than 15% for tantalum.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1983	1984
Columbium products:		
Compounds including alloys	1,049,500	941,820
Metal including worked products	424,400	529,800
Other	20,000	500
Total	1,493,900	1,472,120
Tantalum products:		
Oxides and salts	14,160	45,900
Alloy additive	104,020	86,630
Carbide	114,190	128,760
Powder and anodes	503,800	665,500
Ingot (unworked consolidated metal)	5,700	9,500
Mill products	214,100	307,600
Scrap	59,700	39,000
Other	--	--
Total	1,015,670	1,282,890

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]

	1983	1984
END USE		
Steel:		
Carbon	1,315,624	1,463,886
Stainless and heat-resisting	662,320	951,020
Full alloy	(2)	(2)
High-strength low-alloy	1,348,814	1,693,464
Electric	(3)	--
Tool	(3)	(3)
Unspecified	24,641	27,941
Total	3,351,399	4,136,311
Superalloys	937,463	1,240,295
Alloys (excluding alloy steels and superalloys)	24,333	19,454
Miscellaneous and unspecified	4,877	3,185
Total consumption	4,318,072	5,399,245
STOCKS		
Dec. 31:		
Consumer	W	W
Producer[4]	W	W
Total stocks[e]	760,000	950,000

[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

Prices continued stable for pyrochlore concentrates and columbium products based on them. Unchanged since April 1980, the price for pyrochlore concentrates produced in Canada by Niobec Inc. was quoted at $3.25 per pound of contained pentoxide, f.o.b. Canada, for concentrates with a nominal content of 57% to 62% Cb_2O_5. No price was available for Brazilian pyrochlore concentrates because they are no longer being exported. Contrary to strengthening demand, the spot price of regular-grade ferrocolumbium containing 63% to 68% columbium was lowered by 6%, in March, to about $5.60 per pound of contained columbium, f.o.b. shipping weight.

The price for high-purity ferrocolumbium, selling at $16.50 per pound of contained columbium in January, was raised to $17.70 in October. About the same time, the price for nickel columbium rose from $18.50 per pound of contained columbium to $19.70. Escalating costs of raw materials, energy, and labor were cited by industry sources as reasons for the price increases. Columbium metal price quotes remained unchanged. The average spot price for columbite concentrates was lowered by 30% in mid-September to a range of $3.50 to $5.00 per pound of combined columbium and tantalum pentoxides, c.i.f. U.S. ports. Columbium oxide was reported to be selling at yearend for less than $7 per pound of oxide.

Most tantalum prices continued virtually unchanged, with activity in the tantalite market reportedly still somewhat subdued. The spot market price for tantalite, which began the year at $28 to $31 on the basis of 60% combined tantalum and columbium pentoxides, c.i.f. U.S. ports, was being quoted at $31 to $33 by yearend. The quoted contract price for tantalite from the Canadian tantalum producer, Tantalum Mining Corp. of Canada Ltd. (Tanco), continued unchanged at $45 per pound of contained pentoxide. The contract price for tantalite from Greenbushes in Australia remained suspended. Published price quotations for tantalum mill products and powders were unchanged, as in 1983, at about $150 per pound.

FOREIGN TRADE

Net trade continued at a deficit for both columbium and tantalum. Trade volume was up by over 20% for all export items with total value up by nearly 50%. For imports, trade volume was up appreciably for most items with total value up by 80%. Exports and reexports of tantalum ores and concentrates increased almost 30% to 156,000 pounds valued at $1.5 million. The Federal Republic of Germany was the principal recipient with over 65% 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 about 60%. Imports for consumption from Brazil included 6.7 million pounds of ferrocolumbium, up over 70% and the highest level reported since 1981. Imports for consumption of columbium oxide from Brazil increased substantially to 1.2 million pounds valued at $6.8 million compared with 372,000 pounds valued at $1.8 million in 1983. Contained in the columbium oxide imports were an estimated 32,000 pounds of tantalum oxide valued at over $1 million. 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 more than doubled those of 1983. However, average unit value for overall imports declined by 17% owing to the continued depressed prices for columbium mineral concentrates. Canada remained the leading supplier, providing over 75% of total quantity and almost 70% of total value. Imports were estimated to contain 1.36 million pounds of columbium and 55,000 pounds of tantalum at an average grade of approximately 60% Cb_2O_5 and 3% Ta_2O_5.

Imports for consumption of tantalum mineral concentrates increased over threefold to the highest level since 1980, with average unit value up by 16%. Thailand was the leading source, providing nearly 30% of total quantity and over 19% of total value. Imports were estimated to contain 625,000 pounds of tantalum and 430,000 pounds of columbium at an average grade of approximately 35% Ta_2O_5 and 28% Cb_2O_5.

Data on receipts of raw materials other than mineral concentrates were incomplete.

Imports for consumption of columbium-tantalum synthetic concentrates remained virtually unchanged: 2.1 million pounds valued at $13.7 million, compared with 2.1 million pounds valued at $14.9 million in 1983. These figures are not included in the salient statistics data. Imports for consumption from China in 1984 included over 15,000 pounds of potassium tantalum fluoride at a value of $425,000.

Table 7.—U.S. foreign trade in columbium and tantalum metal and alloys, by class

(Thousand pounds, gross weight, and thousand dollars)

Class	1983 Quantity	1983 Value	1984 Quantity	1984 Value	Principal destinations and sources, 1984
EXPORTS[1]					
Tantalum:					
Powder	123	14,397	151	17,026	West Germany 32, $3,784; Japan 32, $3,661; United Kingdom 28, $3,401; France 31, $3,285.
Unwrought and waste and scrap	154	5,892	252	10,050	West Germany 186, $7,234; Japan 18, $1,474; Belgium-Luxembourg 18, $1,051.
Wrought	57	7,032	100	13,099	Japan 36, $5,556; United Kingdom 18, $2,236; West Germany 20, $1,940; France 13, $1,738.
Total	XX	27,321	XX	40,175	West Germany $13,000; Japan $10,700; United Kingdom $5,700; France $5,100.[2]
IMPORTS FOR CONSUMPTION					
Columbium:					
Ferrocolumbium[e]	3,906	12,992	6,682	20,445	All from Brazil.
Unwrought metal and waste and scrap	3	39	7	125	Brazil 3, $71; West Germany 2, $38; Austria 1, $9; Japan ([3]), $7.
Unwrought alloys	2	4	13	103	All from Brazil.
Wrought	([3])	2	([3])	35	All from West Germany.
Tantalum:					
Waste and scrap	122	2,803	183	4,866	West Germany 77, $2,589; France 26, $593; United Kingdom 20, $407; Japan 9, $362.
Unwrought metal	23	2,022	46	4,878	West Germany 36, $4,166; Netherlands 10, $712.
Unwrought alloys	5	231	1	33	All from Austria.
Wrought	([3])	24	1	48	Austria ([3]), $33; United Kingdom ([3]), $7; West Germany ([3]), $5; Japan ([3]), $2.
Total	XX	18,117	XX	30,533	Brazil $20,600; West Germany $6,800; Netherlands $770; France $600.[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.

Table 8.—U.S. imports for consumption of columbium mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1983 Gross weight	1983 Value	1984 Gross weight	1984 Value
Brazil	52	438	143	431
Canada	1,198	2,119	2,498	4,089
Germany, Federal Republic of[1]	--	--	17	38
Malaysia	67	162	105	163
Netherlands[1]	--	--	8	24
Nigeria	164	597	495	1,284
Total[2]	1,482	3,316	3,265	6,030

[1]Presumably country of transshipment rather than original source.
[2]Data may not add to totals shown because of independent rounding.

Table 9.—U.S. imports for consumption of tantalum mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1983		1984	
	Gross weight	Value	Gross weight	Value
Australia	182	1,543	371	4,799
Belgium-Luxembourg[1]	--	--	21	81
Brazil	240	1,749	351	3,895
China	--	--	22	203
French Guiana[1]	--	--	3	36
Germany, Federal Republic of[1]	(2)	2	205	2,291
Guyana[1]	--	--	1	14
Malaysia	--	--	341	1,354
Mozambique	18	239	16	152
Netherlands[1]	--	--	105	701
Portugal	--	--	11	90
Rwanda	--	--	37	753
Singapore[1]	--	--	10	122
South Africa, Republic of	9	112	7	32
Spain	--	--	71	672
Taiwan[1]	(2)	1	8	93
Thailand	55	159	609	3,688
Zaire	31	212	11	79
Total[3]	536	4,017	2,199	19,054

[1]Presumably country of transshipment rather than original source.
[2]Less than 1/2 unit.
[3]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

A report published by the International Iron and Steel Institute committee on raw materials indicated that the world steel industry was not likely to suffer from shortages in the supply of columbium, vanadium, and molybdenum. However, concentration in a limited number of countries of ore reserves for producing ferroalloys, especially ferrocolumbium, is a cause for concern. The report stated that substitution of columbium, vanadium, and molybdenum in steels is complex and depends on many factors both technical and economic, but some limited substitution is possible in the area of microalloyed steels. Columbium and vanadium act in similar ways in steels, and some limited substitution between the two elements is possible. Molybdenum is more often used in higher alloy steels and cannot generally be replaced by columbium or vanadium in these cases.[8]

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 1980, 1981, 1982, 1983, and 1984 was, in thousand pounds, 1,133, 1,006, 991, 1,049, and 828, respectively, according to data from the Tantalum International Study Center.

Regarding the shipments of old tin slags, data were only available from Thailand. Shipments of old tin slags from Thailand were up to 431 short tons in 1984 compared with no shipments in 1983. Data were not available as to the disposition of the shipments.

Australia.—For the fiscal year ending June 30, 1984, Greenbushes reported that its tin-tantalum plant capacity utilization was increased during the year from 35% to 75%. Mining operations concentrated on tantalite rather than tin ore reserves, owing to continued tin export quotas. Ore treated was 1.7 million tons in fiscal year 1984 compared with 1.1 million tons in fiscal year 1983. Tantalum oxide produced in concentrates increased to 105,200 pounds from 65,300 pounds in fiscal year 1983. The chemical plant produced approximately 22,500 pounds of Ta_2O_5 and 2,200 pounds of Cb_2O_5 in fiscal year 1984. Additionally, tantalum oxide contained in tantalum glass production was 48,500 pounds in fiscal year 1984 compared with 37,500 pounds in fiscal year 1983. The tailings retreatment plant remained inactive the entire year.

Greenbushes secured a 7-year loan, $15 million Australian, to implement its tin-tantalite hard-rock project and to repay existing company loans. First stage development of the project consisted of having a mining and processing operation, with an ore capacity of 331,000 tons per year, in place by January 1986. Existing soft-rock mining will be scaled down as production from the first stage hard-rock project commences. Combined tantalum production capacity from both mining operations will be 500,000 pounds of Ta_2O_5 per year. The project's second stage development envisions doubling the hard-rock mining and processing annual capacity to 660,000 tons of ore.

In 1984, Greenbushes entered into a joint venture agreement with Barbara Mining Corp. Ltd., a subsidiary of Bayer Australia Ltd., to develop the Bynoe tin-tantalum project located near Darwin in the Northern Territory of Australia. Under the terms of the agreement, Barbara Mining has a preemptive right to purchase the tantalite concentrate, and Greenbushes has a similar right to purchase the tin concentrate produced from the project. Greenbushes will operate the joint venture and plans to establish a pilot production facility during 1985.

Goldrim Mining Australia Ltd. announced plans to reopen its tantalite mines in Western Australia in late 1984 in response to firmer tantalum prices. The mines had been on care and maintenance since early 1983. Before closure, the mines reportedly produced about 13 tons of tantalite and minor amounts of tin per year.

West Coast Holdings Ltd. announced the discovery of a strategic mineral find at its Brockman Prospect in the Kimberleys, Western Australia. The deposit is believed to contain about 50 million tons of ore grading 0.5% Cb_2O_5, 0.03% Ta_2O_5, 0.8% BeO, and 0.14% Y_2O_3. The mineralization of the deposit was reported to be very fine, and an investigation of recovery techniques was in progress.

Brazil.—Cia. Brasileira de Metalurgia e Mineração's (CBMM) production of about 14,300 tons of ferrocolumbium was more than double that of 1983, with the plant operating at about 50% of its rated annual capacity. CBMM's columbium oxide production was 750 tons compared with 300 tons in 1983.

Brazil's total production of ferrocolumbium was up almost 60%, 16,800 tons compared with 10,700 tons in 1983. Ferrocolumbium exports were 16,200 tons compared with 10,200 tons in 1983.

By yearend, the Anglo American Corp. of South Africa Ltd. had acquired, from the Hochschild Group, controlling interest in Mineração Catalão de Goiás S.A., Brazil's other ferrocolumbium producer.

Cia. de Pesquisa de Recursos Minerais (CPRM), the Government's mineral research organization, was reported to have discovered a large columbium ore deposit in the Amazon region of Brazil. No plans to develop the deposit had been disclosed, but various companies were reportedly examining an association with CPRM for future exploration and extraction.

Canada.—As reported by Teck Corp. for the fiscal year ending September 30, production of columbium oxide at Niobec's mine at St. Honoré, Quebec, was up over 70% to 6,943,811 pounds, compared with 4,000,660 pounds in 1983. The mine operated at capacity, but milling problems persisted owing to increasing proportions of refractory minerals in the ore. Ore milled was up over 60% to 819,772 tons from 502,400 tons in 1983, as the mill operated on the average of 2,240 tons per day compared with 2,310 tons per day in 1983. Recovery was reduced to 60% from about 62% in 1983, with Cb_2O_5 grade of ore increasing to 0.71% from 0.64% in 1983. Ore reserves declined at the end of the fiscal year to about 11.8 million tons assaying 0.66% Cb_2O_5, compared with 12.6 million tons assaying 0.66% Cb_2O_5 in 1983. Following the fiscal yearend, the mine was on strike effective October 19. However, a new 3-year contract was ratified on November 22, and the mine returned to full production by the end of November.

The Hudson Bay Mining and Smelting Co. Ltd. reported that tantalum mining and milling activity at the Bernic Lake, Manitoba, operation of Tanco remained suspended throughout the year, as in 1983, with no sales or production of Ta_2O_5. However, Tanco temporarily converted the tantalum mill into a pilot plant to produce ceramic-grade spodumene. The effort was assisted by a grant from the Federal Department of Regional Industrial Expansion. Initial indications were that the commercial viability of a spodumene operation was feasible if markets could be established. Discussions with major spodumene users were said to be encouraging. The spodumene operation reportedly will not interfere with the eventual startup of tantalum production. The two materials are located in separate ore bodies, and additional equipment will be added to handle both the tantalum and spodumene operations.

Nuinsco Resources Ltd. completed an exploration program on its Prairie Lake industrial metal property 40 miles northwest of Marathon, Ontario. The property is a circular alkali-carbonatite complex believed to contain significant quantities of columbium, phosphate, uranium, and various rare-earth elements. Preliminary results of drilling in the western quadrant of the property indicates a columbium presence grading 0.57% Cb_2O_5. Nuinsco reportedly plans to spend up to $200,000 on various phases of additional exploration on the property.

Germany, Federal Republic of.—A new electron beam furnace reportedly commissioned by WC Heraeus GmbH, a major producer of tantalum mill products in Europe, will increase its melt power capacity by a factor of up to 10. The furnace is to broaden the company's raw material base to include some materials not previously usable. The first stage of the furnace will have a melt power capacity of 450 kilovolt amperes, with potential expansion to 900 kilovolt amperes depending on tantalum market conditions.

Japan.—Production of ferrocolumbium was 1,136 tons, up considerably from the 584 tons produced in 1983. Columbium ore imported for ferrocolumbium production was 2,251 tons, almost all from Canada, compared with 816 tons in 1983. Ferrocolumbium imports were 2,260 tons compared with 1,960 tons in 1983, with the bulk of imports coming from Brazil. Tantalum ore imports totaled 303 tons, with over 60% of the imports coming from Malaysia, compared with 133 tons in 1983.

The Showa-Cabot Supermetal Co., a joint venture of Japan's Showa Denko K.K. and Cabot of the United States, reportedly was doubling tantalum powder production capacity at its Higashi-Haghara plant. The additional facilities, due to come on-stream by April 1986, will increase capacity to 220 tons per year with projected expansion to about 330 tons per year.

Nigeria.—Production of columbite, as a byproduct of tin mining reported by the group of Amalgamated Tin Mines of Nigeria (Holdings) Ltd. (ATMN), Bisichi-Jantar Nigeria Ltd., Gold & Base Metal Mines of Nigeria Ltd., and Vectis Tin Mines Ltd., was up 18% with a combined output of 114 tons compared with 96 tons in 1983. ATMN continued to be the major producer with over 90% of production, the rest coming from Bisichi-Jantar.

Thailand.—Columbite-tantalite production declined by 13%, and struverite production was down to 33 tons from 303 tons in 1983.

Thailand's Department of Mineral Resources rejected a petition by the Thailand Smelting and Refining Co. Ltd. (Thaisarco), a Billiton Group subsidiary, to revise the company's tin concentrate purchase price formula. Thaisarco's supply contracts with Thai tin miners are based on the Malaysian Kuala Lumpur Tin Market (KLTM) price, but the company sells approximately 80% of its output at the London Metal Exchange (LME) price, which is lower than the KLTM price. Thaisarco had sought permission to introduce a new tin concentrate purchase price formula based on the mean of 20% of the KLTM price and 80% of the LME price. The company in the past had been able to compensate for price discrepancies between the KLTM and the LME through profit margins included in smelting fees and its sales of byproduct tantalum-bearing tin slags. However, in 1984 Thaisarco was reportedly sustaining large financial losses, and by yearend, Billiton was considering the restructure of its Thai tin mining operations. Thaisarco's tin smelter was reported to be operating at about 60% of its 38,000-ton-per-year capacity, owing to tin export controls mandated by the International Tin Council.

A strengthening of the tantalum market reportedly persuaded the Thailand Tantalum Industry Corp. Ltd. (TTIC) to go ahead with plans to construct a smelter to process tin slags containing small quantities of tantalum. The smelter will complement TTIC's chemical plant for the processing of high-grade tin slags and tantalum-containing ores planned for completion by midyear 1986.

Zaire.—Société Minière du Kivu (Somikivu) reportedly discovered a large pyrochlore deposit in its Lueshe concession in eastern Zaire, containing an estimated 3.3 million tons of pyrochlore. A pilot concentrate plant was commissioned at the site in March, having a throughput capacity of about 2 tons of ore per day. The pyrochlore concentrate product was being shipped to the Federal Republic of Germany. Full-scale operations are possible by 1990. However, Somikivu is faced with securing a sufficient energy supply, a reliable water source, and a site for tailings disposal before large-scale development of the deposit can be undertaken. In addition, transportation of the concentrate to a seaport is a serious problem, transport being made by a combination of truck, barge, and rail shipments.

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]				
	1980	1981	1982	1983[p]	1984[e]	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984
Australia: Columbite-tantalite	[r]446	[r]582	256	[e]440	440	90	105	45	80	80	147	205	90	150	150
Brazil:															
Columbite-tantalite	1,186	659	443	582	610	213	138	97	134	140	380	178	130	170	175
Pyrochlore	67,682	65,887	43,195	37,099	54,760	28,426	27,673	18,142	15,582	23,000	--	--	--	--	--
Canada:															
Pyrochlore	[e]8,256	[e]9,040	[r e]10,500	[e]6,830	9,630	[5]3,796	[5]4,224	4,730	2,870	4,330	--	--	--	--	--
Tantalite	[e]620	[e]640	[e]590	--	--	17	19	18	--	--	[5]208	[5]188	170	--	--
Malaysia: Columbite-tantalite	73	51	18	[r e]150	110	18	8	3	23	17	8	4	2	15	8
Nigeria:															
Columbite	1,221	831	397	[r e]190	230	537	363	180	85	100	73	48	24	11	13
Tantalite	2	[r]4	2	[e]2	2	([6])	([6])	([6])	([6])	([6])	1	2	1	1	1
Portugal: Tantalite	9	20	13	[r e]7	--	2	5	4	2	--	2	5	4	2	--
Rwanda: Columbite-tantalite	132	126	137	111	115	42	38	40	33	34	24	28	30	24	25
Spain: Tantalite	112	129	118	104	104	NA	NA	NA	NA	NA	[5]31	[5]36	[5]31	[5]33	33
Thailand: Columbite-tantalite	785	[r]108	86	1,210	1,052	171	18	15	205	180	259	23	20	278	242
United States: Columbite-tantalite	([7])	([7])	([7])	--	--	([7])	([7])	([7])	--	--	([7])	([7])	([7])	--	--
Zaire: Columbite-tantalite	203	165	176	112	112	57	45	48	30	30	43	46	50	31	31
Zimbabwe: Columbite-tantalite	90	99	79	71	71	10	15	12	11	11	23	35	28	25	25
Total	[r]80,817	[r]78,341	56,010	46,908	67,236	33,379	32,651	23,334	19,055	27,922	1,199	798	580	740	703

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

[1]Excludes columbium- and tantalum-bearing tin ores and slags. Table includes data available through June 25, 1985.

[2]In addition to the countries listed, China, Mozambique, Namibia, 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.

TECHNOLOGY

An update of the state of the art of HSLA steels was reviewed in a report entitled "HSLA Steels Technology and Applications." The report offers a comprehensive overview of recent advances in alloy design concepts, steelmaking and casting technologies, and applications as sheet, plate, linepipe, forgings, and castings. The effectiveness of microalloying elements on both grain refinement and precipitation strengthening depends mainly on their precipitation reactions, and it was reported that columbium, titanium, and vanadium were now being used in a more balanced and rational way.[9]

Recent applications and manufacturing considerations in the field of superconductivity was described in a review of fabrication processes of superconducting composite materials. Three large-scale application areas for superconductors were discussed: accelerator magnets for high-energy physics research, magnetic confinement for thermonuclear fusion, and magnetic resonance imaging for health care. A columbium-titanium alloy was reported to be the principal superconducting material in use today.[10]

A new method for increasing the leaching rate of bulk superalloy scrap to facilitate recycling and recovery of critical metals, such as columbium and tantalum, was devised by the Bureau of Mines. Investigation showed that melting bulk alloy scrap with 20% or more aluminum forms a brittle alloy that can be crushed into small particles. The time required to dissolve the metals contained in superalloys was decreased from days or months to hours.[11]

Cabot's KBI Div. reportedly perfected a proprietary low-cost technique for recovering high-quality tantalum from scrap for use in electronics applications. This development is expected to free the company from the need to carry large inventories of tantalum raw materials to guard against sudden disruptions in raw material availability.[12] A new tantalum-base alloy that exhibits high-yield strength at elevated temperatures was also developed by KBI. Designated as KBI Alloy 41, the material is reportedly comprised of 58% tantalum, 37.5% columbium, 2.5% tungsten, and 2% molybdenum. The alloy is said to be the first commercial tantalum alloy to specify molybdenum as part of the chemical composition. Potential applications include welded tubing for heat exchangers and patching material for glass-lined equipment in the chemical processing industry.[13]

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[1]Physical scientist, Division of Ferrous Metals.

[2]National Materials Advisory Board. Priorities for Detailed Quality Assessment of the National Defense Stockpile Nonfuel Materials. Natl. Acad. Sci., Washington, DC, NMAB-403, 1984, 66 pp.

[3]Federal Register. U.S. Environmental Protection Agency. Nonferrous Metals Forming and Iron and Steel/Copper/Aluminum Metal Powder Production and Powder Metallurgy Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 49, No. 44, Mar. 5, 1984, pp. 8112-8182.

[4]———. U.S. Environmental Protection Agency. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. Final Rule. V. 49, No. 47, Mar. 8, 1984, pp. 8742-8831.

[5]Mining Journal (London). V. 302, No. 7759, May 4, 1984, p. 301.

[6]Cabot Corp. 1984 Annual Report. 55 pp.

[7]American Metal Market. Tantalum and Columbium Supplement. V. 92, No. 180, Sept. 14, 1984, pp. 6A, 12A.

[8]International Iron and Steel Institute. Vanadium, Niobium, Molybdenum, and the Steel Industry. Committee on Raw Materials, Brussels, Belgium, 1984, 217 pp.

[9]American Society for Metals. Proceedings of HSLA Steels Technology and Applications Conference (Philadelphia, PA, Oct. 3-6, 1983). 1984, 1,173 pp.

[10]Gregory, E. Applications and Fabrication Processes of Superconducting Composite Materials. J. Met., v. 36, No. 6, June 1984, pp. 30-34.

[11]Atkinson, G. B. Increasing the Leaching Rate of Bulk Superalloy Scrap by Melting With Aluminum. BuMines RI 8833, 1983, 11 pp.

[12]American Metal Market. V. 92, No. 237, Dec. 7, 1984, pp. 1, 16.

[13]———. V. 92, No. 226, Nov. 20, 1984, p. 9.

Copper

By J. L. W. Jolly[1] and D. L. Edelstein[1]

With an average copper price for the year that was lower than in the recession year of 1982 and, in real terms, the lowest since the price-controlled years of World War II, the U.S. copper industry continued to retrench and to institute major efforts to lower operational costs. On the other hand, copper consumption by U.S. copper fabricators continued to recover, with demand exceeding supply nearly every month since December 1983. World stocks of refined copper held by industry and metal exchanges receded almost without interruption by about 486,000 metric tons during the year to 1.2 million tons at yearend 1984. Nevertheless, the continued presence of the large remaining inventories was a major factor in the severely depressed price during the year.

Table 1.—Salient copper statistics

(Metric tons unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Ore produced ---- thousand metric tons--	221,597	277,674	181,944	177,993	171,911
Average yield of copper -----percent--	0.48	0.51	0.55	0.51	0.57
Primary (new) copper produced:					
From domestic ores, as reported by:					
Mines	1,181,116	1,538,160	1,146,975	1,038,098	1,091,284
Value ---------- thousands--	$2,666,931	$2,886,440	$1,840,856	$1,751,476	$1,608,422
Smelters	994,479	1,294,962	940,547	888,130	989,720
Percent of world total	13	16	[r]12	11	12
Refineries	1,126,231	1,430,210	1,064,533	1,003,668	1,084,258
From foreign ores, matte, etc., as reported by refineries	88,957	113,807	162,245	178,422	115,930
Total new refined, domestic and foreign	1,215,188	1,544,017	1,226,778	1,182,090	1,200,188
Refined copper from scrap (new and old)	515,083	493,552	467,549	[r]401,668	309,489
Secondary copper recovered from old scrap only	613,458	598,122	517,726	[r]449,478	465,120
Exports: Refined	14,489	24,397	30,558	81,397	91,414
Imports for consumption:					
Refined	426,948	330,625	258,439	459,568	444,699
Unmanufactured[1]	[r]554,664	[r]437,786	[r]513,202	[r]633,657	530,765
Stocks, Dec. 31: Total industry and COMEX:					
Refined	294,000	465,000	676,000	672,000	536,000
Blister and materials in solution	272,000	277,000	233,000	174,000	232,000
Total	566,000	742,000	909,000	846,000	768,000
Consumption:					
Refined copper (reported)	1,862,096	2,025,169	1,658,142	[r]1,803,931	2,036,202
Apparent consumption, primary and old copper (old scrap only)	[r]2,179,000	[r]2,277,000	[r]1,761,000	[r]2,014,000	2,155,000
Price: Weighted average, cathode, cents per pound, producers	101.31	84.21	72.80	76.53	66.85
World:					
Production:					
Mine------- thousand metric tons--	[r]7,405	[r]7,814	7,583	[p]7,625	[e]7,838
Smelter -----------do----	[r]7,649	[r]8,001	7,910	[p]8,092	[e]8,259
Refineries-----------do----	[r]8,869	[r]9,171	8,978	[p]9,117	[e]9,155
Price: London, high-grade, average cents per pound	99.25	79.35	67.14	72.13	62.43

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Incudes copper content of alloy scrap.

Although U.S. producers continued to talk of the need for restraint, world mine copper production was estimated to have significantly exceeded that of 1983. Increased mine production was indicated by Canada, Chile, Indonesia, Iran, Mongolia, Peru, Poland, Spain, Sweden, the U.S.S.R., Yugoslavia, Zaire, and Zimbabwe. The United States also was able to maintain a production rate that was slightly higher than that achieved in 1983 as the mining industry continued to shift production to lower cost facilities and moved to take advantage of cost cutting resulting from economies of scale. Countries such as Australia, Brazil, Finland, Japan, Morocco, Papua New Guinea, the Philippines, the Republic of South Africa, and Zambia indicated production decreases for the year.

In addition to the influence of market supply and demand on copper prices, several other factors had major impacts and were expected to continue to exert downward pressures on prices. Some analysts attributed as much as 15% of the decline in U.S. prices for copper to the strength of the dollar against most currencies. Speculative interests that influenced copper market fundamentals related to supply and demand in the past seemed to have evaporated. Some analysts related this phenomenon to a decrease in the number of active merchants in the market, and to the increasing role of Government-owned marketing agencies that were paying more attention to changing monetary relationships than to supply and demand.

High imports of copper and copper-alloy products continued to plague much of the domestic industry. Although the brass mill and ingot maker segment of the industry enjoyed a robust first half of the year, by yearend parts of this industry were beginning to feel the impact of foreign competition with depressed domestic prices for their products resulting from increased imports of lower priced materials. Copper-alloy-producer demand for scrap decreased and exports of scrap increased significantly, with the result that there were spot shortages of certain types of scrap in some areas. Nevertheless, some parts of the U.S. fabrication industry were able to conduct brisk business during the year. Copper wire and tube mills and specialty brass mills enjoyed a robust year for many of their products as consumption tied to the housing, automotive, and electronics industries continued healthy growth during the year.

Trade issues relating to tariffs and trade practices of other countries, the free trade versus fair trade debate, foreign producer plans for expansion, the use and effects of the Compensatory Financing Fund of the International Monetary Fund (IMF) by major copper producers, the devaluations of foreign currencies, and the continued high international debt of copper producing developing nations continued to be the focus of attention during the year. High interest rates, scarce funds for technological improvements, and the continued pressures of the need to bring facilities into environmental compliance were issues of special concern to U.S. producers. Several smelters closed by yearend, and some companies announced other closures in early 1985 as a result of these latter issues.

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 the 91 operations to which a survey request was sent in 1984, 84% responded, representing an estimated 99.98% of the recoverable copper content in the total mine production shown in tables 5 through 15. Production for the remaining 15 companies was estimated using data from other surveys.

Legislation and Government Programs.—On January 26, 11 major domestic copper producing companies filed a joint petition with the U.S. International Trade Commission (ITC) seeking relief from imports of refined copper as provided for under section 201, commonly known as the escape clause, of the Trade Act of 1974. Section 201 provides for temporary relief in the form of tariffs, quotas, or orderly marketing agreements for a domestic industry that has suffered or been threatened by serious injury from imports. In this petition, the copper producers cited a 140% increase in refined copper imports in 1983 compared with imports in 1979, huge industry financial losses, and a 38% reduction in the copper industry labor force as evidence of injury.[2] As a remedy, the copper producers sought import quotas on refined and blister copper totaling 350,000 tons per year, about two-thirds of the 1983 import level.

On June 14, the ITC voted unanimously in favor of the petition, finding that the domestic copper industry had been seriously injured and that imports of refined copper had been a substantial cause of the injury. Though unanimous in their determination of injury, the commissioners did not concur on a remedy; two commissioners recommended an annual 425,000-ton quota for 5 years, two commissioners recommended a 5-cent-per-pound tariff increase for 5 years, and a fifth commissioner found no remedy.[3]

On September 6, the Administration announced that it had rejected the domestic producers' petition for relief. The decision was reportedly based on the contention that import restrictions would raise the price of copper for U.S. fabricators and would seriously disadvantage the copper fabricating industry. The Administration belief that far more jobs would be lost than gained by imposing restrictions was cited as the largest single factor in ruling against the petition. The adverse effect that restrictions would have on the export earnings of heavily indebted foreign copper producing countries and the resulting negative impact it might have on the international financial system and on the ability of these countries to import U.S. goods were also cited as reasons for rejecting restrictions.

Public Law 98-573, the Trade and Tariff Act of 1984, effective October 30, contained a nonbinding "sense of Congress" suggestion that instructed the Administration to negotiate voluntary copper import reductions with major foreign producers.

Public Law 98-473, the Continuing Resolution providing Government appropriations for fiscal year 1985, enacted in October, increased the stockpile acquisition fund from the $120 million level requested by the Administration to $185 million, with the suggestion that the low priority given to copper as a stockpile item be reconsidered. In addition, a "Buy America" clause was included requiring that none of the funds be used to purchase stockpile materials not mined and refined in the United States if that material is available in sufficient quantities from domestic sources.

On April 3, S. 2524, the Copper and Extractive Industries Fair Competition Act of 1984, was introduced, which would require the United States to vote against use of the IMF's compensatory financing facility for aiding countries experiencing a shortfall in export earnings from nonfuel minerals when the shortfall results from declining prices of a commodity in surplus on world markets, unless the countries agree to "adjust production and not to add further excess capacity, and to take other necessary action to stabilize the market for such commodity." Other provisions of the bill required U.S. representatives to international lending institutions to take into account in their review of loan applications "the effect that country adjustment programs would have upon individual industry sectors and international commodity markets." In addition, the bill would make it easier for industry to seek import relief from injury caused by import competition and would require the President to take some action when the ITC makes a recommendation for relief. Under the existing law, the President was not required to take action. Another bill, S. 2340, the Copper Environmental Equalization Act of 1984, introduced in February to aid the domestic copper industry, would have increased the import duty on copper by up to 15 cents per pound, to offset the costs incurred by domestic copper producers in meeting environmental requirements. At yearend, neither of these bills had passed Congress.

Legislation was introduced to replace the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), which was to expire on September 30, 1985. The bill H.R. 5640, which was passed by the House and at yearend was under consideration by the Senate, would tax copper, as a toxic element, at the rate of $30 per ton.

On July 11, 1983, the Environmental Protection Agency (EPA) proposed regulations governing arsenic emissions from primary copper smelters processing high-arsenic feed materials—those containing 0.7% or greater arsenic—and primary copper smelters processing low-arsenic feed materials—those containing less than 0.7% arsenic. The proposed standards required additional emissions controls at six copper smelters processing low-arsenic feed materials, and at ASARCO Incorporated's Tacoma, WA, smelter, the only smelter processing high-arsenic feed materials. The public comment period for the proposed standards, which had been extended twice at public request, ended on January 31, 1984. As a result of information submitted by commentators, EPA reevaluated low-arsenic copper smelters and significantly changed some of its emissions and control cost estimates. Estimates of inorganic arsenic emissions were revised downward for the six low-arsenic smelters, and control cost estimates for converter operations and matte- and slag-tapping operations were generally revised upward. Using the criteria set forth in the 1983 proposed regulations, it was likely that fewer smelters would require additional controls under the revised estimates. EPA reopened the public comment period for consideration of its revised estimates from September 20 until November 5.[4] Proposed regulations governing the Tacoma smelter were mooted by Asarco's announced intention to permanently close the smelter in early 1985.

DOMESTIC PRODUCTION

Mine Production.—Copper was produced from 76 mines in 10 States during the year, with Arizona comprising 69% of the total, and New Mexico and Utah in second and third place, respectively. The total number of mines in 1983 was 105. In 1984, 26 copper and 15 byproduct copper mines owned by 19 companies accounted for 99.9% of domestic mine production. The remainder came from 35 smaller copper operations and mines in which copper was a byproduct, and each had an annual production of less than 350 tons. Total U.S. operating mine capacity, in terms of recoverable copper, was estimated to be 1,462,000 tons as distributed among 15 major copper mines (1,376,000 tons), 61 smaller copper mines (38,000 tons), and byproduct copper producers (44,000 tons). In addition, some 332,000 tons of capacity was available at mines maintained on a care-and-maintenance basis. Precipitate capacity at 12 mines, included in the capacity estimates above, was about 139,000 tons of recoverable copper; electrowinning capacity at 9 mines was estimated to be 139,200 tons.

About 9.5% of total U.S. production of gold and 14% of total silver production was derived as a byproduct of copper mining. The estimated value for recovered gold and silver was $0.17 cent per metric ton of ore mined, down significantly from that of 1983, and nearly one-half the value estimated for 1980 when these metals values were at their highest. The amount of copper ore extracted by open pit mining remained high at 92% compared with 8% extracted by underground methods.

The average production cost (excluding byproduct credits, depreciation, and profit) was reduced from 98 cents per pound in 1981 to 76 cents per pound in 1984, based on an analysis of 16 operating U.S. mines.[5] Some capacity lost due to mine closures was expected to be compensated for by increases at several mines that were moving to take advantage of economies of scale.

In the United States, since 1974, about 17 major and 23 smaller copper mines have closed; this is in addition to 19 byproduct copper producing mines. Some companies were seeking to sell their domestic operations. Three major mines (Bingham, Twin Buttes, and Palo Verde) were operating at less than full capacity at yearend. Of the closed mines, some 211,000 tons of capacity at six mines was presumed to be on care-and-maintenance status, and this did not include another 121,000 tons at Carr Fork and Twin Buttes, both of which were considering more permanent closure measures at yearend.

A report by Western Economic Analysis Center of Arizona indicated that copper was the fifth most important source of basic personal income in the State of Arizona. The copper industry had an average basic weekly wage of $555 per week, or some 20% higher than that of the transportation and manufacturing industries in the State in 1984. Considering all indirect and direct contributions, the copper industry generated more than $1.5 billion in personal income for Arizona residents, or 50% more than the copper industry's sales. The total direct and indirect contribution of the copper industry to Arizona in 1984 was $5.4 billion in personal and business income generated and $412 million paid in State and local government revenues. This compared with the peak year of 1981 when the copper industry contributed $8.9 billion in personal and business income and paid $713 million in State and local taxes.[6]

Employment in the U.S. copper industry continued to decline. U.S. Department of Labor statistics indicated that the average number of workers employed during 1984 in the domestic copper smelting, refining, mining, and milling industries was 21,737 compared with 24,390 in 1983. Substantial cutbacks in personnel continued to be made in 1984 in salaried and hourly personnel at all companies. Asarco substantially cut back personnel at continuing operations and administrative offices, and effective January 1, 1985, wages of Asarco's salaried U.S. personnel were to be reduced on a graduated scale of 4% to 10%, depending upon salary level. Shares of Asarco stock were to be held in trust in amounts equal to the salary reduction for each employee. Wage settlements with unions representing Asarco employees in 1984 provided for no increase in wages, some modification of cost-of-living allowances, and for reductions in fringe benefits.[7] Similarly, overhead costs at Phelps Dodge Corp.'s New York and Phoenix offices were lowered, with staff reductions from 524 at the beginning of the year to 290 at yearend—a reduction of about 45%.[8]

Workers at Duval Corp.'s Sierrita Mine voted 314 to 286 to decertify their unions, which included the United Steel Workers of America and three other unions representing employees at the Sierrita property. The National Labor Relations Board was to review the case in early 1985. Decertification elections also were held in the fall of 1984 at Phelps Dodge's Arizona locations and at its El Paso, TX, refinery. In all cases, the employees voted against continued union representation.

AMAX Inc.'s earnings from operations before income taxes in 1984 were $187 million, compared with earnings of $53 million before taxes and provision for losses on properties and investments in 1983. AMAX produced a total of 11,394 tons of refined copper from the Twin Buttes Mine and other sources of unrefined copper. The copper was sold at an average price of 61.3 cents per pound, compared with an average of 71.8 cents in 1983, and comprised 10% of the company's total consolidated 1984 sales.[9]

With the exception of the oxide plant, the Anamax Mining Co. operations in Arizona remained shut down. Anamax owns the Twin Buttes Mine and 50% of the Eisenhower Palo Verde Mine, operated by Asarco. At the Twin Buttes Mine, 1,569,000 tons of oxide ore containing 0.9% copper was processed during 1984. Ore from the Palo Verde deposit was mined by Asarco and processed into concentrates at Anamax's Twin Buttes mill and at Asarco's Mission mill. During 1984, however, the Twin Buttes mill did not operate.

Anamax was a defendant in a lawsuit brought by the U.S. Government, the Papago Indian Tribe, and others alleging withdrawal of excessive amounts of surface and ground water from the Santa Cruz River Basin in derogation of their rights to it. The plaintiffs sought a permanent injunction to prevent the further use of ground water, and damages in a unspecified amount. If the suit is concluded adversely to Anamax, the company could be denied water essential to its operations.

According to Asarco's annual report, 1984 proved to be the most difficult year since the 1930's. The company had a net loss of $306 million in 1984, compared with net earnings of $58.3 million in 1983. The 1984 results included unusual pretax charges of $254 million, reflecting the closing or shutdown of certain facilities and the writedown in value of properties no longer considered to be economic. Asarco recorded a $35 million pretax charge against its fourth quarter results to writeoff the remaining value of its investment at the Sacaton Mine in Arizona, which the company closed in March 1984. The company also reported a charge of $56 million against the 1984 results to reflect the anticipated $78 million cost of closing its Tacoma, WA, smelter in 1985.

At the Asarco Mission copper mining complex, which includes the adjacent Mission, Eisenhower, and San Xavier open pit mines, the cash cost of producing a pound of copper in concentrates was reduced by about 28% between 1981 and yearend 1984. The principal contributing factors were investments made in 1981 to modernize the Mission hauling truck fleet and the mill's flotation cells. A new agreement in 1984 with the Eisenhower Mining Co. joint venture to change the mining plans permitted a significant reduction in the amount of overburden stripped from the ore bodies and a 52% reduction in the work force since 1981 while maintaining copper output at about the 1981 level. The San Xavier Mine and portions of the Mission Mine were held under long-term leases under which the lessor retained a royalty interest. Asarco's production share of the Eisenhower production in 1984 was 33,700 metric tons of copper and 596,000 troy ounces of silver. Mission produced 9,435 metric tons of copper and 1.3 million ounces of silver. San Xavier produced 2.3 million ounces of silver and 8,537 metric tons of copper. Asarco suspended open pit mining operations at its Silver Bell copper mine in Arizona in August. A leaching operation at the mine continued to produce copper at about one-fourth of Silver Bell's normal rate of 19,000 metric tons per year.

The 75% Asarco-owned Troy silver-copper mine in Montana reduced operating costs to a new low in 1984 and made metallurgical improvements that increased metal recovery and the metal content of concentrates, reportedly to a new high. At the Troy Mine, 2.7 million tons of ore was milled, for a recovery of 4.3 million ounces of silver and 17,200 metric tons of copper. Asarco operated the Troy Mine under a lease agreement in which Asarco retains 75% of net proceeds after operating expenses, but before depletion, depreciation, and income taxes. A lawsuit was filed in Montana State Court in 1979 against Asarco, the Montana Department of State Lands (DSL), and the Montana Department of Health and Environmental Sciences by two nonprofit corporations claiming that DSL failed to apply the proper environmental standards when it granted Asarco's mining permit for the Troy Mine.

During 1984, Boliden Minerals Inc., a subsidiary of the Swedish Boliden Group, continued with its evaluation of several relatively small but high-grade copper-zinc-silver ore bodies in the Pinos Altos, NM, area and was proceeding with engineering studies and acquisition of permits. By early 1985, Boliden had filed a plan of operations with the Gila National Forest authority to dispose of mill tailings in an arroyo located near the company's proposed underground mine, and sent a one-time sale of 8,000 tons of chalcopyrite ore to the Chino Mines Co.'s, New Mexico smelter late in 1984.[10] Boliden purchased the deposit from Exxon Minerals Co. in February 1982.

During 1984, the Louisiana Land and Exploration Co. continued to divest itself of mineral-related assets. In May 1984, the company sold its copper and gold mine and smelter operations for $55 million.[11] Its Copper Range Co. assets were purchased by Echo Bay Mines Ltd. of Edmonton, Alberta, Canada, not for the copper properties, which Echo Bay planned to dispose of, but for Copper Range's Nevada gold properties.

Amoco Minerals Co. incurred a loss of $38 million in 1984 from its combined minerals operations in metals, coal, and industrial minerals. This compared with losses of $21 million in 1983 and $48 million in 1982. The primary reasons for the loss reportedly were the startup costs of the Thompson Creek molybdenum mine in Challis, ID, and reduced copper sales volumes, which were 32% below the 1983 level. A loss of $3 million was related to the company's two foreign joint ventures.[12]

The company's Cyprus Bagdad copper mine in Arizona, which was closed temporarily in February, resumed production in November, after implementation of cost-cutting measures that included a new mine plan and new smelting and refining contracts. The company believed the Bagdad Mine to be one of the lowest cost U.S. copper producers. Because of the temporary shutdown, production decreased by 70% to 21,800 tons. Proven reserves, at yearend 1984, were 436 million tons with an average grade of 0.44% copper.

Duval reduced its parent Pennzoil Co. Inc.'s 1984 earnings by $83 million. In the fourth quarter, Pennzoil took a one-time $67 million aftertax write-down on Duval. In the first 9 months of 1984, Duval incurred a $28 million loss on its metals business, with its Sierrita Mine in Arizona reportedly responsible for a principal share of this loss. At yearend, Duval announced the intended sale of its mineral assets, including the Sierrita Mine and the Esperanza and Kingman copper and molybdenum mines, all in Arizona. The latter two mines had been closed since December 1981. Nonetheless, the company had no plans to reduce operating levels or to close down Sierrita, since closure would be extremely costly when the costs of redundancy payments and renegotiating contracts, including power contracts, were taken into consideration.[13] In the past few years, Duval had implemented comprehensive cost-cutting measures at its copper operations, particularly labor cost cuts, which brought the losses down from $261 million in 1982 to $33 million in 1983. The company announced the permanent closure of its CLEAR process electrowinning plant at Sierrita during the year. An increased production schedule was introduced at Sierrita in late 1984, and production at the mine was increased thereby to about 90,000 tons of contained copper in ore per year.

Exxon Minerals continued with exploration, assessment, and applications for various permits for the Crandon zinc-copper deposit in Forest County, WI. About $60 million had been spent to date by Exxon on engineering studies and other activities, and the company expected to spend another $10 to $15 million to complete its preparations.[14] Exxon based an employment projection of 700 workers on a timetable that called for construction of the mine to begin in 1986. The company anticipated processing about 10,000 tons of ore per day; the complex ore averages 5.2% zinc, 1.2% copper, and 0.5% lead.

Camp Bird Colorado Inc., a 100%-owned subsidiary of Federal Resources Corp., owned or leased mining properties covering about 4,380 acres in the San Juan Mountains near Ouray, CO. On July 10, 1984, the company processed its first ore through the recently refurnished 500-ton-per-day flotation mill at the Camp Bird Mine. Federal also executed a mining venture agreement with Westar Resources Inc. to explore and develop Federal's Lordsburg, NM, mining properties. Federal and Westar entered into an operating agreement with Phelps Dodge for exploration, development, and production from the Lordsburg mining properties. Initial drilling results were encouraging, outlining silica ores with precious metal and copper values suitable for shipment as flux material to nearby copper smelters. An ore reserve of some 442,000 metric tons was delineated.[15]

In 1984, Inspiration Consolidated Copper Co., a subsidiary of Inspiration Resources Corp., operated several open pit mines, a two-stage leaching operation, two copper concentrators, a smelter, a sulfuric acid plant, a solvent-extraction plant, an electrowinning and electrorefining tankhouse, and a continuous-cast rod plant. Through its subsidiary, Black Pine Mining Co., Inspiration also operated a silver-copper mine in Montana. Its inactive mines included the Christmas open pit and underground mines in Arizona, with proven reserves of about 8 million short tons of ore averaging 0.63% copper in the open pit and 13 million tons of ore averaging 1.78% copper in the underground mine, and the Oxhide and Sanchez Mines in Arizona, with 29 million tons of 0.30% copper ore and 79.4 million tons of 0.36% copper ore, respectively.

Inspiration focused its mining activities principally in the Joe Bush-Thornton open pit mines near Globe, AZ. Oxide ore was treated by dump leaching and electrowinning with its patented "ferric cure" leaching process. In July 1984, Inspiration acquired the Bluebird property from Ranchers Exploration and Development Corp. The Bluebird property is adjacent to Inspiration at Miami, AZ, and was estimated to contain about 50 million tons of leachable ore grading 0.40% copper. In addition, about 40 million tons of previously unavailable Inspiration-owned resources, at the common border with the Bluebird property, became accessible with the purchase.[16]

Inspiration made substantial improvements in productivity and unit costs during the year, as a result of capital expenditures of previous years and its cost restraint program, begun in late 1981. These cost-saving actions included increased plant efficiencies, reduction of personnel, and implementation of major process improvements resulting in increased metal recovery from greater volumes of copper ore mined. The 1984 capital expenditure program of $50.5 million included $3.3 million for rod plant modernization, $2 million for electrification of blowers at the smelter, $6 million for property acquisition, and $25 million for mine development. The company also intended to spend some $57 million through 1986 for capital expenditures related to environmental protection facilities; of this amount, some $3 million was to be spent between 1984 and 1985 for environmental protection facilities related to the Bluebird property. Inspiration continued to operate with a reduced work force during 1984.[17]

Kennecott was the largest domestic copper producer in 1984 with three open pit mining and two processing operations, the latter of which had a total operating capacity of some 288,000 tons of refined copper per year. Kennecott's operational losses increased from $91 million in 1983 to $160 million in 1984. The effects of lower metal prices were partially offset by improved operating efficiencies at some of the company's operations, but curtailed production at the Bingham Canyon Mine, UT, which operated at about one-third of capacity for one-half of the year, led to higher operating costs, and offset the benefits of these efficiencies. Combined copper reserves at year-end at all Kennecott properties were reported as 2.7 million tons of ore containing 15.4 million tons of copper, 11.5 million ounces of gold, 113.5 million ounces of silver, and 1.7 million tons of molybdenum.[18]

Kennecott's Ray Mine in Arizona also operated at a reduced rate in 1984, producing 89,000 tons of copper, mainly in concentrates, which were sold to Asarco for smelting at its Hayden, AZ, smelter. Chino Mines Co., a two-thirds Kennecott, one-third Mitsubishi Metal Corp. partnership, completed a $280 million project to modernize and expand its mine and concentrator near Silver City, NM. The planned $1 billion mine improvement scheme at Bingham Canyon was being evaluated, and was contingent upon governmental acceptance of the planned improvements and the future of the overall copper market.

In late 1984, Kennecott and Anaconda Minerals Co. signed a letter of understanding for the cooperative operation of the mining and concentrating properties and facilities of the Bingham Canyon Mine and

Anaconda's adjoining Carr Fork property. If concluded, Kennecott, the operator, would receive 96% of the production.

The combined loss before income taxes for those consolidated and affiliated Newmont Corp. companies primarily engaged in the production and sale of copper was $56.4 million in 1984, compared with $51.4 million in 1983, and $60.5 million in 1982. At Newmont's Pinto Valley Mine, in Arizona, the loss in 1984 before taxes was $9.1 million, compared with $1.1 million in 1983.[19] Pinto Valley Copper Corp. was formed in 1983 to acquire certain Arizona assets from Cities Service Co. Newmont began open pit mining and milling operations in May 1984 at the Pinto Valley Mine after being on a standby basis since formation. Probable reserves at the Pinto Valley Mine were estimated at 338.8 million tons containing 0.40% copper and 0.015% molybdenum sulfide (MoS_2). Newmont's Miami East Mine, in Arizona, which remained closed in 1984, had probable reserves estimated at 5.4 million tons containing 3.14% copper. According to Newmont's annual report, metals produced during 1984 were as follows: Pinto Valley Mine had a production of 2,951 ounces of gold, 155,308 ounces of silver, 39,650 tons of copper, and 294 tons MoS_2; Miami East remained closed; Pinto Valley electrowinning plant produced 7,552 tons of copper; and the electrowinning plant at Miami, AZ, produced 4,062 tons of copper cathode.[20]

At yearend, the largest Newmont subsidiary, Magma Copper Co., announced the initiation of a $70 million project involving the mining and leaching of the oxide ore at San Manuel, AZ. Some 52 million metric tons of ore was amenable to open pit mining and leaching-solvent extraction-electrowinning processes. Company estimates indicated potential production of more than 40 million pounds per year of cathode copper from this source starting in mid-1986. Test work also was continuing on in situ leaching of the more extensive deeper portions of the oxide ore body, which has caved because of earlier mining of the underlying sulfide ore. Development work and capital expenditures at the San Manuel Mine were reduced sharply, and development of the Kalamazoo ore body ceased completely during the year. Reserves were estimated as San Manual oxide, 52 million tons of 0.468% copper ore (does not include 204 million tons of 0.37% copper oxide ore under consideration for in situ leaching), and San Manuel Mine, 284 million tons of 0.694% copper ore containing 0.00143 ounce of gold per ton, 0.0263 ounce of silver per ton, and 0.028% MoS_2. The Kalamazoo ore body had reserves totaling 322 million tons, containing 0.715% copper, 0.00143 ounce of gold per ton, 0.026 ounce of silver per ton, and 0.028% MoS_2.[21]

Magma's Superior Mine, in Arizona, which was closed in 1982, remained on care-and-maintenance status throughout 1984. Total proven and probable reserves at Superior were estimated at 4.0 million tons of ore with 0.0236 ounce of gold per ton, 0.644 ounce of silver per ton, and 5.69% copper. Complete closure of the mine would probably result in permanent loss of the remaining small reserve owing to the high costs of reopening the mine.

Phelps Dodge, the second largest copper producer in 1984, reported a net loss for the year of $267.8 million. According to the company's annual report, this was the third consecutive year of net losses. The company, which at yearend had a total debt of $606 million, was reducing its debt by continuing to sell off overseas investments as well as to rationalize existing operations and improve operating costs.

Capital expenditures on mining, concentrating, and smelting by Phelps Dodge were $54.9 million in 1984, compared with $43.3 million in 1983 and $65.7 million in 1982, according to the company annual report. Unit operational costs at Phelps Dodge mines and facilities were slightly lower in 1984 than in 1983, which was also a year of significant cost-cutting progress. According to the company's annual report, 1984 production totaled 300,465 tons of recoverable copper, up from 238,684 tons in 1983. Precipitate production at the Phelps Dodge Copper Queen Mine, Bisbee, AZ, continued and was 1,905 metric tons of recoverable copper in precipitates in 1984, compared with 2,359 tons in 1983.[22]

Phelps Dodge's cost to produce a pound of copper in the third quarter of 1984 declined by 32% when compared with its average costs in 1980, after adjusting for inflation. Cost-cutting measures included a reduction in the number of workers from 18,000 in 1970 to 8,150 in September 1984. Cutbacks included shutting down of the New Cornelia (Ajo) Mine, at Ajo, AZ, in August for an indefinite period. The mine had a capacity of about 36,000 tons of copper per year, and copper ore reserves were estimated at about 110 million tons containing an average of

0.50% copper as well as some silver and gold values. The underground mine development program at the company's Safford, AZ, property was suspended in April 1982, and in August 1984, the mine was allowed to flood. Safford had estimated ore reserves of 238 million tons averaging 0.88% copper. In addition, Phelps Dodge owned the Copper Basin property southwest of Prescott, AZ, which contained an estimated 158.8 million tons of copper-bearing material averaging 0.55% copper and 0.021% molybdenum.

At the Morenci Mine in Arizona, Phelps Dodge's principal copper producer, nearly 196,862 tons of copper was produced, compared with 176,000 tons in 1981, and with a 1984 work force that averaged 2,040 employees, compared with a work force of 3,230 in 1981. Of the copper recovered at the mine, 170,000 tons came from concentrates, and 26,580 tons was from precipitates. The Morenci Mine and the adjacent Metcalf Mine have a combined ore reserve of about 755 million tons with an average ore grade of 0.76% copper. As part of the company's restructuring program, Phelps Dodge proposed a joint venture with Sumitomo Metal Mining Co. Ltd. and Sumitomo Corp. of Japan for a significant minority interest in the Morenci, AZ, properties and facilities, excluding the Morenci smelter. A letter of intent was expected to be signed in January 1985.

At Phelps Dodge's Tyrone, NM, open pit mine, the operating schedule in November was increased from 5 to 7 days per week, in order to achieve significant unit cost improvements. To maintain continuous production, an additional $5 million tailings disposal facility was under construction at yearend. Ore reserves at the Tyrone Mine were estimated to be 170 million metric tons of ore with an average grade of 0.80% copper. The average grade of ore mined in 1984 was 0.77% copper.

Smelter Production.—Despite the continued contraction in various parts of the industry, U.S. smelter production of copper increased in 1984, compared with production in 1983. Twelve primary smelters with a total output capacity of 1,544,000 tons of copper operated during the year. One closed late in the year, and companies announced that three more were expected to close in early 1985. About 524,000 tons of capacity would be affected by the four smelter closures. Some 210,000 tons of secondary smelter capacity also operated during the year at 10 plants. Operations at the AMAX secondary smelter complex at Carteret, NJ, continued to be curtailed. Federated Metals Co. also was to shut its secondary plants in Texas and New Jersey.

Installed at a cost of $132.6 million, the modernization project at Asarco's Hayden, AZ, smelter was completed in 1984. In August, the smelter achieved its highest monthly operating rate in 10 years with its new oxygen flash smelting furnace. The new Inco-type furnace proved to be more energy efficient and cost effective by eliminating production curtailments for air quality control purposes, although a problem was encountered with dust in the gas handling system, requiring frequent cleaning. To solve this problem, an electrostatic precipitator was to be installed during 1985. The new furnace also was damaged when the furnace arch brick failed prematurely. About 155 workers were laid off while repairs were made in late 1984.[23]

Processing margins for Asarco's custom smelting and refining business suffered during 1984 as low copper prices caused idling of about 40% of U.S. copper mine capacity. Competition for the reduced supply of available concentrates resulted in a reduction in smelting and refining fees. Asarco responded by cutting costs through shutting down facilities and making substantial cutbacks in salaried and hourly personnel at continuing operations and administrative offices. The full effect of the cutbacks was expected by the company to reduce its operating costs by over $60 million in 1985.[24]

In June, Asarco announced plans to terminate copper smelting operations at its Tacoma, WA, plant in March 1985. The Tacoma plant had been operating at a loss for the past 5 years and was faced with exditures in excess of $150 million over the next 3 years to install new copper smelting facilities that would comply with environmental regulations. Production of arsenic trioxide from arsenical residues received from other smelters may be continued at Tacoma. The total cost of shutting down Tacoma was estimated at $60 million, partially offset by a credit of $22 million from changes to estimated costs for previous plant closings elsewhere. According to the company's 1984 annual report, total combined production from the two smelters at El Paso, TX, and Hayden, AZ, in 1984 was 207,000 tons of blister copper.

In December 1983, Wickland Oil Terminals, a California corporation, brought suit against Asarco as the company alleged to be solely responsible for cleanup costs caused by emissions from slag piles at the site of Asarco's former Selby, CA, smelter. Asarco's interests in the Selby site were sold to Wickland in 1977. Asarco's motion to dismiss all Federal causes of action was granted in 1984. The case was continued with respect to causes of action under State law.

In response to Federal and State air quality standards, Inspiration spent about $101 million over the 12-year period ending December 31, 1983, for the construction of a new electric smelter and acid plant and related pollution control facilities at Claypool, AZ. It had not been considered economically feasible to retrofit the existing older smelter to meet environmental standards. The 1984 capital expenditures program included about $2 million spent on the electrification of the newly installed blower at the smelter. A prototype converter designed by Inspiration had been installed in 1981 at a cost of $8 million and had proven to be successful in eliminating converter fugitive emissions. Using a two-converter operation, the new smelter was capable of processing some 336,000 tons of concentrate per year; a third converter remained inoperative during the year because of a lack of concentrate.[25]

Negotiations between Amoco Minerals and Inspiration on a proposed joint venture, under which Amoco Minerals would take a 50% interest in Inspiration's copper smelter, were terminated on May 1. A project to invest approximately $70 million for new pollution control equipment and increase the effective capacity of the smelter by 36,000 tons to a full capacity of 136,000 tons of copper per year was postponed indefinitely.

The Kennecott-Mitsubishi smelter at Chino, NM, was modified in 1984 to meet all environmental standards and to increase its capacity to 120,000 tons of copper per year, matching Chino's modernized mine and concentrator. According to Kennecott's annual report for 1984, Chino operated at a reduced rate and Kennecott's share of production was 59,000 tons of copper. The Kennecott copper smelter in Nevada remained closed in 1984 owing to a shortage of copper concentrates for custom smelting.

Magma Copper Co. had spent approximately $50 million through 1984 for environmentally related capital additions, mostly for the acid plant at its smelter in Arizona. In order to be in full compliance with prescribed regulations as of January 1, 1988, and to maintain uninterrupted the current rate of smelter production, Magma was expected to have to start modifying its smelter by late 1985. Preliminary estimates indicated the compliance program would require about $150 million.[26]

Phelps Dodge spent $19.4 million at its Morenci, AZ, smelter in 1984, bringing the total to $248 million spent at the smelter for pollution control measures. In addition to these direct costs, both the Morenci and Ajo plants had been either closed or had production limited at times in recent years to enable retrofitting with more effective pollution control equipment. An oxygen sprinkle system designed to reduce sulfur dioxide emissions was installed at Morenci in 1983, and production was curtailed from time to time to comply with ambient air standards. Although it has a design capacity of 160,000 tons per year of blister copper, the smelter has been producing at only about 100,000 tons per year because of recurring curtailments.[27]

At yearend, Phelps Dodge decided not to invest the additional money necessary to meet environmental compliance standards for the Morenci smelter, and on December 31, 1984, operations at the smelter were suspended. With the shutdown of the New Cornelia (Ajo) Mine in Arizona in September 1984 and the negotiated termination of a toll smelting contract with Cyprus Minerals Co., smelting requirements no longer justified the immediate completion of the capital program to bring the Morenci smelter into full compliance with air quality regulations. The smelter was not, however, expected to reopen until it was brought into full compliance with air quality regulations, which the company expected to require capital expenditures of about another $50 million.

Phelps Dodge had planned for the Ajo, AZ, smelter to be in full compliance with Federal environmental regulations by yearend 1985, but decided finally in late 1984 to close the smelter instead early in 1985. This action followed the decision to close the mine at Ajo. Additional facilities also would be required at the company's Douglas, AZ, smelter in order to bring that smelter into compliance with existing environmental regulations. According to the 1984 annual report, Phelps Dodge believed that the cost could not be economically justified. As a result, the Douglas facility was scheduled for closure by the end of 1987, at the latest. An environmental group filed a lawsuit contesting the company's right to continue operating the smelter during the interim period.[28]

Table 2.—U.S. smelter capacity, by process and company[1]

(Metric tons, copper content of blister or anode)

Process and company	Location	Status	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Electric:[2]												
Anaconda Minerals Co	Great Falls, MT	Closed 1980	180,000	180,000	180,000	180,000	180,000	180,000	--	--	--	--
Inspiration Consolidated Copper Co.	Globe, AZ	Operating	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	100,000	100,000
Tennessee Chemical Co	Copperhill, TN	do	20,000	20,000	20,000	20,000	12,000	12,000	12,000	12,000	12,000	12,000
Total			336,000	336,000	336,000	336,000	328,000	328,000	148,000	148,000	112,000	112,000
Inco flash:[2]												
ASARCO Incorporated	Hayden, AZ	Operating	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	168,000
Chino Mines Co	Hurley, NM	do	72,500	72,500	72,500	72,500	72,500	72,500	72,500	72,500	100,000	120,000
Phelps Dodge Corp	Tyrone, NM	do	--	90,000	90,000	160,000	160,000	160,000	160,000	160,000	160,000	180,000
Total			232,500	322,500	322,500	392,500	392,500	392,500	392,500	392,500	420,000	468,000
Noranda, modified:[2]												
Kennecott	Garfield, UT	Closed 1985	254,000	254,000	254,000	210,000	210,000	210,000	210,000	210,000	210,000	210,000
Reverberatory:[2]												
ASARCO Incorporated	Tacoma, WA	do	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000
	El Paso, TX	Operating	104,000	104,000	104,000	104,000	104,000	104,000	104,000	104,000	104,000	104,000
Copper Range Co	White Pine, MI	Closed 1982	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	(82,000)	(82,000)
Kennecott	McGill, NV	Closed 1983	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	(50,000)
	Hayden, AZ	Closed 1982	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	(72,000)	(72,000)
Magma Copper Co	San Manuel, AZ	Operating	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
Phelps Dodge Corp	Ajo, AZ	Closed 1985	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000	64,000
	Douglas, AZ	Operating	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000	136,000
	Morenci, AZ	Closed 1984	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000	160,000
Total			958,000	958,000	958,000	958,000	958,000	958,000	958,000	958,000	804,000	754,000

See footnotes at end of table.

Table 2.—U.S. smelter capacity, by process and company[1] —Continued

(Metric tons, copper content of blister or anode)

Process and company	Location	Status	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Reverberatory:[3]												
AMAX Copper Inc	Carteret, NJ	Operating	55,000	68,000	68,000	68,000	68,000	68,000	68,000	68,000	68,000	68,000
Cerro Copper Products	Sauget, IL	do	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Chemetco Metals Corp	Alton, IL	do	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000
Federated Metals Co	Houston, TX	Closed 1985	900	900	900	900	900	900	900	900	900	900
	San Francisco, CA	Operating[4]	900	900	900	900	900	900	900	900	900	900
	Newark, NJ	Closed 1984	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Franklin Smelting & Refining Co.	Philadelphia, PA	Operating	13,600	13,600	13,600	13,600	13,600	13,600	13,600	13,600	13,600	13,600
Nassau Recycling Industries	Gaston, SC	do	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000	35,000
North Chicago Smelting & Refining Co.	Chicago, IL	do	500	500	500	500	500	500	500	500	500	500
Southwire Co	Carrollton, GA	do	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total			197,400	210,400	210,400	210,400	210,400	210,400	210,400	210,400	210,400	210,400
Grand total			1,977,900	2,080,900	2,080,900	2,106,900	2,098,900	2,098,900	1,918,900	1,918,900	1,756,400	1,754,400

[1]Operating capacity only; totals do not include available capacity, indicated in parentheses, at closed plants on care and maintenance status except in the year of closure.
[2]Mostly primary feed.
[3]Mostly secondary (scrap) feed.
[4]Acquired by Cookson Group PLC in Mar. 1984; currently operating as Federated-Fry Metals Co.

Phelps Dodge's Hildalgo, NM, copper smelter was taken out of service for 4 months for a $27 million overhaul of the flash furnace and refurbishing of other facilities in the smelting and sulfuric acid production complex. Renovations reportedly resulted in increased operating efficiencies and throughput.

Refinery Production.—Compared with the 1983 level, production of refined copper from U.S. primary and secondary plants was down in 1984. This was largely the result of decreased processing of secondary materials. Refined production from primary plants increased slightly. In 1984, 12 electrolytic refineries, 10 electrowinning plants, and 9 fire-refining facilities operated. By yearend, however, one fire-refining plant and three secondary electrolytic refining plants had closed.

By early 1984, the copper processing operation at the Carteret, NJ, plant of AMAX's subsidiary, U.S. Smelting and Refining Co., was converted from secondary copper smelting and refining to an operation emphasizing the processing of precious metals-bearing raw materials and the production of specialty coppers. In this connection, an asset write-down of $11 million was taken, applicable to the phaseout of the major copper refining facilities.

AMAX also expected to close its Port Nickel, LA, copper-nickel refinery, following termination of its matte supply contract with Bamangwato Concessions Ltd. (BCL) of Botswana, early in 1985. BCL requested AMAX to terminate the long-term contract in order to allow BCL to replace AMAX with other refiners as purchasers of its output. Negotiations were in progress at yearend regarding the compensation to be paid to AMAX. With the contract terminated, AMAX would close its Port Nickel copper-nickel refinery, including property, plant and equipment, and related supplies valued at $67 million. BCL is a subsidiary mining company of Botswana RST Ltd.

Asarco's Amarillo copper refinery in Texas increased its operating rate to about 85% of capacity for most of 1984, up from about 55% in late 1983 and early 1984, according to the company's annual report, but operations continued to be affected by shortages of raw materials, particularly copper scrap. A new process for parting gold at the refinery was started up in August and significantly reduced the amount of gold held in other byproducts during copper refining. The Realtrol process for electrolytic refining, in use at Amarillo since 1980, continued to generate an estimated savings in excess of $1 million per year. The process was patented by Asarco in 1984 and has been licensed to two other copper producers. The rated refinery capacity at Amarillo was 376,000 tons of cathode copper. In 1984, Asarco's refined metal production was derived 26% from its own mines, 54% from custom refining, and 20% from toll refining. This constituted a change since 1980 when 17% was from the company's mines, 47% was from custom refining, and 36% was from toll refining.

As a result of the disposal of its mining properties, Louisiana Land and Exploration realized a loss of $4.2 million in 1984, including a $28.9 million charge for the write-down of the Copper Range electrolytic copper refinery at White Pine, MI, to its estimated realizable value. In the transaction, the refinery was retained by the company, but leased to the purchaser with an option to acquire the refinery at the end of a 3-year lease term.

The electrowinning plant at the Cyprus Bagdad Mine, in Arizona, produced some 13 million pounds of high-grade cathode, according to the company's annual report. The Cyprus Johnson electrowon plant also produced 9 million pounds of cathode copper from already mined ore, but operations reportedly were scheduled to be shut down in 1985.

Refined copper produced by Inspiration was either sold or fabricated into continuous-cast rod at the Inspiration copper rod plant. Upgrading the refinery operations over the 5-year period through yearend 1983 at a cost of $3 million had greatly improved operating efficiency during 1984. The company's 1984 capital expenditure program included an outlay of $3.3 million for rod plant modernization. A new quality control laboratory had been installed in 1982 for rod quality optimization.

Operations remained curtailed at Kennecott's Refining Div. copper processing plant near Baltimore, MD. The plant had been closed since mid-1983.

Magma, Newmont's largest subsidiary, produced 130,294 tons of refined copper in 1984, compared with 99,111 metric tons in 1983. In addition to refined copper, the company also produced precious metals, molybdenum-bearing concentrates, and sulfuric acid as byproducts. Magma suffered its fourth consecutive year of losses in 1984 because of low copper prices, despite achieving significant reductions in operating costs during the year.

Table 3.—U.S. copper refining capacity, by process and company[1]

(Metric tons, copper content)

Process and company	Location	Status	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Electrolytic:[2]												
Anaconda Minerals Co	Raritan, NJ	Closed 1975	105,000	--	--	--	--	--	--	--	--	--
	Great Falls, MT	Closed 1980	200,000	200,000	200,000	200,000	200,000	200,000	--	--	--	--
ASARCO Incorporated	Baltimore, MD	Closed 1975	290,000	--	--	--	--	--	--	--	--	--
	Tacoma, WA	Closed 1979	118,000	118,000	118,000	118,000	118,000	--	--	--	--	--
	Perth Amboy, NJ	Closed 1976	218,000	218,000	--	--	--	--	--	--	--	--
	Amarillo, TX	Operating	200,000	376,000	376,000	376,000	376,000	376,000	376,000	376,000	376,000	376,000
Inspiration Consolidated Copper Co.	Globe, AZ	do	53,000	65,000	65,000	65,000	65,000	65,000	77,000	77,000	77,000	77,000
Kennecott	Baltimore, MD	Closed 1983	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	(200,000)
	Garfield, UT	Closed 1985	170,000	170,000	170,000	170,000	186,000	186,000	186,000	195,000	195,000	195,000
Magma Copper Co	San Manuel, AZ	Operating	180,000	180,000	180,000	180,000	180,000	180,000	195,000	195,000	195,000	195,000
Phelps Dodge Corp	Laurel Hill, NY	Closed 1983	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	--
	El Paso, TX	Operating	380,000	380,000	380,000	380,000	380,000	380,000	380,000	380,000	380,000	380,000
Southwire Co	Carrolton, GA	do	65,000	65,000	65,000	65,000	110,000	110,000	110,000	110,000	110,000	110,000
Total			2,329,000	2,122,000	1,904,000	1,904,000	1,965,000	1,847,000	1,674,000	1,683,000	1,683,000	1,333,000
Electrolytic:[3]												
AMAX Copper Inc	Carteret, NJ	Operating	177,000	177,000	177,000	177,000	177,000	177,000	177,000	177,000	100,000	100,000
Cerro Copper Products	Sauget, IL	do	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000	45,000
Chemetco Metals Corp	Alton, IL	Closed 1984	36,000	36,000	36,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000
Copper Range Co	White Pine, MI	do	--	--	--	--	--	--	--	54,000	54,000	54,000
Federated Metals Co	Houston, TX	Closed 1985	800	800	800	800	800	800	800	800	800	800
Nassau Recycling Industries.[4]	Gaston, SC	Operating	54,000	54,000	54,000	65,000	65,000	65,000	65,000	65,000	65,000	65,000
Total			312,800	312,800	312,800	357,800	357,800	357,800	357,800	411,800	334,800	334,800
Electrowinning:[2]												
AMAX Nickel Inc	Braithewaite, LA	Operating	23,500	23,500	23,500	23,500	23,500	23,500	30,000	30,000	30,000	30,000
Anaconda Minerals Co. (Arbiter).	Butte, MT	Closed 1978	14,500	14,500	14,500	--	--	--	--	--	--	--
Anamax Mining Co	Twin Buttes, AZ	Operating	6,350	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
Cyprus Minerals Co	Bagdad, AZ	do	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800	6,800
	Johnson, AZ	do	3,600	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400
Duval Corp	Sierrita, AZ	Closed 1983	--	--	--	29,000	29,000	36,000	36,000	36,000	36,000	(36,000)
	Battle Mountain, NV	Operating	--	--	--	2,000	5,000	5,000	5,000	5,000	5,000	5,000
Inspiration Consolidated Copper Co.	Globe, AZ	do	4,500	4,500	4,500	4,500	4,500	18,000	42,000	42,000	42,000	42,000
Kennecott	Hayden, AZ	Closed 1982	18,000	18,000	18,000	23,600	23,600	23,600	23,600	29,000	(29,000)	(29,000)
Magma Copper Co	Pinto Valley, AZ	Operating	--	--	--	--	--	8,000	8,000	8,000	8,000	8,000
	Miami, AZ	do	--	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Noranda Exploration Inc	Casa Grande, AZ	do	--	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000

Phelps Dodge Corp	Tyrone, NM	do	--	--	--	--	--	--	--	--	--	15,000
Ranchers Exploration and Development Corp.	Globe, AZ	Closed 1983	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	7,300	--
Total			84,550	137,000	137,000	159,100	162,100	190,600	221,100	226,500	197,500	169,200
Fire-refining:[2]												
Chino Mines Co	Hurley, NM	Closed 1984	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000	90,000
Copper Range Co	White Pine, MI	Closed 1982	82,000	82,000	82,000	82,000	82,000	82,000	82,000	82,000	(82,000)	(82,000)
Phelps Dodge Corp	El Paso, TX	Operating	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000	23,000
	Laurel Hill, NY	Closed 1984	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	18,000	--
Total			213,000	213,000	213,000	213,000	213,000	213,000	213,000	213,000	131,000	113,000
Fire-refining:[3]												
AMAX Copper Inc	Carteret, NJ	Closed 1980	5,000	5,000	5,000	5,000	5,000	5,000	(5,000)	(5,000)	(5,000)	(5,000)
Cerro Copper Products	Sauget, IL	Operating	55,000	55,000	55,000	55,000	80,000	80,000	80,000	80,000	80,000	80,000
Essex Group	Three Rivers, MI	do	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000	34,000
The Metal Bank of America Inc.[5]	Philadelphia, PA	do	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200
Nassau Recycling Industries.	Gaston, SC	do	--	--	--	32,000	32,000	32,000	32,000	32,000	32,000	32,000
Reading Metals[6]	Reading, PA	do	36,000	36,000	45,000	70,000	70,000	70,000	70,000	70,000	70,000	70,000
Thermal Reduction Corp., TALCO Div.	Philadelphia, PA	do	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500	4,500
Warrenton Refining Co.[7]	Warrenton, MO	do	32,000	32,000	32,000	32,000	32,000	(32,000)	(32,000)	32,000	32,000	32,000
Total			173,700	173,700	182,700	239,700	264,700	232,700	227,700	259,700	259,700	259,700
Grand total			3,113,050	2,958,500	2,749,500	2,873,600	2,962,600	2,841,100	2,693,600	2,794,000	2,606,000	2,209,700

[1]Operating capacity only; totals do not include available capacity, indicated in parentheses, at closed plants on care and maintenance status except in the year of closure.
[2]Mostly primary feed.
[3]Mostly secondary (scrap) feed.
[4]Located in New York prior to 1978.
[5]Closed at yearend 1984 for renovations.
[6]Reading Industries Inc., owned by J. Lash Acquisition Corp. from 1983 to present.
[7]General Cable Corp. prior to 1982; currently a subsidiary of Metal Traders, New York.

Phelps Dodge's new $35 million solvent extraction and electrowinning plant at Tyrone, NM, began production in April. Designed to produce about 15,000 tons of good-quality copper per year, it was reported to be producing copper at a cost well below 30 cents per pound. At yearend, the company announced plans to double the capacity of the plant at a cost of about $30 million, of which $11 million was to be spent in 1985 and $4 million in 1986, with production at a rate of about 27,000 tons per year expected early in 1986. According to the company's 1984 annual report, Phelps Dodge's El Paso, TX, refinery processed 340,380 tons of copper and had a capacity of about 380,000 tons of electrolytic copper per year.

Sulfuric Acid Production.—Approaching that of the record-high years of 1978, 1979, and 1981, sulfuric acid production at domestic copper plants totaled 2.2 million tons in 1984, a significant 22% increase above that of 1983. Rather than being a reflection of increased copper production, however, the increased sulfur capture was the result of more efficient recovery capture methods at smelters. Marketing of the increased sulfuric acid supply was a problem for copper smelters. There existed a need to address the problem of transportation and distribution systems in order to move and market the acid. Hampered by a limited mix of grades, the quality of acid produced was also being addressed. In addition, since bypass operations were no longer allowed, smelters could not operate independently of acid production, and it became more apparent that the production of acid was an integral part of the cost of smelting. Turning sulfuric acid production into a credit rather than a liability was a challenge that copper producers considered a high priority.

Copper Sulfate.—Copper sulfate was produced from copper scrap, blister copper, electrolytic refinery solutions, and spent electroplating solutions by at least seven companies. It was usually sold as pentahydrate crystal containing about 25% copper by weight, and available in several mesh sizes or as basic copper sulfate powder, containing about 53% copper. Imports, primarily from Canada, Italy, and Peru, accounted for about 5% of domestic consumption during the year.

An estimated 55% of shipments from domestic producers was for agricultural uses such as fungicides and fertilizers, and 45% was for industrial uses such as metal finishing, mineral flotation, and wood preservatives. At midyear, Anaconda began producing small quantities of copper sulfate at the electrowinning plant associated with its Twin Buttes Mine in Arizona.

Table 4.—Copper sulfate producers in the United States in 1984

Company	Plant location
Anaconda Minerals Co	Twin Buttes, AZ.[1]
Chevron Chemical Co	Richmond, CA.
CP Chemicals Inc	Sewaren, NJ, and Sumter, SC.[1]
International Metals Recycling Corp.	Casa Grande, AZ.
Madison Industries Inc	Old Bridge, NJ.
Phelps Dodge Corp	Laurel Hill, NY, and El Paso, TX.
Southern California Chemical Co.	Santa Fe Springs, CA,[1] Union, IL,[1] Garland, TX.[1]
Tennessee Chemical Co	Copperhill, TN.

[1]Production from these plants is not included in production data.

CONSUMPTION AND USES

Apparent consumption of refined copper increased 7% over that of 1983 and was 22% higher than the recession year of 1982. However, it remained some 5% below the 1981 level and 11% below the record 1979 level. The increase in demand during 1984 was mostly met by shipments from stocks, the slight increase in refinery production from primary domestic and foreign materials being more than offset by the decline in net imports of refined copper and the amount of copper recovered from old scrap.

Refined copper was consumed in the manufacture of fabricated and semifabricated shapes and chemicals at approximately 20 wire rod mills, 40 brass mills, and 1,000 foundries, chemical plants, and miscellaneous manufacturers. The end-use distribution of copper and copper-alloy mill products in 1984 was estimated, according to the Copper Development Association Inc. (CDA), to be 36% in building and construction, 26% in electrical and electronic products, 16% in industrial machinery and equipment, 11% in transportation equipment, and 11% in consumer and general products. If the electrical components are extracted from the end-use categories described above, electrical uses accounted for about 60% of copper demand.

Although copper has lost market share owing to substitution of alternate materials in some areas such as overhead high-voltage power transmission, plumbing pipe and fixtures, telecommunications, and automotive radiators, there were several areas where copper was experiencing a growth in demand. According to industry analysts, the use of beryllium-copper alloys was expected to grow in the near term at an annual rate of 12% per year in materials applications requiring a combination of high electrical conductivity and mechanical strength, and for applications requiring wear and corrosion resistance. Although the copper content per automobile for radiators has declined in recent years owing to downsizing, the use of thinner gauged metal, and aluminum alternatives, the use of electronically controlled devices requiring copper connectors and wiring has proliferated. As a result, copper product shipments for automotive use, which according to CDA estimates rose 17% in 1984 to 182,000 tons, outstripped by several percentage units the growth in domestic automotive production.[29] Other areas where copper usage was expanding included copper roofing, large-diameter domestic copper pipe for applications such as sprinkler systems in commercial buildings, and saltwater piping systems.

In 1984, copper wire rod mills, producers of the wire rod semifabricated product used for drawing into wire at wire mills, accounted for 70% of reported refined copper consumption. Though the majority of wire and wire rod mills are located in the heavily industrialized areas of the Eastern and North-Central United States, some were associated with copper refineries in Texas and Arizona. Most of domestic wire and rod mill capacity was operated by primary and secondary copper producers that processed their own refined copper as well as both purchased and tolled material. It was estimated that while most domestic producers of refined copper continued to publish prices for cathode, nearly 70% of their sales of refined copper was in the form of wire rod.

Consumption of refined copper at brass mills, the second largest copper consuming industry, increased in 1984 by 16% over 1983 levels to the highest level since 1979. The CDA reported a 15% increase in primary brass mill shipments, the highest level since 1979,[30] and the Copper and Brass Servicenter Association reported the highest level of shipments from service center warehouses since 1978, when it first started recording service center shipments. The importance of service centers in supplying copper fabricators with semimanufactured products continued to grow during 1984 in the face of high interest rates and the consumer's desire to reduce inventory carrying costs.

At yearend, however, demand for brass mill products had eased considerably, and lead times for delivery of products, which had reportedly been as long as 16 weeks during the first half of 1984, had been reduced by one-half.[31] Imports of alloyed and unalloyed copper and brass mill products also increased by 44% over 1983 levels to a record-high level of 263,000 tons.

STOCKS

Most of the decline of domestic refined stocks, including those held by producers, consumers, the Commodity Exchange Inc. (COMEX) of New York, and the U.S. Government, was attributed to offtake of 120,000 tons from COMEX. Stocks on the London Metal Exchange (LME) fell even more markedly, declining by 310,000 tons to 126,000 tons, the lowest level since February 1982.

Despite the large deficit in U.S. copper production relative to demand, COMEX stocks fell relatively little when compared with the LME stock decline. This was generally ascribed to the low quality of stocks held in COMEX warehouses owing to the existence of a single copper contract based on electrolytic cathode but which allowed delivery of other forms of copper at specific discounts or premiums. Consequently, in the face of strong rod mill demand, much of the domestic deficit was met by imports of electrolytic cathode.

Most of the decline in COMEX stocks occurred during the second half of the year. This was attributed to producers such as Kennecott, which had cut production and had reportedly purchased copper to satisfy customer demands. Domestic producer stocks of refined copper declined markedly in response to strong demand early in the year to a low point in May, when a sharp upturn in inventories occurred in response to weakened consumer demand. Producer stocks declined again in the last quarter of 1984 in response to production cutbacks and the need to meet contract commitments. Consumer stocks rose during the first quarter of 1984 owing to strong demand and increasing prices, but reversed their upward trend at midyear.

On November 2, Chicago's Mid-America Commodity Exchange began trading a 12,500-pound copper futures contract, one-half the size of the COMEX contract. Settlement prices were to be established by the corresponding COMEX contract. The base grade was to be electrolytic cathode, with wirebar and electrolytic ingot and ingot bar carrying slight premiums. The contract was designed to attract medium-sized manufacturers, scrap dealers, and secondary refiners.[32]

PRICES

U.S. producer prices for refined copper cathode increased from a monthly average of 66.097 cents per pound in January to an average of 74.67 cents per pound in April. On October 27, the domestic copper producers cathode delivered price dropped to 61.674 cents per pound, the lowest level since the mid-1970's. The reduction came following a drop in copper prices on the COMEX and the LME. By December 1984, the price had dropped to a monthly average of 63.538 cents per pound. The average U.S. producer price for the year was 66.854 cents per pound, and the average annual LME high-grade cash price was 62.425 cents per pound.

The continued presence of large refined copper inventories on the world's stock exchanges and at producers and consumers was a major factor in the continued depressed price during the year. In addition, other factors that combined to further depress copper prices were the valuation of national currencies relative to one another, interest rates, national and international debt obligations, and investment, marketing, and expansion policies of other producers. Since byproduct credits had become increasingly important factors in copper mining, the prices of gold, silver, molybdenum, and cobalt were also important factors bearing on the price of copper. Intermittent trade with the centrally planned economy countries, mostly China and Poland, also had temporary but significant influence on the copper price.

Consumers in Japan helped to raise prices in early 1984 with heavy refined copper purchases, but subsequently withdrew from world markets except for occasional spot purchases. By April, economic predictions of a return to higher interest rates in the United States caused copper prices to retreat sharply within a few days as speculators and commission houses sold their positions to move their funds into other investments. At the same time, automobile output leveled off during April, housing starts were down, and brass mill consumption, which had been strong during the first quarter, dropped significantly. The price decline was considered by some to be a paradox with prices falling coincident to shrinking inventories. The downward movement was a reflection of the continued market pessimism over the poor state of the copper market.

According to some analysts, as much as 10% to 15% of the decline in U.S. prices for copper could be attributed to the dollar's strength. The strong dollar, along with high interest rates and the developing countries' debt crisis to which it was linked, pressured resource-rich developing countries to step up their metal exports. The weak economies allowed for less internal consumption, again encouraging exports, regardless of metal prices.

Since many raw materials produced abroad were priced in dollars, even in foreign markets, the stronger dollar made it more expensive for foreign countries to buy these commodities with their own currencies. This depressed demand worldwide, but increased import competition in the United States, thus helping to push down the price of the commodity. Most Western industrial nations did not enjoy the robust recovery that the United States experienced.

In late 1984, the copper industry worked out contractual agreements with customers, specifying tonnage, terms, premiums, and the numerous factors making up typical copper supply arrangements, but producers remained less than enthusiastic about selling because of the poor market. Corporación Nacional del Cobre de Chile (CODELCO-Chile) raised its premium on copper cathode in its November contracts from 0.75 cent per pound to 1.5 cents per pound effective January 1, 1985. CODELCO-Chile's price was c.i.f. U.S. ports with customers paying for unloading and freight. Customers were also to pay financing costs incurred while the copper is on ship, adding another 2 cents per pound to the CODELCO-Chile premium. Even so, U.S. producers were charging about a 6-cent-per-pound premium over the base COMEX price for cathode.

Severe competition for wire rod sales between copper producers and from imports during 1984 led to innovative pricing and marketing strategies. For example, early in the year, Phelps Dodge began offering a COMEX-based, rather than a producer-price-based, rod premium.

Since 1980, the world copper concentrate supply situation had been steadily tightening. This trend accelerated during 1984 with smelters having to compete for supplies, and smelter charges were reduced accordingly. The range of delivered prices quoted for shipments of relatively clean concentrate for delivery periods of up to 1 year in October 1984 was $30 to $40 per ton for smelting and $0.055 to $0.06 per pound for refining. This compared with an average 1980 smelting charge of $65 per ton of concentrate and a charge of some 8 cents per pound for refining.

At yearend, beryllium copper (alloy No. 25) strip was selling at $7.25 per pound, and rod, bar, and wire were selling at $8.05 per pound. Beryllium copper master alloy, f.o.b. Reading, PA, Detroit, MI, and Elmore, OH, per pound of contained beryllium for a 5-pound ingot was priced at $144.00. Beryllium copper alloy prices reflect a $1 per pound base copper price and are composed of about 97% copper. Representative prices of brass and bronze ingots in cents per pound, as quoted by ingot makers, effective December 4, 1984, were as follows: alloy 100 at 91 cents; alloy 110 at 85 to 90.25 cents; alloy 193 (88-10-2 group) at 209.50 cents; alloy 327 (80-10-10 group) at 86.25 cents; and alloy 295 at 164.00 cents. In the yellow group, alloy 400 was quoted at 70.25 cents and alloy 409 at 81.75 cents.[33]

December prices for No. 1 scrap ranged from 42 to 46 cents per pound; for No. 2 scrap, from 34 to 38 cents per pound; for red brass turnings and borings, 37 to 38 cents per pound; and for No. 115 ingot scrap, 81.50 to 84.50 cents per pound. This contrasted with January 1984 prices, when No. 1 scrap was priced at 50 to 51 cents per pound; No. 2 scrap at 42 to 43 cents per pound; red brass turnings and borings at 41 to 42 cents per pound; and No. 115 alloy scrap at 84 to 86 cents per pound.

Buying prices for key grades of recyclable alloys by a number of major brass and bronze ingot producers had moved up modestly in March in response to upward pressures, increased export competition, and shortages that developed in red and yellow brass scrap. Although prices softened at yearend in response to the drop in primary copper prices, foreign producers, because of their lower production costs, continued to outbid domestic alloy producers for scarce scrap supplies.

TRADE

Increased imports of low-priced copper during 1983 and 1984 depressed prices below the cost to producers for many U.S. mines, prompting the 11 major primary copper producers to petition under section 201 of the Trade Act of 1974 for import relief. Although the ITC found that import injury had occurred, calling this a classic case for which the section 201 clause was intended, the Commissioners were split on relief recommendations with two recommending a tariff, two recommending import quotas, and one abstaining. On September 6, import relief was denied. A proposal made by the U.S. industry to negotiate international production cutbacks, or orderly marketing agreements, also was rejected. Nevertheless, it was speculated that a temporary cutback of 12% would increase total export revenues for countries such as Chile by as much as 3% within a short period of time.

In the United States, Japanese firms had contracts for concentrates from AMAX, Anaconda, Cyprus Mining Co., Duval, and Chino Copper Co., and were negotiating terms with Phelps Dodge for broader involvement. Japanese companies increased purchases of refined copper early in the year to compensate for a shortage of concentrates. U.S. exports of refined copper to Japan increased significantly in early 1984, and in addition, Canada, the Republic of Korea, and Japan were leading importers of copper scrap from the United States. U.S. copper scrap exports in 1984 were up by 29% and 47%, compared with those of 1982 and 1983, respectively.

WORLD REVIEW

Consumption of refined copper by market economy countries increased by over 9% from depressed 1983 levels, to the highest level since 1979, according to preliminary data from the World Bureau of Metal Statistics.[34] Strong demand in the United States for imports of semifabricated shapes and other brass mill products as well as finished goods served to bolster demand in the rest of the world, particularly in Canada where demand increased by about 18%. Despite an increase in exports, demand in Western Europe was relatively weak, with the exception of the Federal Republic of Germany, which experienced a 9% growth in demand. Demand for refined copper in both Asia and Latin America was strong, increasing by 11% and 9%, respectively.

World mine production of copper increased significantly during 1984. Production increases in the Americas, the centrally planned economy countries, and Iran were contrasted by production declines in Africa, the Far East, and Oceania. World production of refined copper, primary plus secondary, also was slightly higher than that of 1983, despite a decline in refined copper recovered from scrap that resulted from a general shortage of suitable scrap in the industrialized countries.

As a result of increased world demand and a relatively stable refinery production, the oversupply that had resulted in increasing world stocks during most of 1983 was sharply reversed at the end of 1983. Total world stocks of refined copper declined in 1984 by about 486,000 tons. Nevertheless, despite an improved supply-demand balance and spot shortages of some types of cathode, continued stock excess exerted a downward pressure on copper prices. Most of the decline in world stocks was attributed to the stock exchanges, LME and COMEX stocks having fallen by 310,000 and 120,000 tons, respectively. The large decline in LME high-grade cathode stocks was attributed not only to strong demand in Europe and China early in the year, but also to the practice of switching; the strong demand for refined copper in Japan during the first half of the year led foreign producers, particularly in Chile, to ship production to Japan and to cover commitments in Europe by taking delivery from the LME of high-grade cathode. Wirebar stocks, on the other hand, increased during the first half of 1984. Owing to a price reversal beginning in May, with standard-grade cathode demanding a premium over high-grade copper owing to short supply in European markets, stocks of wirebar, which were deliverable under the high-grade contract, were withdrawn as a replacement for standard-grade cathode. Because wirebar was viewed as a detriment to the high-grade contract, serving to depress prices, much criticism was focused on its inclusion in the high-grade contract, and at yearend, the LME Committee was receiving comments on the creation of a separate wirebar contract.

At the IMF annual meetings in September, delegates from developing nations called for negotiation of new international commodity stabilization agreements to help overcome declining price trends for raw materials. In a statement issued after a meeting of the finance ministers of developing nations, including Zaire and Zambia, there was a call for urgent steps to foster stabilization and improvement of commodity prices.

A working group was created in March within the General Agreement of Trade and Tariffs (GATT) to study international trade problems affecting nonferrous metals and minerals at the request of Australia, Canada, Chile, Colombia, Peru, and Zaire. The group was to identify measures taken by importing and exporting countries that hampered world trade and was to make recommendations on how trade might be liberalized. The European Economic Community (EEC) presented its complaints to the GATT Council, alleging that Japanese buyers of copper ore and concentrates were pushing European companies out of the markets. The EEC said that because of a protective tariff, Japanese copper processing firms consistently pay higher prices for copper concentrates than European firms can afford, thus assuring raw material supplies for themselves to the detriment of European competitors.

In the face of high demand and continued mine production cutbacks in Canada, the United States, and Africa, and an excess world refinery capacity, the tight supply of concentrates in the international market continued from 1983. Treatment and refinery charges, which had trended sharply downward during 1983 in response to supply shortages, seemed to stabilize at the beginning of 1984 in response to announced smelter cutbacks in Japan of about 15%.

The source of copper concentrates for custom smelting encompassed many developing nations such as Chile, Papua New Guinea, and the Philippines, as well as some mines in Canada and the United States. By far, the dominant member of the copper custom smelting industry was Japan, which operated behind a tariff barrier enabling it to be extremely competitive when purchasing concentrates and affording greater protection in terms of supplies. In addition, a number of other nations (Brazil, the Republic of Korea, and Taiwan) also evolved tariff schemes similar to that of Japan, and it was estimated that more than 80% of custom copper concentrates were shipped to smelters in countries that employ some form of tariff scheme. Since the tariff was set by the government in each case, it was interpreted by some as government collusion providing an indirect subsidy to smelters. The Japanese Government argued that the import charge on refined copper was levied only as a means of subsidizing the small Japanese mining industry.

Poland and China were important during the year in continuing east-west trade. Poland was reported as expanding refined copper production for the purpose of export to Western Europe—nearly one-half as high-grade cathodes. Poland also exported copper as concentrates, some of which went to Japan, as well as about 40,000 tons of brass mill products, about one-fourth of which was delivered to Western customers. Although Impexmetal, Poland's import-export agency for nonferrous metals, sold copper on the LME and the spot market, most of its exports were sold on long-term contracts. Continuing a trend that started in 1982, Poland expected increases in refined copper production to reach a level of 400,000 tons per year by the late 1980's.

As in 1983, China continued to make large refined copper purchases during 1984. Copper consumption was increasing in China, where the industry was going more and more into downstream operations and higher processing. A Japanese-built copper smelter at Quixi with 90,000 tons of annual copper capacity was completed in 1984, but startup was being postponed for 2 years because of infrastructure and mine development problems. Chinese refined copper purchases in early 1984 were considered to be one of the reasons for the continuous decline in LME stocks. At yearend, however, customs figures indicated a sharp drop in China's imports of copper compared with that of 1983, with refined copper imports through October reported as 148,627 tons compared with 278,604 tons in 1983.

Canada.—Copper mine production was regionally divided between the Provinces of British Columbia and the central and eastern Provinces, principally Ontario. Production in Ontario amounted to 41% of total production and accounted for most of the overall production increase. Despite the increased production from central and eastern mines, several of the six Canadian smelters experienced concentrate shortages. Production from western Provinces was generally exported to Pacific Rim smelters. In the face of low copper and byproduct prices, many producers worked to increase their productivity while an estimated 170,000 tons per year of copper production capacity remained closed. Cost-cutting measures by Kidd Creek Mines Ltd. allowed it to return to profitability during the third quarter.

In the face of weakened metal prices, the Quebec Provincial government offered incentives to several copper projects. In May, it was announced that Corporation Falconbridge Copper would receive funds toward development of a shaft on its Ansil property near the Lake Dufault copper mine in order to determine the viability of the high-grade copper deposit. Noranda Mines Ltd. received a loan for accelerated development at its closed Gaspe underground mine at Mardochville.

Sherritt Gordon Mines Ltd.'s Ruttan copper mine, with a capacity of about 20,000 tons per year of copper, faced closure by June. However, closure was forestalled when, in March, the Manitoba government offered to contribute funds toward a mine deepening project that was necessary to reduce costs and return the mine to profitability. At yearend, Sherritt Gordon was still seeking to sell a 50% interest in the mine in order to help finance the deepening project. Declining ore grades at its nearby Fox copper-zinc mine led to announced closing of that mine by early 1986. Closing of both these mines could adversely affect Hudson Bay Mining and Smelting Co. Ltd.'s Flin Flon smelter, which received nearly one-half of its concentrates from Sherritt Gordon. At midyear, Noranda Mines cut production at its Canadian Copper Refiners Ltd. copper refinery in Quebec owing to a shortage of blister stemming from cutbacks at Quebec mines and a shortage of concentrates.

Other selected openings and closings that occurred during 1984 included the indefinite closure of Tech Corp.'s Highmount Mine in British Columbia in September; closure of Esso Resources Canada Ltd.'s Granduc Mine in April; reopening of Noranda's copper-molybdenum mine in May, followed by closure again in December; and the announced closure by Corporation Falconbridge Copper of its Lake Dufault copper mine in Quebec in late 1986 or early 1987 owing to depletion of the ore body.

Chile.—Copper mine production increased slightly to record-high levels in 1984. The Government-owned CODELCO-Chile, with ore reserves estimated at 113 million tons of recoverable copper, increased production from 1.01 million tons in 1983 to 1.05 million tons in 1984 and accounted for 81% of Chilean copper production; it operated four mining divisions, Chuquicamata, El Teniente, El Salvador, and Andina. Chuquicamata and El Teniente, the world's largest open pit, as measured in terms of copper produced, and underground copper mines, respectively, accounted for about 81% of CODELCO-Chile copper production. The state-owned custom smelting and refinery company, Empresa Nacional de Minería (ENAMI), which buys ores from smaller mines and sells refined copper, produced 173,000 tons of refined copper in 1983. Though mining's share of export earnings dropped about 20% from that of 1983, mining remained as the chief source of export earnings, accounting for 60% of the country's export earnings in 1983; export earnings from copper in 1984 were $1.57 billion, compared with $1.85 billion in 1983, and represented 43% of total export income. The unexpected decline in foreign exchange earnings from copper owing to lower than predicted prices contributed to a 1984 trade deficit of $2 billion. In September, to help compensate for the decline in copper prices and high U.S. dollar interest rates, the peso was devalued by 24%.

Exports of copper to the United States and Europe dropped by 40% and 12%, respectively, from 1983 levels but were compensated for by an increase in exports to Asiatic countries, particularly Japan. CODELCO-Chile, which exported 95% of all copper it sold, marketed its products directly through a worldwide network of subsidiaries and sales agents.

As part of a $2 billion, 5-year expansion plan announced by CODELCO-Chile in December 1983, Fluor Mining and Metals Inc. was to construct an expansion of the Chuquicamata concentrator from 100,000 to 150,000 tons per day of copper ore. The expansion, which was aimed at maintaining copper production levels in the face of a declining ore grade, was expected to increase copper production at Chuquicamata from 550,000 to 650,000 tons per year in 1988. CODELCO-Chile also let a contract for development of the Mina Norte deposit at El Teniente, which will include a 15,000-ton-per-year concentrator module. Copper production at El Teniente had been dropping for the past 3 years, having declined from 336,000 tons in 1982 to 280,000 tons in 1984. At midyear, Chile's Economic Ministry issued a revised 3-year plan that forecast copper output rising to 1,410,000 tons in 1986 from an investment in CODELCO-Chile of over $14 million.

In September, a 2.5-kilometer conveyor belt to the new crushing station at Chuquicamata broke during startup and delayed dismantling of the old crusher station, which was located in an area of high-grade ore that was scheduled to be mined during the year. Mining of alternate, lower grade ore was expected to reduce production during 1985 by 45,000 tons.

Manto Blancos, majority owned by the Anglo-American Corp. of South Africa Ltd., was the largest privately owned mine in Chile. In 1984, it produced 64,000 tons of copper from its open pit oxide mine and underground sulfide mine. The underground mine Nora came on-stream in 1981, and in March 1983, a mine concentrator and powerplant expansion was initiated to restructure the mine completely toward sulfide ore owing to the depletion of the oxide ore. The planned expansion was expected to increase capacity to 85,000 tons per year of copper by 1990.

India.—Copper was produced by Hindustan Copper Ltd. (HCL), a Government of India enterprise that operated three divisions, the Malanjkhand open pit mine, the Indian Copper Complex (ICC), and the Khetri Copper Complex (KCC). The development of the Malanjkhand Mine, which came on-stream during 1983, served to reverse India's declining trend in mine production. The Malanjkhand Mine, with a capacity of about 23,000 tons of copper in concentrates, had reserves estimated at 366 million tons of ore grading 1.16% copper with a 0.2% cutoff. In 1984, Malanjkhand reportedly produced 19,000 tons of copper in concentrates from 1.4 million tons of ore grading 1.55% copper. Concentrates were shipped to the Khetri smelter for processing.[35]

Both ICC and KCC were fully integrated units with capacities estimated at 16,500 and 31,000 tons per year of refined copper, respectively. Mine production at these units was generally below capacity owing to power shortages and available power being diverted to smelter and refinery operations. Prior to the opening of the Malanjkhand Mine, mine production was supplemented with concentrate imports estimated at about 40,000 tons per year. Despite a 25% decline in consumption during 1984 to 72,000 tons, India remained a major importer of refined copper.

Japan.—Japan was the leading world importer of copper contained in concentrates. In response to the tightening of the world market in copper concentrates, most of Japan's 11 primary copper smelters, with a combined capacity exceeding 1.4 million tons, cut production by 10% to 15%. Consequently, production of refined copper declined by 14% to the lowest level since 1977. Mine closures and new smelters in the Pacific Rim area resulted in some changes in concentrate supply sources. The new Philippines Associated Smelting and Refining Corp. (PASAR) smelter in the Philippines reduced by one-third the tonnage of concentrates from the Philippines available to the custom smelting market. By 1984, Japan's imports had increased to over 6% from sources outside the Pacific Rim. Japan's concentrate imports were approximately 2.93 million tons in 1984. Despite Japan's excess smelter capacity, Dowa Mining Co. Ltd. announced plans to increase the capacity of its Kosaka smelter from 55,000 tons per year of blister to 66,000 tons per year.

Among market economy countries, Japan was the second largest consumer of refined copper, with 1984 consumption estimated at about 1.35 million tons, up 11% over that of 1983. According to Japan's Ministry of International Trade and Industry (MITI), demand for brass mill products accounted for most of the increase in consumption. In the face of low production, Japanese smelters met their supply commitments by increasing imports of refined copper; thus, imports of refined copper during 1984 increased by almost 15%, to 470,000 tons.

Mexico.—Although smelter development projects were planned that could more than triple smelter capacity by the end of 1986, smelter capacity during 1984 remained far behind mine production, and Mexico continued to be a major exporter of copper concentrates. Smelters continued to be unable to meet domestic demand for blister copper. Consumption of refined copper, which had declined steadily since 1981 as a result of Mexico's international debt problems, increased during 1984 by about 10%.

Reserve estimates at Mexicana de Cobre S.A.'s La Caridad Mine, the country's largest copper mine, were revised upward to 1.2 billion tons of ore, making it one of the world's major copper deposits. Following a 3-day strike in March, production at the mine and mill were reportedly at 100% capacity. Despite high mining rates, declining ore grades have kept production of copper in concentrates below the nominal 180,000 tons per year capacity. An estimated 95% of La Caridad concentrates was exported during 1984. Work on a new $400 million, 180,000-ton-per-year smelter, 70% complete in 1983, remained stalled, reportedly owing to lack of low-interest financing. Construction of a new refinery had been indefinitely postponed.

Expansion of Ciá. Minera de Cananea S.A.'s mine and smelter complex was reportedly proceeding at a reduced rate with local financing following the indefinite deferral of a $430 million International Bank for Reconstruction and Development (World Bank) loan in 1983. Construction of a 50,000-ton-per-day concentrator and associated crushing plant had a target completion date of December 1985. Completion of the $250 million expansion would increase annual capacity to 150,000 tons of concentrate. Plans also included increasing electrowinning capacity from an estimated 17,000 tons per year to 60,000 tons per year of refined copper. Construction of the controversial Cananea smelter, which posed potential air pollution problems to the United States because of its location only 20 miles from the international border, had not begun, but projections still called for completion during 1986. Proven recoverable reserves at Cananea were estimated at 1.3 billion tons grading 0.65% copper.

Papua New Guinea.—Production of copper by Bougainville Copper Ltd. declined by 19,000 tons to 164,000 tons owing to a 2-week strike in November and to declining ore grades. Reserves were estimated at 720 million tons grading 0.40% copper and 0.46 gram of gold per ton. This compares with original reserve estimates prior to beginning operations in 1972 of 900 million tons grading 0.48% copper and 0.55 gram of gold per ton. The company reportedly planned to install a 13th ball mill by mid-1985 to help offset declining ore grades.

Gold production at the OK Tedi Mining Ltd. gold-copper deposit, 30% owned by Amoco Minerals, began in May, but production of copper, originally scheduled to begin during 1986, was postponed until at least mid-1987. OK Tedi, which has been described as a mountain of copper with a crown of gold, is 500 miles inland on a 7,100-foot mountain peak. Its remoteness and climate, averaging over 340 inches of rain annually, has hampered development of the estimated 350 million tons of copper ore. The total overall cost of the project has been projected at about $2 billion.

Peru.—Southern Peru Copper Corp. (SPCC), which was jointly owned by the U.S. corporations of Asarco, Phelps Dodge, Newmont Mining, and Cerro Corp., along with the state-owned Empresa Minera del Perú (Minero Perú) and Empresa Minera del Centro del Perú (Centromín Perú), comprised Peru's large-scale mining sector and accounted for 92% of Peru's copper production. The remaining production was from the medium- and small-scale mining sector, which consisted of about 30 mining companies. Increased production balanced lower copper prices, and copper export earnings, which accounted for about 14% of Peru's total export earnings, remained at about the same level as in 1983.

At yearend, the Tintaya copper project, 45% owned by Minero Perú, 45% owned by Centromín Perú, and 10% owned by Corporación Financiera de Desarrollo, the state-owned holding company, was nearing completion, and was expected to start operations during the first quarter of 1985. The $320 million open pit mine and concentrator project was expected to produce 160,000 tons per year of 33% copper concentrate. When opened, it would be Peru's first new copper mine since Cuajone opened in 1976.

At yearend, Minero Perú was still unsuccessful in securing a long-stalled $130 million financing package for development of the Cerro Verde II copper sulfide project and was considering two smaller projects as an alternative. One project would ensure the continued use of the Cerro Verde refinery when Cerro Verde oxides run out in 1985 by shipping oxides from the new Tintaya project. A second project would involve the high grading of sulfide ore from Cerro Verde II and the construction of a smaller concentrator. The projected cost of the two plants was $55 million. During 1984, production disruptions included a wildcat strike in July at Centromín Perú's mines and the La Oroya smelter; a strike in November at SPCC's Toquepala and Cuajone Mines and Ilo smelter; and weather-related problems in March, which caused supply shortages at Centromín Perú's La Oroya metallurgical complex.

Philippines.—Copper mine production in the Philippines declined by about 22% from the 1983 level. Many of the smaller mines remained closed, and Marinduque Mining and Industrial Corp.'s (MMIC) Sipalay Mine, which closed in October 1983, remained closed for the entire year. In 1982, its last full year of operation, the Sipalay Mine produced 41,000 tons of copper. Atlas Consolidated Mining and Development Corp., the country's largest copper producer, accounted for about 52% of Philippine copper mine production. In July, the President suspended all taxes, duties, fees, and all other Government charges on copper mines that were unable to maintain viable operations without such relief in the face of poor copper prices and escalating operating costs. As of the end of November, three companies, Atlas Consolidated Mining, Marcopper Mining Corp., and North Davao Mining Corp., had qualified for relief. The suspension of payments was to be lifted if world market prices for copper became adequate to sustain the mining industry.

In April, MMIC, then 36% Government-owned, unsuccessfully sought to restructure its massive debt into common shares and reopen its copper and nickel mines. However, in September, two state-owned banks foreclosed on Marinduque and subsequently purchased its assets at auction, bringing state control up to 87%. At yearend, the Japanese trading house, Marubeni Corp., acting as agent for Mitsui Mining & Smelting Co. Ltd., the principal purchaser of Sipalay concentrates prior to its closure, was reportedly discussing plans for reopening the mine in February.

In order to compensate for concentrate shortfalls at the new 138,000-ton-per-year PASAR smelter and refinery, which was 36% Government-owned, the Philippine Government imposed restrictions on the export of copper concentrates. The controversial restrictions required Government clearance for all concentrate exports, including those previously contracted for and were particularly worrisome to Japanese smelters, which were dependent on the Philippines for an estimated 40% of their concentrate feed. In addition, in March, all domestic mining companies were required to deliver at least 38% of their output to PASAR. On June 5, an accidental blister spill at the PASAR smelter closed the smelter and acid plant for 5 weeks and resulted in a declaration of a force majeure on copper shipments. The closure of the smelter served to ease the pressure on export restrictions, implementation of which was delayed until June.

In a move designed to lessen mining company objections to shipping concentrates to the PASAR smelter, PASAR reduced its smelting charge by 5.91 cents for 1985 shipments, reportedly making the charges competitive with Japanese rates. Under the new contracts, six mines are committed to supply a total of 510,000 tons of concentrates in 1985, from which PASAR expects to produce 138,000 tons of cathode.

Zaire.—Copper was produced by the two state-owned companies, La Générale des Carrières et des Mines du Zaire (Gécamines) and by Société de Developpement Industriel et Minière Zaire (Sodimiza). Gécamines, which accounted for over 90% of Zaire's production, operated 12 open pit and 3 underground mines in the Province of Shaba near the Zambian border. Sodimiza, which until 1983 was 80% owned by a consortium of Japanese companies, operated two underground copper mines in Shaba. Gécamines operated two smelters—the Lubumbashi, which was by far the largest, and the Panda, which produced black copper—as well as two electrowinning refineries. Most of the electrowon copper was fire refined into wirebar at the Shituru refinery while black, blister, and the remaining anode, which together accounted for about 50% of production, were further refined in Belgium. Longstanding refining arrangements with Métallurgie Hoboken-Overpelt SA (MHO) of Belgium were renegotiated at the end of 1983, Zaire having obtained more favorable terms in light of tight world supplies of copper concentrates and blister. At the end of 1984, Sodimiza reportedly negotiated a 3-year contract with General Motors Corp. for Sodimiza's entire output of copper, which was estimated at about 35,000 tons per year, and was to be toll refined in Zambia.

Beginning in January 1983, Zaire, in collaboration with the IMF, began a 15-month economic stabilization program that, among other things, succeeded in reducing Government debts, improving management in major parastatal firms, and cutting 1984 inflation rates to one-fifth of the 1983 level. As part of the reform, the IMF extended Special Drawing rights on $228 million in December 1983, and an additional $200 million credit line was expected in 1985. In July 1984, the Société Zairoise de Commercialisation de Minerais (Sozacom) was abolished, and late in the year, Gécamines, upon urging from the World Bank, was split up into a holding company with three subsidiaries, which were to oversee production, marketing, and agricultural development. According to the new Lubumbashi-based production division, a new rehabilitation and modernization program aimed at maintaining annual copper production at 470,000 tons would be initiated in 1986 and would include a new 100,000-ton-per-year smelter and refinery. About 60% of the proposed $750 million budget would go toward maintenance.

Zambia.—Copper mine, smelter, and refinery production in Zambia was from the state-controlled company Zambia Consolidated Copper Mines Ltd. (ZCCM). ZCCM, 60.3% Government-owned, had 7 mining divisions, which operated 10 underground and 7 open pit mines, as well as 3 smelters, refineries, and electrowinning plants. According to ZCCM, the company had developed and undeveloped reserves totaling 435.5 million tons of copper ore at a weighted-average grade of 3.05% copper. At 1984 extraction rates, this represented about 16 years of reserves.

Zambia had been experiencing serious financial difficulties in recent years in large part owing to depressed prices for copper, which accounted for over 90% of its export earnings. Insufficient foreign exchange led to severe shortages of spare parts and raw materials at copper mines and to severe disrepair of Zambia's railroads. Economic reforms begun in April 1983 encouraged increased foreign assistance, and in March 1984, a World Bank-led $300 million loan package ($152 million from ZCCM, $75 million from the World Bank, $70 million from the European Development Bank, and $3 million from the African Development Bank) was negotiated with the intent of rehabilitating and extending the life of Zambia's copper mines while reducing production by about 50,000 tons per year of copper. Development plans included a new tailings leach plant at the Nchanga Div., which was expected to produce 520,000 tons of copper over a 15-year period. As a result of the Government decision in January allowing ZCCM to retain 35% of its foreign exchange earnings to purchase mining equipment and spare parts, ZCCM reportedly began to reverse its trend toward declining copper production.

TECHNOLOGY

A number of copper-nickel alloys were being evaluated, some in the fundamental stages of investigation, while the technology for others was being marketed. The new alloys under investigation had the potential for corrosion-resistant, high-temperature applications such as those in jet engines and aerospace equipment that now use more costly, and more difficult to form, superalloys. The new alloys were expected to find applications in batteries, lightweight aircraft, automotive and aerospace applications, high-temperature and advanced structural uses, fine-particle permanent magnets, electrical contacts, welding electrodes, bearings, and superconducting and superplastic materials.

Using rapid solidification and solid-state microblending technology, Battelle Research Laboratory in Columbus, OH, developed a class of alloys including copper-chromium and two other new alloys—aluminum indium and copper lead—that differed from their conventionally processed counterparts in having more refined microstructures. These microcomposite alloys also lend themselves to control and manipulation of microstructure and properties during processing, permitting users to better modify strength, corrosion resistance, ductility, creep resistance, magnetic properties, and friction and wear properties. Battelle was marketing the copper-lead alloy technology. Made through rapid solidification, the copper-lead alloy was believed to be particularly well suited for use in self-lubricating bearings and offered possible ordnance and structural applications. The fine dispersions of lead in copper provide a continuous supply of lead in applications where self-lubricating conditions are desirable.[36]

Research was conducted by the Bureau of Mines to develop technology for electrodepositing copper-nickel alloy coatings on substrates of minimal critical metal content to provide corrosion protection or to enhance joining. Copper-nickel alloys are noted for their excellent corrosion resistance and strength and are preferred alloys for marine environments. Bureau research has shown that copper-nickel coatings can be uniquely electroplated in alloy form onto metallic substrates from acetate electrolytes. The use of thin copper-nickel coatings facilitated the soft soldering of aluminum and its alloys, normally not solderable with tin-lead solders.[37] This patented technology[38] may find wide use in joining applications for aluminum wiring and bus bars, and solar energy heat exchangers.

The application of continuous casting technology to various parts of the industry was continuing. A rapid-solidification, continuous foil caster for copper alloys was installed at the research laboratories of the Signal UOP Research Center at Des Plaines, IL. The foil would be consolidated into other forms by sintering, pressing, or extruding. In this process, hot metal spinning to produce foil achieves a significantly more rapid cooling and solidification rate than the more conventional methods.[39]

New reclaiming equipment, scrap analyzing instrumentation, and quality control devices at brass and bronze ingot makers and mills continued to raise the quality levels of scrap, in addition to saving energy and preserving the environment. New technology was expected to continue to change the competitive posture of the metal casting industry, thus improving productivity and profitability. Robotics were being customized to perform materials handling, manipulation, and transfer functions. New robot vision capabilities were allowing foundries to use them to identify, sort, and inspect castings.[40]

The copper industry continued evaluation of smelter technologies and their applications and economic potentials. Greenfield smelter construction has become prohibitive in recent years. Plant construction costs and consumer price indexes have increased at a much faster rate than metal prices, thus reducing profitability and potential for new smelter construction. Retrofit of existing pyrometallurgical plants and changes in operating practices can be viable solutions, however, especially if energy efficiencies and operating costs are improved, and sulfur emissions and other toxic wastes reduced. Which process to use in a retrofit situation has depended upon a number of factors including environmental constraints, cost and availability of energy, impurity levels of the concentrate, and smelting rate required. A comparison of capital costs for converter aisle structures and equipment, converters, and sulfuric acid plants suggested that for optimum economy, the converter aisle operations should not involve the use of more than four to five converters and should operate at increasingly higher matte grades. A logical development from the treatment of high-grade mattes was the development of the continuous conversion of such mattes to copper. Since 1959, work had been carried out on this subject in Australia, Canada, Czechoslovakia, Japan, and the U.S.S.R.[41]

Kennecott announced an agreement signed with Outokumpu Oy of Finland for the joint development and worldwide marketing of the solid matte oxygen converting process patented by Kennecott. The process offered significant capital and operating cost advantages for new smelters and upgraded plants. The new process uses an oxygen flash furnace to process solidified copper mattes to blister copper, providing an alternative to Pierce-Smith copper converters, standard in copper smelters since 1906. One furnace operating continuously and employing the Kennecott-patented process would replace multiple Pierce-Smith converters operating intermittently. The process also would permit better process control and reduce offgas emissions. Kennecott has authorized Outokumpu to license the process throughout the world.[42]

Studies by the Bureau[43] have demonstrated that copper electrowinning can be combined with electrochemical production of sodium perchlorate to achieve a significant decrease in the use of electrolysis energy. In order to improve the anode current efficiency, research was conducted on an electrowinning procedure using a cation-membrane (perfluorosulfonic acid membrane) to separate the anodic and cathodic reactions. The method of combining electrowinning with coal slurry oxidation to achieve a significantly lower cell voltage also was investigated.

Minor element behavior and interaction in the copper matte-iron silicate slag system and interactions among the minor elements such as antimony, arsenic, bismuth, selenium, and tellurium were investigated by the Bureau.[44] A better understanding of minor element behavior relative to their concentration, distribution, and association with other elements in the matte and slag of smelting systems was expected to lead to improved recovery and more efficient extraction of copper.

In other Bureau research, hydrometallurgical methods were investigated for treating low-grade, complex silver concentrates containing metal values such as copper, lead, and zinc, with a view toward recovering these metals by electrolysis from solution. Ferric and cupric chloride leaching of complex silver concentrates containing lead, copper, and zinc were investigated in addition to chloride-oxygen leaching used in the treatment of complex copper-cobalt-arsenic concentrate. A stable iron- and arsenic-bearing residue, copper, and cobalt sulfide were recovered through solution processing techniques.[45]

Significant amounts of cobalt are known to be present in readily accessible copper recycling leach solutions. The Bureau of Mines developed a procedure for extracting 95% of the cobalt using a commercial chelating ion-exchange resin. Recovery of cobalt from an existing 10,000-gallon-per-minute stream at a U.S. copper leaching operation would yield 1.3 million pounds of cobalt per year, enough to satisfy about 10% of U.S. consumption.[46]

An investigation of the Tangse, northern Sumatra, porphyry copper deposit by the Indonesian Directorate-General of Mines and the U.S. Geological Survey produced encouraging results in the study of rutile distribution in the delineation of porphyry copper deposits in tropical terrains. Because rutile is highly resistant to tropical weathering in alteration zones associated with porphyry copper systems, it provides potential for a prospecting indication. Deep leaching of soils and the subsequent removal of diagnostic or trace elements derived from them frequently render conventional geochemical exploration methods unsatisfactory in tropical terrains. In the United States, rutile is most commonly associated with the biotite potassium feldspar alteration zone, which diminishes toward peripheral zones. In some porphyry deposits, the distribution of rutile and copper ore is much the same.[47]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Steptoe & Johnson Chartered. Prehearing Brief in Support of Petition for Relief From Imports of Refined and Blister Copper Under Section 201 of the Trade Act of 1974. U.S. International Trade Comm. Invest. No. TA-201-52, May 8, 1984, p. 9.

[3]Federal Register. International Trade Commission. Refined and Blister Copper Industry, Prospects for Adjustment Assistance for Firms. V. 49, No. 156, Aug. 10, 1984, pp. 32095-32096.

[4]Federal Register. Environmental Protection Agency. National Emission Standards for Hazardous Air Pollutants, Proposed Standards for Inorganic Arsenic. V. 49, No. 184, Sept. 20, 1984, pp. 36877-36879.
[5]Jolly. J. L. W. Copper. Ch. in Mineral Facts and Problems, 1985 Edition. BuMines B 675, 1985, 25 pp.
[6]Leaming, G. F. The Copper Industry's Impact on the Arizona Economy 1984. West. Econ. Anal. Cent., Marana, AZ, Apr. 1985, 32 pp.
[7]ASARCO Incorporated. 1984 Annual Report. 32 pp.
[8]Phelps Dodge Corp. 1984 Annual Report. 32 pp.
[9]AMAX Inc. 1984 Annual Report. 34 pp.
[10]Pay Dirt. Boliden Minerals Files Plan for Los Altos Tailings Facility. Feb. 1985, p. 22A.
[11]The Louisiana Land and Exploration Co. 1984 Annual Report. 48 pp.
[12]Standard Oil Co. (Indiana). 1984 Annual Report. 52 pp.
[13]American Metal Market. Duval Intends To Run Mines as Usual Until Sold. V. 93, No. 4, Jan. 8, 1985, p. 7.
[14]Green Bay Press Gazette. Environmentalists Skeptical of Exxon Mine in Forest Co. Green Bay, WI. Feb. 17, 1985, p. B-8.
[15]Federal Resources Corp. 1984 Annual Report. 20 pp.
[16]Inspiration Resources Corp. SEC 10K Report. Dec. 31, 1983.
[17]———. Prospectus. July 18, 1984.
[18]Standard Oil Co. of Ohio. 1984 Annual Report. 70 pp.
[19]Newmont Mining Corp. 1984 Annual Report. 56 pp.
[20]Work cited in footnote 19.
[21]Work cited in footnote 19.
[22]Work cited in footnote 8.
[23]Work cited in footnote 7.
[24]Work cited in footnote 7.
[25]Work cited in footnote 16.
[26]Work cited in footnote 19.
[27]Work cited in footnote 8.
[28]Work cited in footnote 8.
[29]American Metal Market. U.S. Copper Product Shipments for Auto Use Rose 17% in 1984. Mar. 11, 1985, p. 4.
[30]Copper Development Association Inc. Market Data. Copper-Brass-Bronze. Annual Reports 1984, 47 pp.
[31]American Metal Market. Record Deliveries Anew. Copper and Brass Service Centers Supplement. Mar. 21, 1985, p. 3A.
[32]Metals Week. Mid-America Will Introduce Copper Contract. Oct. 22, 1984, p. 1.
[33]American Metal Market. Brass and Bronze Ingot Prices. V. 93, No. 35, Feb. 2, 1985, p. 9.
[34]World Bureau of Metal Statistics. World Metal Statistics. V. 38, No. 4, Apr. 22, 1985, p. 36.
[35]Engineering and Mining Journal. Hindustan Copper Limited: India's Copper Producer. June 1985, pp. 26-42.
[36]American Metal Market. Battelle Markets Know-How for its Copper-Lead Alloy. V. 93, No. 62, Apr. 4, 1985.
Advanced Battery Technology. V. 21, No. 3, Mar. 1985, p. 4.
[37]Falke, W. L., A. Y. Lee, and L. A. Neumeier. Development of a Soft-Soldering for Aluminum. BuMines RI 8747, 1983, 15 pp.
[38]Lee, A. Y., W. L. Falke, and A. E. Schwaneke. Electroplating With Ni-Cu Alloy. U.S. Pat. 4,167,459, Sept. 11, 1979.
[39]American Metal Market. Signal UOP Investigates Copper Alloy Foil Caster. V. 92, No. 140, July 19, 1984, p. 4.
[40]Institute of Scrap Iron and Steel. Survival Means Change for Basic Industries. Winter 1985, pp. 5-10.
[41]Verney, L. R. Economic and Technological Aspects of Sulfide Smelting Processes. J. Met., Jan. 1984, pp. 35-42.
[42]Tribune (Salt Lake City, UT). Finnish Firm, Kennecott OK Contract. Dec. 11, 1984, p. 2.
[43]Smith, G. R. Zinc and Copper Electrowinning Combined With Sodium Perchlorate Production. Paper in Proceedings of the International Symposium on Electro-Chemistry in Mineral and Metal Processing (Cincinnati, OH, May 6-11, 1984). Electrochem. Soc. Inc., Aug. 1984, pp. 548-561.
[44]Johnson, E. A., L. L. Den, P. E. Sanker, and R. L. Fulton. Minor Element Interactions in Copper Matte Smelting. BuMines RI 8874, 1984, 9 pp.
[45]Lei, K. P. V., and T. G. Carnahan. Oxidative Electrolysis Leaching of an Arsenical Copper Sulfide Concentrate. Paper in Proceedings of Symposium on Energy Reduction Techniques in Metal Electro-Chemical Processes, 114th Annual AIME Meeting, New York, Feb. 24, 1985.
[46]Jeffers, T. H. Separation and Recovery of Cobalt From Copper Leach Solutions. J. Met., v. 37, No. 1, Jan. 1985, pp. 47-50.
[47]Mining Journal. Rutile Distribution as Guide to Porphyry Copper. Oct. 26, 1984, p. 290.

Table 5.—Copper produced from domestic ores in the United States

(Thousand metric tons)

Year	Mine	Smelter	Refinery
1980	1,181	994	1,126
1981	1,538	1,295	1,430
1982	1,147	941	1,065
1983	1,038	888	1,004
1984	1,091	990	1,084

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]
1980	91	86	9	14
1981	89	84	11	16
1982	88	82	12	18
1983	89	85	11	15
1984	92	87	8	13

[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

(Metric tons)

Month	1983	1984
January	90,025	92,016
February	77,664	86,960
March	89,274	95,136
April	84,646	90,313
May	92,170	94,069
June	89,717	96,993
July	76,323	87,328
August	79,211	88,117
September	86,704	87,169
October	89,608	93,412
November	93,706	91,557
December	89,050	88,214
Total	1,038,098	1,091,284

Table 8.—Mine production of recoverable copper in the United States, by State

(Metric tons)

State	1980	1981	1982	1983	1984
Alaska	--	--	W	W	--
Arizona	770,118	1,040,813	769,521	678,216	746,453
California	W	W	W	W	W
Colorado	461	W	575	W	W
Idaho	3,103	4,245	3,074	3,556	3,701
Michigan	W	W	W	--	--
Missouri	13,576	8,411	7,941	7,725	5,818
Montana	37,749	62,485	64,951	33,337	W
Nevada	W	W	W	W	W
New Mexico	149,394	154,114	W	W	W
Oregon	--	W	--	W	--
South Carolina	--	W	--	--	--
Tennessee	W	W	W	W	W
Utah	157,775	211,276	189,090	169,751	W
Washington	--	W	W	--	--
Total	1,181,116	1,538,160	1,146,975	1,038,098	1,091,284

W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 9.—Twenty-five leading copper-producing mines in the United States in 1984, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Morenci	Pima, AZ	Phelps Dodge Corp	Copper ore and copper precipitates.
2	Bingham Canyon	Salt Lake, UT	Kennecott	Do.
3	Chino	Grant, NM	Chino Mines Co	Do.
4	San Manuel	Pinal, AZ	Magma Copper Co	Copper ore and copper tailings (slag).
5	Ray	do	Kennecott	Copper ore and copper precipitates.
6	Sierrita	Pima, AZ	Duval Corp	Copper ore.
7	Tyrone	Grant, NM	Phelps Dodge Corp	Do.
8	Inspiration	Gila, AZ	Inspiration Consolidated Copper Co.	Do.
9	Pinto Valley	do	Pinto Valley Copper Corp	Do.
10	Eisenhower	Pima, AZ	Eisenhower Mining Co	Do.
11	Twin Buttes	do	Anamax Mining Co	Do.
12	New Cornelia	do	Phelps Dodge Corp	Copper ore and copper precipitates.
13	Bagdad	Yavapai, AZ	Cyprus Bagdad Copper Co	Copper ore.
14	Troy	Lincoln, MT	ASARCO Incorporated	Silver ore.
15	Silver Bell	Pima, AZ	do	Copper ore and copper precipitates.
16	Mission	do	do	Copper ore.
17	San Xavier	do	do	Do.
18	Copperhill (1 mine)	Polk, TN	Tennessee Chemical Co	Copper-zinc ore.
19	Lakeshore	Pinal, AZ	Noranda Lakeshore Mines Inc	Copper ore.

Table 9.—Twenty-five leading copper-producing mines in the United States in 1984, in order of output —Continued

Rank	Mine	County and State	Operator	Source of copper
20	Berkeley	Silver Bow, MT	Anaconda Copper Co	Copper ore and copper precipitates.
21	Esperanza	Pima, AZ	Duval Corp	Copper precipitates.
22	Miami	Gila, AZ	Pinto Valley Copper Corp	Copper ore.
23	Johnson	Cochise, AZ	Cyprus Johnson Copper Co	Do.
24	Sacaton	Pinal, AZ	ASARCO Incorporated	Do.
25	Battle Mountain	Lander, NV	Duval Corp	Copper ore and copper precipitates.

Table 10.—Mine production of recoverable copper in the United States, by source

Source	Ore treated (thousand metric tons)	Recoverable copper: Metric tons	Recoverable copper: Percent yield	Remarks
1983				
Mined copper ore:				
By concentration or leaching	[1]177,930	915,081	0.51	
By direct smelting	63	24	.04	
Total or average	177,993	915,105	.51	
Tailings, dump, in-place material by leaching	--	89,274	--	
Miscellaneous:				
Silver ore	4,097	19,384	--	
Lead ore	7,303	7,725	--	
Gold ore, gold-silver ore, lead-zinc ore, molybdenum ore, tungsten ore, cleanup, tailings	2,652	6,610	--	
Grand total	XX	1,038,098	XX	
1984				
Mined copper ore:				
By concentration or leaching	[2]171,813	978,606	.57	See table 12.
By direct smelting	98	87	.09	See table 13.
Total or average	171,911	978,693	.57	
Tailings, dump, in-place material by leaching	--	80,845	--	See table 14.
Miscellaneous:				
Silver ore	4,042	22,335	--	
Lead ore	4,749	5,817	--	
Gold ore, gold-silver ore, lead-zinc ore, molybdenum ore, tungsten ore, cleanup, tailings	7,014	3,594	--	
Grand total	XX	1,091,284	XX	

XX Not applicable.
[1]Includes 6,153,969 tons of ore leached for electrowinning.
[2]Includes 3,184,033 tons of ore leached for electrowinning.

Table 11.—Copper ore shipped directly to smelters or concentrated in the United States in 1984, by State, with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or 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	122,315	612,365	0.50	48,465	3,727,075	$0.39
New Mexico	W	W	W	W	W	W
Tennessee[1]	W	W	W	--	W	W
Utah	W	W	W	W	W	W
Total or average	168,728	883,425	.52	195,380	6,372,847	.73

W Withheld to avoid disclosing company proprietary data; included in "Total or average."
[1]Copper produced in Tennessee is from copper-zinc ore.

Table 12.—Copper ore concentrated[1] in the United States in 1984, by State, with content in terms of recoverable copper

State	Ore concentrated (thousand metric tons)	Recoverable copper content: Metric tons	Recoverable copper content: Percent
Arizona	122,274	612,328	0.50
New Mexico	W	W	W
Tennessee[2]	W	W	W
Utah	W	W	W
Total or average	168,629	883,338	.52

W Withheld to avoid disclosing company proprietary data; included in "Total or average."
[1]Includes the following methods of concentration: dual process (leaching followed by concentration), leach-precipitation-flotation, and froth flotation.
[2]Copper produced in Tennessee is from copper-zinc ore.

Table 13.—Copper ore[1] shipped directly to smelters in the United States in 1984, by State, with content in terms of recoverable copper

State	Ore shipped to smelters: Metric tons	Recoverable copper content: Metric tons	Recoverable copper content: Percent
Arizona	40,646	37	0.09
New Mexico	57,853	50	.09
Total or average	98,499	87	.09

[1]Primarily smelter fluxing material.

Table 14.—Copper precipitates[1] (leached from dump and in-place material or tailings) shipped directly to smelters in the United States in 1984, by State

(Metric tons)

State	Precipitates shipped	Recoverable copper content
Arizona	69,205	46,804
California	W	W
Montana	W	W
Nevada	W	W
New Mexico	W	W
Utah	W	W
Total	120,437	80,845

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]In terms of recoverable copper.

Table 15.—Copper ore shipped to smelters and ore concentrated and leached in the United States and average yield

Year	Direct smelted ore: Thousand metric tons	Direct smelted ore: Yield in copper (percent)	Concentrated and leached ore: Thousand metric tons[1]	Concentrated and leached ore: Yield in copper (percent)	Total: Thousand metric tons[1]	Total: Yield in copper (percent)	Total: Yield per metric ton in gold (troy ounces)	Total: Yield per metric ton in silver (troy ounces)	Total: Value per metric ton in gold and silver
1980	111	0.38	221,486	0.48	221,597	0.48	0.0013	0.053	$1.90
1981	158	.14	277,516	.51	277,674	.51	.0013	.053	1.18
1982	118	.14	181,826	.55	181,944	.55	.0013	.052	.90
1983	63	.04	177,930	.51	177,993	.51	.0015	.041	1.09
1984	98	.09	171,813	.57	171,911	.57	.0011	.037	.71

[1]Includes some ore classed as copper-zinc and a minor amount of tailings.

Table 16.—Copper produced by primary smelters in the United States

(Metric tons)

Year	Domestic	Foreign	Secondary	Total
1980	994,479	13,918	44,876	1,053,273
1981	1,294,962	21,794	60,882	1,377,638
1982	940,547	35,148	45,105	1,020,800
1983	888,130	39,609	59,276	987,015
1984	989,720	24,296	45,839	1,059,855

Table 17.—Primary and secondary copper produced by primary refineries and electrowinning plants in the United States

(Metric tons)

	1980	1981	1982	1983	1984
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	924,190	1,194,566	891,615	820,778	886,683
Electrowon	[2]117,572	161,083	131,858	101,935	110,120
Fire-refined	84,469	74,561	41,060	80,955	87,455
Total	1,126,231	1,430,210	1,064,533	1,003,668	1,084,258
From foreign ores, etc.:[1]					
Electrolytic	88,957	113,807	162,245	178,422	115,930
Electrowon	W	W	W	W	W
Fire-refined	W	--	--	--	--
Total primary	1,215,188	1,544,017	1,226,778	1,182,090	1,200,188
SECONDARY					
Electrolytic[3]	315,062	303,338	268,952	224,721	191,128
Fire-refined	W	W	W	W	W
Total secondary	315,062	303,338	268,952	224,721	191,128
Grand total	1,530,250	1,847,355	1,495,730	1,406,811	1,391,316

W Withheld to avoid disclosing company proprietary data; included with "Electrolytic."
[1]The separation of refined copper into metal of domestic and foreign origin is only approximate because accurate separation is not possible at this stage of processing.
[2]Includes some smelter-level electrowinning in order to avoid disclosing company proprietary data.
[3]Includes fire-refined quantities indicated by symbol W.

Table 18.—Copper cast in forms at primary refineries in the United States

(Thousand metric tons)

	1983	1984
Billets	97	98
Cakes	22	5
Cathodes	1,184	1,219
Ingots and ingot bars	81	41
Wirebars	22	26
Other forms	1	--
Total	1,407	1,389

Table 19.—Production, shipments, and stocks of copper sulfate in the United States

(Metric tons)

Year	Production		Shipments[1]	Stocks, Dec. 31
	Quantity	Copper content		
1980	31,010	8,445	34,135	5,736
1981	35,636	9,413	36,103	5,269
1982	32,227	8,385	33,355	4,142
1983	37,500	9,789	[r]36,614	5,029
1984	33,730	9,016	36,116	3,324

[r]Revised.
[1]Includes consumption by producing companies.

Table 20.—Byproduct sulfuric acid[1] (100% basis) produced in the United States

(Metric tons)

Year	Copper plants[2]	Lead plants[3]	Zinc plants[4]	Total
1980	2,097,692	410,266	560,784	3,068,742
1981	2,593,762	405,974	545,890	3,545,626
1982	1,879,983	310,606	341,728	2,532,317
1983	1,837,827	319,137	384,529	2,541,493
1984	2,251,312	248,474	442,517	2,942,303

[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 21.—Copper recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1983	1984
KIND OF SCRAP		
New scrap:		
Copper-base	r611,890	652,592
Aluminum-base	21,926	21,919
Nickel-base	254	68
Zinc-base	31	31
Total	r634,101	674,610
Old scrap:		
Copper-base	r431,243	448,010
Aluminum-base	18,015	16,929
Nickel-base	158	102
Tin-base	NA	NA
Zinc-base	r62	79
Total	r449,478	465,120
Grand total	r1,083,579	1,139,730
FORM OF RECOVERY		
As unalloyed copper:		
At primary plants	r224,761	191,128
At other plants	r194,093	135,531
Total	r418,854	326,659
In brass and bronze	r625,349	766,976
In alloy iron and steel	r1,434	1,519
In aluminum alloys	r36,704	43,390
In other alloys	r162	138
In chemical compounds	1,076	1,048
Total	r664,725	813,071
Grand total	r1,083,579	1,139,730

rRevised. NA Not available.

Table 22.—Secondary copper produced in the United States

(Metric tons unless otherwise specified)

	1980	1981	1982	1983r	1984
Copper recovered as unalloyed copper	534,556	514,518	481,565	418,854	326,659
Copper recovered in alloys[1]	902,871	903,594	705,901	664,725	813,071
Total secondary copper[1]	1,437,427	1,418,112	1,187,466	1,083,579	1,139,730
Source:					
New scrap	823,969	819,990	669,740	634,101	674,610
Old scrap	613,458	598,122	517,726	449,478	465,120
Percentage equivalent of domestic mine output	122	92	104	104	104

rRevised.
[1]Includes copper in chemicals as follows, in metric tons: 1980—2,869; 1981—3,227; 1982—2,250; 1983—1,076; and 1984—1,048.

Table 23.—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	
	1983	1984	1983	1984	1983	1984
Secondary smelters	91,014	97,994	184,021	224,517	275,035	322,511
Primary copper producers	40,925	20,391	r183,837	170,737	r224,762	191,128
Brass mills	464,032	513,802	26,640	15,790	490,672	529,592
Foundries and manufacturers	r14,758	20,052	r36,002	36,243	r50,760	56,295
Chemical plants	361	353	743	723	1,104	1,076
Total	r611,090	652,592	r431,243	448,010	r1,042,333	1,100,602

rRevised.

Table 24.—Production of secondary copper and copper-alloy products in the United States, by item produced from scrap

(Metric tons)

Item produced from scrap	1983	1984
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	r224,761	191,128
Refined copper by secondary smelters	r176,907	118,361
Copper powder	r11,455	12,783
Copper castings	5,731	4,387
Total	r418,854	326,659
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronzes	15,824	15,390
Leaded red brass and semired brass	98,111	116,228
High-leaded tin bronze	10,375	14,063
Yellow brass	7,628	10,796
Manganese bronze	7,520	8,000
Aluminum bronze	6,331	8,263
Nickel silver	3,265	3,455
Silicon bronze and brass	3,596	4,496
Copper-base hardeners and master alloys	14,977	17,304
Total	167,627	197,995
Brass-mill products	612,820	663,583
Brass and bronze castings	r32,894	40,358
Brass powder	644	879
Copper in chemical products	1,076	1,048
Grand total	r1,233,915	1,230,522

rRevised.

Table 25.—Composition of secondary copper-alloy production in the United States

(Metric tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production:[1]							
1983r	134,102	5,029	8,381	19,612	419	84	167,627
1984	158,396	5,940	9,900	23,165	495	99	197,995
Secondary metal content of brass mill products:							
1983	r490,257	429	r3,064	116,129	r2,929	r12	612,820
1984	530,866	465	3,318	125,749	3,172	13	663,583
Secondary metal content of brass and bronze castings:							
1983r	27,247	893	1,731	2,959	3	61	32,894
1984	33,430	1,096	2,124	3,631	3	74	40,358

rRevised.
[1]About 95% from scrap and 5% from other than scrap in 1983 and 1984.

Table 26.—Stocks and consumption of purchased copper scrap in the United States in 1984, 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						
No. 1 wire and heavy	1,594	36,024	7,962	27,388	35,350	2,268
No. 2 wire, mixed heavy and light	5,660	133,846	42,339	90,966	133,305	6,201
Composition or soft red brass	2,643	48,152	11,504	36,740	48,244	2,551
Railroad-car boxes	108	624	--	722	722	10
Yellow brass	3,681	52,930	18,214	33,092	51,306	5,305
Cartridge cases	8	238	--	234	234	12
Automobile radiators (unsweated)	3,544	70,321	2,020	67,858	69,878	3,987
Bronze	1,535	19,098	2,132	16,654	18,786	1,847
Nickel silver and cupronickel	632	2,277	692	1,718	2,410	499
Low brass	350	2,052	684	971	1,655	747
Aluminum bronze	95	163	143	49	192	66
Low-grade scrap and residues	4,379	87,487	60,829	24,097	84,926	6,940
Total	24,229	453,212	146,519	300,489	447,008	30,433
PRIMARY PRODUCERS						
No. 1 wire and heavy	784	15,315	4,168	11,385	15,553	546
No. 2 wire, mixed heavy and light	15,658	156,672	15,291	145,917	161,208	11,122
Refinery brass	545	20,354	4	10,213	10,217	10,682
Low-grade scrap and residues	29,427	34,666	10,964	44,425	55,389	8,704
Total	46,414	227,007	30,427	211,940	242,367	31,054
BRASS MILLS[1]						
No. 1 wire and heavy	9,660	190,299	176,053	14,246	190,299	8,508
No. 2 wire, mixed heavy and light	3,519	68,543	66,849	1,694	68,543	3,591
Yellow brass	16,196	307,493	307,493	--	307,493	18,730
Cartridge cases and brass	9,150	70,547	70,547	--	70,547	9,803
Bronze	1,178	4,880	4,880	--	4,880	1,248
Nickel silver and cupronickel	4,428	19,245	19,214	31	19,245	4,214
Low brass	3,044	14,447	14,447	--	14,447	2,813
Aluminum bronze	--	18	18	--	18	--
Total	47,175	675,472	659,501	15,971	675,472	48,907
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy	2,638	28,239	9,368	19,658	29,026	1,851
No. 2 wire, mixed heavy and light	464	4,501	1,537	2,843	4,380	585
Composition or soft red brass	621	10,559	6,003	4,741	10,744	436
Railroad-car boxes	745	5,548	--	4,786	4,786	1,507
Yellow brass	550	10,971	5,869	5,005	10,874	647
Automobile radiators (unsweated)	1,085	5,445	889	4,673	5,562	968
Bronze	854	924	314	613	927	851
Nickel silver and cupronickel	23	160	2	154	156	27
Low brass	56	1,384	692	698	1,390	50
Aluminum bronze	105	759	21	741	762	102
Low-grade scrap and residues	--	3	--	3	3	--
Total	7,141	68,493	[2]24,695	[2]43,915	68,610	7,024
GRAND TOTAL						
No. 1 wire and heavy	14,676	269,877	197,555	72,673	270,228	13,173
No. 2 wire, mixed heavy and light	25,301	363,562	126,016	241,420	367,436	21,498
Composition or soft red brass	3,263	58,711	17,507	41,481	58,988	2,987
Railroad-car boxes	854	6,172	--	5,508	5,508	1,517
Yellow brass	20,428	371,394	331,576	38,097	369,673	24,682
Cartridge cases	9,158	70,785	70,547	234	70,781	9,815
Automobile radiators (unsweated)	4,629	75,766	2,909	72,531	75,440	4,955
Bronze	3,568	24,902	7,326	17,267	24,593	3,946
Nickel silver and cupronickel	5,084	21,682	19,908	1,903	21,811	4,741
Low brass	3,450	17,883	15,823	1,669	17,492	3,610
Aluminum bronze	199	940	182	790	972	169
Low-grade scrap and residues[3]	34,352	142,510	71,797	78,738	150,535	26,325
Total	124,962	1,424,184	861,146	572,311	1,433,457	117,418

[1]Brass-mill stocks include home scrap; purchased scrap consumption is assumed equal to receipts, so lines in "GRAND TOTAL" section do not balance.
[2]Of the totals shown, chemical plants reported 360 tons of new unalloyed copper scrap and 738 tons of old unalloyed copper scrap.
[3]Includes refinery brass.

Table 27.—Consumption of copper and brass materials in the United States, by item

(Metric tons)

Item	Primary producers	Brass mills	Wire rod mills	Foundries, chemical plants, miscellaneous users	Secondary smelters	Total
1983:						
Copper scrap	r313,290	624,466	--	r61,491	r380,392	r1,379,639
Refined copper[1]	--	500,263	r1,269,859	r30,658	3,151	r1,803,931
Brass ingot	--	14,759	--	r 2132,812	--	r147,571
Slab zinc	--	99,664	--	4,327	3,944	107,935
Miscellaneous	--	--	--	--	4,980	4,980
1984:						
Copper scrap	242,367	675,472	--	68,610	447,008	1,433,457
Refined copper[1]	--	578,138	1,416,325	34,817	6,922	2,036,202
Brass ingot	--	16,553	--	2135,056	--	151,609
Slab zinc	--	115,970	--	5,035	4,589	125,594
Miscellaneous	--	--	--	--	5,127	5,127

rRevised.
[1]Detailed information on consumption of refined copper can be found in table 30.
[2]Shipments to foundries by smelters and changes in stocks at foundries.

Table 28.—Foundry consumption of brass ingot in the United States, by type

(Metric tons)

Type	1980	1981	1982	1983	1984
Tin bronzes	30,327	28,885	24,577	r24,448	24,529
Leaded red brass and semired brass	95,138	94,142	75,402	r80,741	85,086
Yellow brass	17,780	19,659	12,584	r11,155	10,950
Manganese bronze	6,287	6,270	5,220	5,423	4,901
Hardeners and master alloys	5,446	4,411	2,499	r2,511	2,432
Nickel silver	2,579	2,030	1,619	r1,612	1,458
Aluminum bronze	6,727	6,853	5,038	5,675	5,700
Total	164,284	162,250	126,939	r131,565	135,056

rRevised.

Table 29.—Foundries and miscellaneous manufacturers consumption of brass ingot and refined copper and copper scrap in the United States in 1984, 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
New England:										
Connecticut	427	1,248	282	78			359	2,491	101	523
Maine, New Hampshire, Rhode Island, Vermont	111	1,884	109	105	16	352	88	5,177	596	331
Massachusetts	506	1,915	16	172						
Total	1,044	5,047	407	355	16	352	447	7,668	697	854
Middle Atlantic:										
New Jersey	230	950	33	62			125	1,413	2,886	6,863
New York	433	5,478	252	123	344	333	23	6,354		
Pennsylvania	6,257	5,300	573	500			1,298	14,547	4,369	6,410
Total	6,920	11,728	858	685	344	333	1,446	22,314	7,255	13,273
East North Central:										
Illinois		9,216	16	379			1,200	11,466	166	
					1,261	135				10,016
Indiana	2,875	9,826	609	157			35	12,344	397	
Michigan		3,434	281	850			317	6,781	7,832	5,518
Ohio	7,577	7,808	153	261	517	110	318	15,179	7,567	7,752
Wisconsin		6,456	1,999	449			61	10,530		2,492
Total	10,452	36,740	3,058	2,096	1,778	245	1,931	56,300	15,962	25,778
West North Central:										
Iowa, Kansas, Minnesota	143	4,097	75	552			145	5,136		
					80	81			2,356	4,238
Missouri, Nebraska, South Dakota	78	1,371	175	250			347	2,258		
Total	221	5,468	250	802	80	81	492	7,394	2,356	4,238

Table 29.—Foundries and miscellaneous manufacturers consumption of brass ingot and refined copper and copper scrap in the United States in 1984, by geographic division and State —Continued

(Metric tons)

Geographic division and State	Tin bronzes	Leaded red brass and semi-red brass	Yellow brass	Manganese bronze	Hardeners and master alloys	Nickel silver	Aluminum bronze	Total brass ingot	Refined copper consumed	Copper scrap consumed
South Atlantic:										
Delaware, District of Columbia, Florida, Georgia, Maryland	271	390		43			35	1,025		
North Carolina, South Carolina, Virginia, West Virginia	63	10,192	317	55	--	309	107	10,757	492	5,793
Total	334	10,582	317	98	--	309	142	11,782	492	5,793
East South Central:										
Alabama, Kentucky, Mississippi, Tennessee	1,005	3,865	1	306				5,437		5,231
West South Central:										
Arkansas, Louisiana, Oklahoma, Texas	2,791	8,665	228	58	130	115	1,022	12,738	6,769	213
Mountain:										
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	311	410	76	7			10	825		430
Total	4,107	12,940	305	371	130	115	1,032	19,000	6,769	5,874
Pacific:										
California	1,390	7,330	950	494	82	22	204	10,319	726	11,294
Oregon and Washington	66	60						279		408
Total	1,456	7,390	950	494	82	22	204	10,598	726	11,702
Grand total	24,534	89,895	6,145	4,901	2,430	1,457	5,694	135,056	34,257	67,512

Table 30.—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
1983:							
Wire rod mills	1,205,290	r63,192	W	W	--	1,377	r1,269,859
Brass mills	232,044	12,007	43,609	114,102	98,501	--	500,263
Chemical plants	W	--	--	--	--	608	608
Secondary smelters	1,030	--	2,117	--	--	4	3,151
Foundries	955	2,173	3,860	--	3,336	r930	r11,254
Miscellaneous[1]	8,753	W	3,636	1,149	W	r5,258	r18,796
Total	1,448,072	r77,372	53,222	115,251	101,837	r8,177	r1,803,931
1984:							
Wire rod mills	1,359,556	56,246	W	W	--	523	1,416,325
Brass mills	263,600	13,268	58,480	127,448	115,191	151	578,138
Chemical plants	W	--	--	--	--	563	563
Secondary smelters	2,657	--	4,240	--	--	25	6,922
Foundries	762	2,548	8,456	--	3,314	938	16,018
Miscellaneous[1]	8,820	W	3,202	208	W	6,006	18,236
Total	1,635,395	72,062	74,378	127,656	118,505	8,206	2,036,202

rRevised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and other manufacturers.

Table 31.—Stocks of copper in the United States, December 31

(Metric tons)

Year	Blister and materials in process of refining[1]	Refined copper					
		Primary producers	Wire rod mills	Brass mills	Other[2]	New York Commodity Exchange	Total
1980	272,000	49,000	50,000	22,000	10,000	163,000	294,000
1981	277,000	151,000	109,000	26,000	9,000	170,000	465,000
1982	233,000	268,000	125,000	25,000	9,000	249,000	676,000
1983	174,000	154,000	116,000	26,000	5,000	371,000	672,000
1984	232,000	122,000	129,000	27,000	7,000	251,000	536,000

[1]Includes copper in transit from smelters in the United States to refineries therein.
[2]Includes secondary smelters, chemical plants, foundries, and miscellaneous plants.

Table 32.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1983,[1] by grade

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 heavy copper scrap	42.55	46.71	51.50	51.50	53.74	54.50
No. 1 composition scrap (red brass)	42.12	42.92	46.50	46.50	48.26	49.50
No. 115 brass ingot (85-5-5-5)	80.15	82.51	84.00	85.52	86.00	88.00

Grade	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 heavy copper scrap	54.50	53.54	51.74	48.12	43.30	42.50	49.52
No. 1 composition scrap (red brass)	49.50	48.54	47.12	45.31	43.55	43.50	46.11
No. 115 brass ingot (85-5-5-5)	88.00	88.00	87.95	85.52	84.00	84.00	85.30

[1]Data not available for 1984.

Source: Metal Statistics, 1984.

Table 33.—Average monthly prices for electrolytic copper in the United States and on the London Metal Exchange

(Cents per pound)

Month	1983				1984			
	Domestic delivered		London spot[1]		Domestic delivered		London spot[1]	
	Cathode	Wirebar	Cathode	Wirebar	Cathode	Wirebar	Cathode	Wirebar
January	77.54	80.22	68.86	71.28	66.10	68.79	61.65	62.38
February	81.05	84.02	73.09	74.70	68.35	70.75	64.09	64.84
March	79.24	82.07	71.13	72.44	72.71	75.31	67.43	67.77
April	80.85	83.49	74.58	75.95	74.67	77.39	69.36	69.49
May	82.93	85.63	77.50	80.07	69.55	72.23	64.49	64.43
June	79.16	81.84	74.87	77.14	67.29	69.85	68.10	61.91
July	80.19	82.95	74.61	77.29	64.40	64.40	60.64	60.35
August	77.94	80.54	72.14	74.36	64.54	64.54	61.14	60.65
September	74.38	77.59	68.77	70.77	63.41	63.41	58.94	58.66
October	69.70	72.39	63.58	65.08	62.04	62.04	57.87	57.73
November	71.57	74.23	61.88	62.99	65.65	65.65	61.43	60.99
December	68.14	70.81	63.06	64.18	63.54	63.54	60.30	59.91
Average	76.53	79.26	70.29	72.13	66.85	68.16	62.95	62.43

[1]Based on average monthly rates of exchange.

Source: Metals Week.

Table 34.—Average weighted prices of copper delivered

(Cents per pound)

Year	Domestic copper[r 1]	Foreign copper
1980	101.3	99.3
1981	84.2	[2]79.4
1982	72.8	67.1
1983	76.5	72.1
1984	66.8	62.4

[r]Revised.
[1]Producers cathode, delivered.
[2]Based on Jan.-Nov. monthly averages; wirebar contract replaced by high-grade contract in Nov. 1981.

Source: Metals Week.

Table 35.—U.S. exports of copper, by country

Country	Ore and concentrate (copper content)		Ash 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)
1983	42,738	$48,060	6,934	$11,616	81,397	$132,653	47,986	$66,929	7,454	$8,083
1984:										
Belgium-Luxembourg	193	274	2,402	3,907	12	18	2,005	5,174	711	1,620
Canada	79	78	1,066	2,536	2,931	4,659	11,249	14,630	391	729
China	--	--	--	--	50	76	--	--	--	--
France	--	--	--	--	793	1,461	52	76	--	--
Germany, Federal Republic of	1,536	898	350	3,336	1,247	2,038	2,968	2,488	233	1,541
Greece	--	--	--	--	--	--	--	--	--	--
Hong Kong	--	--	--	--	151	279	405	570	194	414
India	--	--	462	571	27	27	--	--	--	--
Israel	2	2	--	--	10	22	1,168	1,167	--	--
Japan	56,249	63,685	127	554	71,181	107,389	15,311	18,285	17	8
Korea, Republic of	2,898	4,090	2	1	1,543	2,376	13,278	15,678	5,878	4,811
Mexico	--	--	17	46	2,803	4,165	13,533	17,683	42	56
Netherlands	10	15	2	3	6,439	9,850	984	921	251	329
Oceania	--	--	--	--	--	--	--	--	--	--
Spain	--	--	250	110	115	209	1,867	1,927	--	--
Sweden	--	--	21	12	9	15	441	559	--	--
Taiwan	--	--	--	--	3,151	4,607	15,813	14,090	76	162
Turkey	--	--	--	--	--	--	--	--	--	--
United Kingdom	--	--	--	654	725	1,213	517	1,770	--	--
Other	32	43	451	181	227	430	1,219	1,248	586	892
Total	60,999	69,085	5,150	11,911	91,414	138,834	80,810	96,266	8,379	10,562

See footnotes at end of table.

Table 35.—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[2]	
	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)
1983	3,621	$11,827	1,370	$3,413	8,313	$30,395	62,963	$354,307	r11,281	r$30,893
1984:										
Belgium-Luxembourg	--	--	--	194	6	51	121	4,625	1	13
Canada	1,463	4,062	2,933	6,140	1,394	4,625	7,200	28,275	2,114	4,749
China	--	--	--	--	--	--	111	960	--	1
El Salvador	6	12	--	--	61	191	8	83	--	2
France	1	5	1	8	4	201	289	8,961	26	147
Germany, Federal Republic of	14	98	12	63	10	167	500	8,948	19	303
Greece	--	--	--	--	--	--	2	58	--	13
Haiti	13	16	--	--	168	634	240	1,046	35	123
Hong Kong	--	--	8	47	10	61	185	1,548	77	574
India	--	--	1	5	10	74	182	3,500	157	629
Israel	64	180	378	998	11	111	137	1,510	77	376
Italy	34	349	--	--	20	95	44	830	12	174
Japan	38	262	209	292	5	44	269	7,938	51	424
Korea, Republic of	12	23	82	844	39	94	236	2,532	30	121
Kuwait	285	745	--	--	--	--	10	89	3	10
Mexico	171	276	930	1,434	4,951	13,046	13,241	44,448	5,347	8,782
Netherlands	172	539	--	--	1	6	182	3,644	41	218
Oceania	20	126	--	--	66	288	--	--	290	1,031
Saudi Arabia	856	2,500	7	22	76	231	607	4,165	118	918
Singapore	18	48	2	9	17	111	511	6,171	58	256
South Africa, Republic of	76	229	--	--	35	100	491	4,456	390	640
Spain	119	332	2	6	6	58	21	393	4	37
Sweden	--	--	--	--	--	--	18	965	6	55
Taiwan	53	544	12	69	17	146	199	2,613	175	1,291
Turkey	--	--	--	--	--	--	53	383	--	3
U.S.S.R.	--	--	--	--	--	--	27	113	--	--
United Kingdom	362	1,101	4	24	61	578	777	11,410	54	551
Venezuela	68	329	16	65	9	46	220	1,178	3,567	5,530
Other	459	1,765	50	167	402	1,065	2,260	16,372	1,165	3,467
Total	4,304	13,541	4,647	10,387	7,379	22,023	28,141	167,214	13,817	30,438

rRevised.
[1]Includes matte.
[2]Excludes copper wire cloth.

Table 36.—U.S. exports of copper scrap, by country

Country	Unalloyed copper scrap				Copper-alloy scrap			
	1983		1984		1983[r]		1984	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium-Luxembourg	2,429	$8,587	2,005	$5,174	4,758	$8,715	3,112	$7,027
Canada	13,373	15,563	11,249	14,630	17,758	21,691	30,895	37,715
France	18	12	52	76	275	1,204	205	523
Germany, Federal Republic of	686	744	2,968	2,488	2,701	3,093	3,732	3,496
Hong Kong	72	113	405	570	356	374	239	268
India	2,326	2,377	--	--	3,915	4,270	8,278	8,476
Italy	--	--	762	766	6	15	2,449	2,400
Japan	3,467	3,924	15,311	18,285	16,119	19,368	28,072	31,652
Korea, Republic of	14,831	21,389	13,278	15,678	8,618	10,681	7,614	8,735
Mexico	8,502	11,546	13,533	17,683	5,477	6,064	2,416	2,013
Netherlands	155	174	984	921	1,961	1,188	603	717
Spain	362	338	1,867	1,927	446	549	1,263	1,250
Sweden	56	91	441	559	5,351	6,717	2,556	3,414
Switzerland	--	--	--	--	448	620	471	307
Taiwan	1,216	1,032	15,813	14,090	12,153	8,200	14,642	13,959
United Kingdom	440	961	517	1,770	469	1,608	594	1,732
Other	53	78	1,625	1,649	237	631	1,190	1,263
Total	47,986	66,929	80,810	96,266	81,048	94,988	108,331	124,947

[r]Revised.

Table 37.—U.S. imports for consumption of unmanufactured copper (copper content), by country

Country	Ore and concentrate		Matte		Blister		Refined		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)
1983	90,597	$81,695	r3,286	r$4,318	46,371	$66,027	459,568	$700,564	r23,086	r$32,183	r622,908	r$884,787
1984:												
Australia	858	485	--	--	--	--	2,966	4,317	--	--	3,824	4,802
Belgium-Luxembourg	--	--	--	--	15	27	12,118	17,664	--	--	12,133	17,691
Canada	747	436	1,873	2,185	4	19	158,876	222,127	16,080	21,461	177,580	246,228
Chile	2,289	1,765	68	76	20,201	24,338	124,819	168,999	2,067	3,065	149,444	198,243
Honduras	175	209	--	--	--	--	--	--	10	8	185	217
Japan	198	127	--	--	--	--	3,776	5,467	--	--	3,974	5,594
Korea, Republic of	--	--	--	--	--	--	--	--	246	332	246	332
Kuwait	--	--	--	--	--	--	--	--	41	65	41	65
Mexico	123	139	104	220	6,367	8,469	--	--	2,934	2,483	9,528	11,311
Norway	--	--	--	--	--	--	1,777	3,338	1	(1)	1,778	3,338
Peru	940	851	30	76	12,132	19,538	49,892	70,154	33	77	63,027	90,696
Philippines	5,726	5,851	--	--	--	--	952	1,325	48	56	6,726	7,232
South Africa, Republic of	--	--	--	--	--	--	503	471	--	--	503	471
United Kingdom	--	--	--	--	1	13	37	58	613	242	651	313
Zaire	--	--	--	--	--	--	28,039	39,226	--	--	28,039	39,226
Zambia	--	--	--	--	--	--	59,514	85,427	--	--	59,514	85,427
Other	--	--	19	29	229	546	1,430	2,101	932	1,136	2,610	3,812
Total	11,056	9,863	2,094	2,586	38,949	52,950	444,699	620,674	23,005	28,925	519,803	714,998

rRevised.

[1]Less than 1/2 unit.

Table 38.—Copper: World mine production,[1] by country

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Albania[e]	15.3	15.5	16.2	16.5	17.0
Algeria	.2	.2	.1	.1	[2].1
Argentina	.2	.1	(3)	.5	.5
Australia	243.5	231.3	245.3	261.5	236.3
Bolivia	1.9	2.6	2.3	2.0	1.8
Botswana[4]	15.6	17.8	18.4	20.3	21.0
Brazil	1.4	[r]11.8	24.4	40.0	35.0
Bulgaria	62.0	62.0	70.0	80.0	80.0
Burma	[r](3 4)	[r](3 4)	(3 4)	4.2	12.0
Canada[5]	716.4	691.3	612.4	653.0	712.4
Chile[6]	1,067.9	1,081.1	1,242.2	1,257.1	[2]1,290.0
China[e]	[r]165.0	[r]170.0	[r]175.0	[r]175.0	180.0
Colombia[7]	.4	.3	.3	.5	.5
Congo (Brazzaville)	1.3	.2	.1	.1	(3)
Cuba	3.3	2.9	2.6	2.7	2.7
Cyprus[8]	--	--	.8	1.2	(3)
Czechoslovakia[e]	6.6	5.2	5.2	5.2	5.2
Ecuador	.9	.8	.1	.2	.2
Finland	[r]36.8	[r]38.2	37.8	39.3	35.0
France	.1	.1	.2	.2	.2
German Democratic Republic[e]	11.8	12.0	13.0	12.0	12.0
Germany, Federal Republic of[5]	1.3	1.4	1.3	1.2	1.0
Greece	.1	.1	--	--	--
Guatemala	.8	.7	[e].7	[e].7	.7
Honduras	.3	.5	.5	.6	.7
India	27.6	25.2	[e]24.0	37.8	44.1
Indonesia	59.0	62.5	77.9	81.6	[2]82.5
Iran[9]	1.0	2.0	43.0	48.5	160.0
Ireland	4.2	3.5	1.6	(10)	--
Israel	.4	4.4	4.1	4.8	3.5
Italy	.6	.8	.8	.1	--
Japan	52.6	51.5	50.7	46.0	[2]43.3
Korea, North[e]	15.0	15.0	15.0	15.0	15.0
Korea, Republic of	.4	.5	[e].3	.4	.4
Malaysia	27.0	28.6	31.5	29.0	29.0
Mexico[11]	184.1	232.9	229.2	196.0	180.0
Mongolia[e]	44.0	71.8	90.0	104.0	118.0
Morocco	7.2	6.9	21.0	23.0	[2]22.1
Mozambique[e]	.2	.2	.2	.2	.2
Namibia	39.2	46.1	49.8	50.4	44.8
Nepal	--	(3)	(3)	(3)	(3)
Norway[8]	28.9	28.2	27.4	26.2	24.3
Papua New Guinea	146.8	165.4	170.0	201.9	[2]164.5
Peru[6]	366.8	342.1	356.6	322.2	364.1
Philippines	304.5	302.3	292.1	273.3	[2]226.1
Poland	346.1	[r]315.2	338.0	349.0	360.0
Portugal[6]	[r]5.2	[r]4.8	.5	.4	.4
Romania[e 5]	28.0	27.0	26.0	27.0	25.0
South Africa, Republic of[6]	200.7	208.7	188.7	205.0	198.2
Spain	42.5	50.9	47.6	49.9	50.0
Sweden	42.8	[r]51.5	54.9	64.5	69.0
Taiwan	1.9	[e].5	--	--	.5
Turkey[12]	26.4	31.9	34.4	25.0	32.1
U.S.S.R.[e 5]	[r]590.0	[r]570.0	[r]560.0	[r]570.0	590.0
United Kingdom	.2	.7	.6	.6	.7
United States:[5]					
By concentration or leaching	1,063.5	1,377.1	1,015.1	936.2	[2]981.2
Leaching (electrowon)	117.6	161.1	131.9	101.9	[2]110.1
Yugoslavia[12]	114.8	110.9	119.3	129.5	150.0
Zaire	539.5	555.1	519.0	535.0	540.0
Zambia:[13]					
By concentration or leaching	471.0	465.8	436.9	455.6	[2]406.6
Leaching (electrowon)	124.8	122.2	130.9	118.9	[2]134.4
Zimbabwe	26.9	24.6	24.7	21.6	23.6
Total	[r]7,404.5	[r]7,814.0	7,582.6	7,624.6	7,838.0

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

[1]Data represent copper content by analysis of concentrates produced except where otherwise noted. Table includes data available through June 25, 1985.

[2]Reported figure.

[3]Less than 1/2 unit.

[4]Copper content of matte produced.

[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]Series for Colombia revised according to published data of Government for output of copper concentrate.

[8]Includes copper content of cupriferous pyrite.

[9]Data are for years beginning Mar. 21 of that stated.

[10]Revised to zero.

[11]Series revised to show actual mine output reported by Mexico for each State and municipality.

[12]Copper content by analysis of ore mined.

[13]Data are for fiscal years ending Mar. 31 of year stated.

Table 39.—Copper: World smelter production,[1] by country

(Thousand metric tons)

Country and metal origin	1980	1981	1982	1983[p]	1984[e]
Albania, primary[e]	9.9	10.0	11.2	11.5	12.0
Argentina, primary	(2)	(2)	(2)	(2)	(2)
Australia:					
Primary	174.9	[r]172.2	175.5	173.6	181.6
Secondary	7.1	5.0	4.8	[e]5.0	5.0
Total	182.0	[r]177.2	180.3	[r e]178.6	186.6
Austria, secondary	26.1	27.1	30.0	30.0	33.0
Belgium:[e]					
Primary	.7	3.1	2.5	[r]2.8	2.7
Secondary	49.3	47.5	47.5	[r]47.5	47.5
Total	50.0	50.6	50.0	[r]50.3	50.2
Brazil, primary	--	--	9.6	[e]10.0	10.0
Bulgaria:[e]					
Primary	61.0	61.0	61.0	61.0	61.0
Secondary	3.0	3.0	3.0	3.0	3.0
Total	64.0	64.0	64.0	64.0	64.0
Canada:					
Primary[e]	473.7	450.1	394.3	499.7	555.5
Secondary[e]	19.0	15.0	10.0	[r]11.0	11.0
Total	492.7	465.1	404.3	510.7	566.5
Chile, primary[3]	953.1	953.8	1,046.8	1,058.1	[4]1,097.8
China, primary[e]	[r]175.0	[r]190.0	[r]205.0	[r]195.0	210.0
Czechoslovakia:[e]					
Primary	7.6	7.4	7.4	7.4	7.4
Secondary	2.4	2.4	2.4	2.4	2.4
Total	10.0	9.8	9.8	9.8	9.8
Finland:					
Primary	47.9	54.7	66.3	70.1	74.3
Secondary	12.0	13.0	19.1	12.6	13.0
Total	[r]59.9	67.7	85.4	82.7	87.3
France, secondary	7.3	6.5	6.0	6.3	6.0
German Democratic Republic, primary[e]	16.0	16.0	17.0	[r]17.0	17.0
Germany, Federal Republic of:					
Primary	153.9	163.1	161.8	159.1	158.0
Secondary	103.9	88.3	78.2	94.5	94.0
Total	257.8	251.4	240.0	253.6	252.0
Hungary, secondary[e]	.1	.1	.1	.1	.1
India, primary	28.5	25.7	32.6	35.5	38.0
Iran, primary[e]	.8	.8	13.5	23.5	14.3
Japan:					
Primary	889.5	930.0	948.2	944.6	826.0
Secondary	39.8	50.1	98.1	117.3	103.0
Total	929.3	980.1	1,046.3	1,061.9	929.0
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	64.1	101.2	119.4	[r e]124.0	105.0
Mexico, primary	[r]87.9	[r]65.3	63.8	59.4	70.4
Namibia, primary	40.0	39.7	49.8	54.2	[4]48.6
Norway, primary (including electrowon)	33.7	32.0	24.4	27.2	40.0
Oman, primary	--	--	--	[e]12.0	15.1
Peru, primary	323.1	279.3	294.4	258.3	[4]298.8
Philippines, primary	--	--	--	38.8	96.0
Poland:					
Primary[e]	346.0	315.0	338.0	[r]349.0	360.0
Secondary[e]	17.0	15.8	[r]13.0	[r]13.0	15.0
Total	363.0	330.8	351.0	362.0	375.0

See footnotes at end of table.

Table 39.—Copper: World smelter production,[1] by country —Continued

(Thousand metric tons)

Country and metal origin	1980	1981	1982	1983[p]	1984[e]
Portugal:					
Primary	2.7	3.1	1.1	r e3.3	3.0
Secondary	.5	.4	.4	r e3.0	3.0
Total	3.2	3.5	1.5	r e6.3	6.0
Romania:					
Primary	40.7	39.4	e35.0	e34.0	32.0
Secondary[e]	4.0	4.0	4.0	5.0	6.0
Total[e]	44.7	43.4	39.0	39.0	38.0
South Africa, Republic of, primary	185.8	185.4	184.7	205.0	200.0
Spain:					
Primary	85.1	87.9	e110.0	r e100.0	105.0
Secondary	18.0	20.0	e25.0	r e18.0	15.0
Total	103.1	107.9	e135.0	r e118.0	120.0
Sweden:					
Primary	45.7	60.6	72.5	78.7	79.8
Secondary	10.7	13.2	17.4	23.1	22.9
Total	56.4	73.8	89.9	101.8	102.7
Taiwan, primary	17.0	53.1	47.3	37.9	48.0
Turkey:					
Primary	15.3	26.7	24.9	e18.2	31.0
Secondary	.6	.6	.4	e.3	.5
Total	15.9	27.3	25.3	18.5	31.5
U.S.S.R.:[r e]					
Primary	665.0	673.0	680.0	700.0	734.0
Secondary	135.0	137.0	138.0	139.0	141.0
Total	800.0	810.0	818.0	839.0	875.0
United States:					
Primary[5]	1,008.4	1,316.8	975.7	927.7	[4]1,014.0
Secondary	44.9	60.9	45.1	59.3	[4]45.8
Total[6]	1,053.3	1,377.6	1,020.8	987.0	[4]1,059.8
Yugoslavia, primary	93.8	92.5	94.0	119.3	120.0
Zaire, primary:					
Electrowon	285.7	301.9	302.4	291.6	290.0
Other	162.1	178.5	171.1	175.0	170.0
Total	447.8	480.4	473.5	466.6	460.0
Zambia, primary	609.9	560.6	584.7	e581.2	525.0
Zimbabwe, primary[e]	26.1	23.0	23.2	19.6	22.0
Grand total[6]	r7,649.3	r8,000.7	7,909.6	8,091.6	8,258.5
Of which:					
Primary	r6,795.8	r7,084.8	6,942.3	7,082.7	7,293.3
Electrowon	285.7	301.9	302.4	291.6	290.0
Secondary	r503.7	r512.9	545.5	593.4	570.2
Undifferentiated	64.1	101.2	119.4	124.0	105.0

[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 June 25, 1985.

[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. Estimates provided in previous editions are not regarded as reliably based.

[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: 1980—107,980; 1981—113,991; 1982—104,791; 1983—89,274; and 1984—80,845.

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

Table 40.—Copper: World refinery production,[1] by country

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Albania, primary[e]	7.7	9.0	9.0	10.0	11.0
Australia:					
Primary	144.8	164.2	160.2	165.5	171.7
Secondary	[r]20.6	[r]15.3	17.9	27.3	35.0
Total[2]	[r]165.5	[r]179.5	178.1	192.8	206.7
Austria:					
Primary	[r]8.9	[r]8.8	8.8	8.8	8.8
Secondary	[r]34.7	[r]30.3	32.8	33.1	35.0
Total[2]	[r]43.5	39.1	41.6	41.9	[3]43.8
Belgium:					
Primary	304.7	[r]370.5	376.8	333.5	357.6
Secondary	69.0	[r]58.0	81.0	71.0	70.0
Total	373.7	[r]428.5	457.8	404.5	[3]427.6
Brazil:					
Primary	--	--	9.6	10.0	11.0
Secondary	63.0	45.0	47.4	39.3	50.3
Total	63.0	45.0	57.0	49.3	[3]61.3
Bulgaria, primary and secondary[e]	63.0	62.0	65.0	[r]62.0	62.0
Canada:					
Primary	[r]505.2	[r]476.7	[r]337.8	464.3	515.0
Secondary[e]	44.0	31.9	16.5	33.0	35.0
Total[e]	[r]549.2	[r]508.6	[r]354.3	497.3	550.0
Chile, primary	810.7	775.6	852.5	833.4	[3]879.2
China, primary and secondary[e]	[r]295.0	[r]295.0	[r]300.0	[r]310.0	310.0
Czechoslovakia, primary and secondary	25.6	[r]25.5	25.6	25.7	25.0
Egypt, secondary	2.0	2.0	2.4	2.4	2.6
Finland:					
Primary[e]	30.5	23.8	38.0	45.4	47.3
Secondary[e]	10.0	10.0	10.0	10.0	10.0
Total	40.5	33.8	48.0	55.4	[3]57.3
France:					
Primary[e]	23.0	23.0	24.0	22.0	20.0
Secondary[e]	23.5	23.0	23.1	21.9	20.9
Total	46.5	46.0	47.1	43.9	[3]40.9
German Democratic Republic, primary and secondary[e]	51.0	[r]54.0	51.0	[r]50.0	50.0
Germany, Federal Republic of:					
Primary	302.5	304.1	313.7	332.4	298.0
Secondary	71.5	83.4	80.4	87.9	83.0
Total[2]	374.0	387.4	394.1	420.3	381.0
Hungary, primary and secondary[e]	12.0	12.0	[3]12.2	[r]12.5	12.8
India:					
Primary (electrolytic cathode)	[r]24.6	[r]24.0	25.6	28.4	32.6
Secondary	[r]1.0	[r]1.2	[e]1.0	[r][e]1.0	1.0
Total	[r]25.6	[r]25.2	26.6	29.4	33.6
Iran, primary[4]	.8	.8	1.0	10.0	90.0
Italy:					
Primary[e]	2.0	1.0	--	--	--
Secondary[e]	10.2	22.7	[2]19.6	20.0	20.0
Total	12.2	23.7	19.6	[e]20.0	20.0

See footnotes at end of table.

Table 40.—Copper: World refinery production,[1] by country —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Japan:					
Primary	889.5	930.0	948.2	944.6	[3]821.1
Secondary	124.8	120.2	126.8	147.4	[3]114.1
Total[2]	1,014.3	1,050.1	1,075.0	1,091.9	[3]935.2
Korea, North, primary and secondary[e]	22.0	22.0	22.0	22.0	22.0
Korea, Republic of:					
Primary	72.9	108.0	110.8	123.3	[3]129.1
Secondary[e]	6.1	5.0	5.0	[r]11.5	7.9
Total[e]	79.0	113.0	115.8	[r]134.8	137.0
Mexico:					
Primary	74.6	61.3	61.4	[r]80.9	80.0
Secondary[e]	11.0	10.0	14.0	15.0	15.0
Total[e]	85.6	71.3	75.4	[r]95.9	95.0
Norway:					
Primary (electrowon)[5]	25.8	26.1	18.0	22.7	[3]30.3
Secondary[e]	6.0	6.0	6.0	6.0	6.0
Total[e]	31.8	32.1	24.0	28.7	36.3
Oman, primary	--	--	--	[e]12.0	[3]15.1
Peru, primary:					
Electrowon	[r]33.8	[r]33.8	33.9	33.0	30.8
Other	195.7	175.6	194.4	158.1	188.6
Total	[r]229.5	[r]209.4	228.3	191.1	219.4
Philippines, primary	--	--	--	38.8	77.0
Poland, primary[6]	357.3	327.2	348.0	360.0	[3]372.3
Portugal, primary	4.5	[r]4.8	4.6	[e]4.6	4.6
Romania:[r e]					
Primary	40.7	39.4	38.0	35.0	33.0
Secondary	24.3	20.6	12.0	12.0	12.0
Total	65.0	60.0	50.0	47.0	45.0
South Africa, Republic of, primary[7]	140.9	144.1	142.8	138.7	[3]155.7
Spain:					
Primary[e]	138.7	137.1	151.3	[e]143.6	135.0
Secondary[e]	[r]15.0	15.0	20.6	[r]15.0	15.0
Total	[r]153.7	152.1	171.9	[e]158.6	150.0
Sweden:					
Primary	43.2	50.1	[e]50.3	[r e]51.4	51.9
Secondary	12.5	11.8	[e]12.0	[e]12.0	12.0
Total	55.7	61.9	62.3	[r]63.4	[3]63.9
Taiwan:					
Primary[e]	11.5	45.2	39.4	30.0	40.4
Secondary[e]	8.0	8.0	8.0	8.0	8.0
Total	19.5	53.2	47.4	38.0	[3]48.4
Turkey, primary	[r]15.6	24.2	32.2	30.0	32.0
U.S.S.R.:[r e]					
Primary	720.0	730.0	759.0	776.0	798.0
Secondary	135.0	137.0	138.0	139.0	141.0
Total	855.0	867.0	897.0	915.0	939.0
United Kingdom:					
Primary	68.3	59.8	63.2	[e]67.5	69.5
Secondary	93.0	76.3	71.0	[e]76.8	67.4
Total[2]	161.3	[r]136.2	134.2	[e]144.3	136.9

See footnotes at end of table.

Table 40.—Copper: World refinery production,[1] by country —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
United States:					
Primary:					
Electrowon	117.6	161.1	131.9	101.9	[3]110.1
Other	1,097.6	1,382.9	1,094.9	1,080.2	[3]1,090.0
Secondary	515.1	493.6	467.5	401.7	[3]309.5
Total	1,730.3	2,037.6	1,694.3	1,583.8	[3]1,509.6
Yugoslavia:					
Primary	91.8	90.7	82.5	[e]91.0	94.6
Secondary	39.5	41.9	44.4	[e]32.7	33.0
Total	131.3	132.6	126.9	123.7	[3]127.6
Zaire, primary	144.0	151.3	175.0	226.7	[3]224.5
Zambia, primary:					
Electrowon	124.8	122.2	130.9	119.0	[3]134.4
Other	482.8	438.2	453.7	456.4	387.5
Total	607.6	560.4	584.6	575.4	[3]521.9
Zimbabwe, primary	3.1	8.0	23.0	21.6	21.6
Grand total[2]	[r]8,868.5	[r]9,171.2	8,977.6	9,116.7	9,154.6
Of which:					
Primary	[r]7,060.1	[r]7,432.6	7,244.4	7,410.7	7,569.3
Secondary	[r]1,339.8	[r]1,268.2	1,257.4	1,224.0	1,103.7
Primary and secondary, undifferentiated	[r]468.6	[r]470.5	475.8	482.2	481.8

[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 June 25, 1985.

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

[3]Reported figure.

[4]Data are for years beginning Mar. 21 of that stated.

[5]Includes electrowon cathode produced from imported matte.

[6]May include small quantities of secondary.

[7]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 1984, all in four Western States, was 627,000 short tons, a slight increase over that of 1983. California continued to be the leading producing State.

Exports of diatomite decreased 13% to 127,000 tons and comprised 20% of domestic production, compared with 24% in 1983.

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)

	1980	1981	1982	1983	1984
Domestic production (sales)	689	687	613	619	627
Total value of sales	$100,610	$113,010	$107,619	$114,279	$120,926

DOMESTIC PRODUCTION

Domestic production of diatomite was 627,000 tons valued at $121 million compared with 619,000 tons valued at $114 million in 1983. Seven companies processed diatomite in nine plants in four States. California continued to be the leading producing State, followed by Nevada, Washington, and Oregon.

The major diatomite producers were 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 Chemical Corp., Inorganic Specialities Div., at Quincy, WA. Other producers were Lassenite Industries Inc. in Herlong, CA; Cyprus Diatomite Co. in Fernley, NV; and Oil-Dri Production Co. in Christmas Valley, OR.

American Resources Equity Corp., Denver, CO, mined diatomite in Shasta County, CA, and shipped unprocessed material instate for use as a silica source in making cement.

Eagle-Picher announced plans in early 1984 to construct a processing plant near Vale, Malheur County, OR. The plant, when completed, was to be supplied from diatomite deposits in Malheur and Harney Counties.

CONSUMPTION AND USES

Apparent domestic consumption of processed diatomite increased 6% to 500,000 tons. Domestic and export sales of filter-grade diatomite were up slightly to 418,000 tons, while sales of filler-grade diatomite also increased slightly to 137,000 tons. Diatomite used as absorbents and additives increased 12% to 66,000 tons. Insulation use decreased 67% during the year to 6,500 tons.

Table 2.—Diatomite sold or used,[1] by principal use

(Percent of U.S. production)

Use	1980	1981	1982	1983	1984
Filtration	66	64	68	66	67
Fillers	21	23	19	21	22
Insulation	3	2	1	3	1
Other[2]	10	11	12	10	10

[1]Includes exports.
[2]Includes abrasives (1980-82), absorbents, and additives.

PRICES

The average unit value of sales for processed diatomite increased $8 per ton to $193.

Table 3.—Average annual value per ton[1] of diatomite, by use

Use	1982	1983	1984
Fillers	$160.72	$176.77	$175.10
Filtration	191.85	200.16	210.60
Insulation	121.61	119.26	136.98
Miscellaneous[2]	111.55	116.05	120.85
Weighted average	175.63	184.58	192.62

[1]Based on unrounded data.
[2]Includes abrasives (1982), absorbents, catalysts (1982), lightweight aggregates (1982), and silicate admixtures (1983-84).

FOREIGN TRADE

U.S. exports of processed diatomite decreased 13% from that of 1983. Average unit value of exports increased from $216 per ton to $232 per ton. Diatomite was exported to 80 countries and represented 20% of domestic production. The following five countries received 60% of the total: Canada, 29,400 tons; Japan, 17,300 tons; Australia, 13,400 tons; the United Kingdom, 8,400 tons; and the Federal Republic of Germany, 7,800 tons.

Imports of diatomite totaled 338 tons valued at $105,000, with Mexico supplying 75% of the total.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value[1]
1981	162	32,933
1982	141	29,863
1983	146	31,569
1984	127	29,461

[1]U.S. Customs.

WORLD REVIEW

World production of diatomite remained at near an estimated 1.7 million tons. The United States produced 38% of the world output, followed by the U.S.S.R. with 16% and France with 14%.

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[1]Industry economist, Division of Industrial Minerals.

Table 5.—Diatomite: World production, by country[1]

(Thousand short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Algeria[e]	5	5	5	5	5
Argentina	7	5	7	12	11
Australia	3	[r]2	2	[r e]9	9
Brazil (marketable)	16	10	14	[e]18	18
Canada	[2]4	4	2	2	2
Chile	1	(3)	(3)	1	1
Colombia[e]	1	1	1	1	1
Costa Rica	1	1	1	[e]1	1
Denmark:					
Diatomite	[e]28	[r]4	--	--	--
Moler[e]	138	138	138	[r]151	143
Egypt	--	--	--	(3)	(3)
France[e]	240	230	[2]269	[r]244	240
Germany, Federal Republic of	58	47	47	49	49
Iceland	20	22	28	28	28
Italy[e]	33	28	22	28	26
Kenya	(3)	(3)	2	2	2
Korea, Republic of	28	46	61	62	60
Mexico	62	62	62	48	50
Peru[e]	8	8	8	8	8
Portugal	3	3	[e]3	2	2
Romania[e]	45	45	45	45	45
South Africa, Republic of	1	1	1	1	(3)
Spain	26	42	70	61	60
Thailand	2	(3)	(3)	(3)	(3)
Turkey[e]	10	11	11	[2]11	10
U.S.S.R.[e]	250	250	260	260	265
United Kingdom[e]	1	1	1	[r](3)	1
United States	689	687	613	619	[2]627
Total	[r]1,680	[r]1,653	1,673	1,668	1,664

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 16, 1985.
[2]Reported figure.
[3]Less than 1/2 unit.

Feldspar, Nepheline Syenite, and Aplite

By Michael J. Potter[1]

Total U.S. feldspar output in 1984, including soda, potash, mixed, and feldspar-silica mixtures, was 710,000 short tons with a value of $23.5 million. The tonnage of feldspar used in glass decreased compared with that of 1983, while the tonnage used in ceramic articles, such as in housing construction, increased slightly. Imports of crude and ground nepheline syenite decreased 7% to about 378,000 tons with total value remaining about the same.

Domestic Data Coverage.—Domestic production data for feldspar are developed by the Bureau of Mines by means of a voluntary survey. Of the 16 active mines, 14, or 88%, responded, representing an estimated 95% of the total production data for feldspar shown in table 1. The remaining 5% 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 1984, the depletion rate allowed on domestic and foreign feldspar production was 14%.

Table 1.—Salient feldspar and nepheline syenite statistics

	1980	1981	1982	1983	1984
United States:					
Feldspar:					
Produced[1] short tons	710,000	665,000	615,000	710,000	710,000
Value thousands	$23,200	$21,000	$20,300	$22,500	$23,500
Exports short tons	13,000	14,025	10,800	9,360	10,080
Value thousands	$896	$1,110	$989	$856	$920
Imports for consumption short tons	404	206	48	64	25
Value thousands	$133	$61	$24	$31	$15
Nepheline syenite:					
Imports for consumption short tons	504,340	506,100	455,596	407,351	377,945
Value thousands	$11,264	$11,529	$13,751	$13,997	$14,218
Consumption, apparent[2] (feldspar plus nepheline syenite) thousand short tons	1,202	1,157	1,060	1,108	1,078
World: Production (feldspar) do	[r]3,530	[r]3,595	3,865	[p]4,082	[e]4,011

[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 more than 8% K_2O are defined as potash feldspars. Hand-cobbed or hand-sorted feldspar is usually obtained from pegmatites and is relatively high in K_2O

compared to 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 the year.

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 72% of the total. Eleven U.S. companies operating 16 mines and 12 plants produced feldspar or feldspar-silica mixtures for shipment to more than 31 States and foreign countries, primarily Canada and Mexico; of these companies, 3 produced potash feldspar, and the remainder produced mixed feldspar or feldspathic sand mixtures. North Carolina had six 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).

The Owens-Illinois Inc. sand operation, near San Juan Capistrano, CA, was purchased by California Silica Products Co., a subsidiary of Oglebay Norton Co.[2]

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
1980	14	229	566	18,240	130	4,780	710	23,200
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

[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 1984

Company	Plant location	Product
Arkhola Sand & Gravel Co	Muskogee, OK	Feldspar-silica mixture.
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.	Kings Mountain, NC	Potash feldspar.
Lithium Corp. of America	Bessemer City, NC	Feldspar-silica mixture.
Owens-Illinois Inc	San Juan Capistrano, CA	Do.
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.

Fifty-five percent of the total feldspar consumed in the United States was used in glassmaking, including container glass and glass fiber; 41% was used in pottery; and the remaining 4% was used in enamels, electrical insulators, etc.

The use of feldspar in ceramic articles such as plumbing fixtures and tile increased by about 5% compared with that of 1983 as a result of continued growth in housing construction.

Areas of glass fiber growth in reinforced plastics included dishes for microwave ovens, receiving dishes for television signals relayed from satellites, automobiles, construction, highway signs, and in hulls of advanced minesweepers.[3]

Table 4.—Destination of shipments of feldspar[1] sold or used by producers in the United States, by State

(Short tons)

State	1980	1981	1982	1983	1984
Alabama	21,100	19,600	16,500	14,600	15,100
California[e 2]	40,000	35,000	30,000	45,000	45,000
Connecticut	18,400	17,800	18,800	W	W
Florida	32,800	25,700	21,000	22,700	20,300
Georgia	64,700	68,300	74,600	96,900	96,000
Illinois	36,600	31,100	26,900	46,600	38,000
Indiana	26,700	22,700	20,200	37,200	35,500
Kentucky	12,800	11,700	13,400	11,400	13,300
Louisiana	14,600	13,900	12,200	17,400	21,300
Maryland	5,100	4,300	4,600	4,500	7,400
Massachusetts	11,100	8,800	9,300	1,200	10,600
Michigan	2,700	W	2,000	W	W
Mississippi	15,600	13,000	15,800	15,900	12,000
Missouri	4,900	4,300	4,100	5,000	4,400
New Jersey	64,600	63,400	51,700	56,600	53,200
New York	23,100	19,400	17,800	18,300	9,000
North Carolina	W	17,000	16,500	20,100	16,400
Ohio	56,400	52,800	51,600	53,600	62,700
Oklahoma	31,000	34,700	31,900	W	W
Pennsylvania	46,200	42,900	28,800	33,200	36,200
South Carolina	15,600	16,400	14,900	18,400	17,400
Tennessee	18,300	16,100	15,300	W	W
Texas	35,000	39,400	36,700	41,900	41,300
West Virginia	55,400	36,100	31,600	38,100	27,400
Wisconsin	W	W	W	9,400	11,100
Other destinations[r 3]	57,300	40,600	43,800	102,000	96,400
Total	710,000	655,000	610,000	710,000	690,000

[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	1980	1981	1982	1983	1984
Illinois, Indiana, Wisconsin	13,400	11,300	8,000	6,000	5,600
Maryland, New York, West Virginia	28,200	24,800	21,600	25,300	19,000
Ohio	10,700	9,800	8,100	8,100	6,800
Pennsylvania	8,200	9,100	6,400	7,100	12,500
Texas	400	200	200	300	200
Canada	4,300	4,900	3,200	4,300	3,700
Mexico	1,600	2,800	2,400	W	W
Other[2]	18,200	17,500	16,300	14,100	15,900
Total	85,000	80,400	66,200	65,200	63,700

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	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Hand-cobbed:				
Pottery	(2)	26	6	487
Other	7	427	1	51
Total	7	453	7	538
Flotation concentrate:				
Glass	254	7,393	229	7,063
Pottery	249	10,875	249	11,817
Other	W	W	W	W
Total	W	W	W	W
Feldspar-silica mixtures:[3]				
Glass	157	7,570	153	7,468
Pottery	19	1,399	28	1,367
Other	W	W	W	W
Total	W	W	W	W
Total:[4]				
Glass[5]	410	14,963	382	14,531
Pottery	268	12,300	283	13,671
Other[6]	32	1,683	24	1,398
Total	710	28,946	690	29,600

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes potash feldspar (8% K_2O or higher).
[2]Less than 1/2 unit.
[3]Feldspar content.
[4]Data may not add to totals shown because of independent rounding.
[5]Includes container glass and glass fiber.
[6]Includes enamel, filler, etc., and unknown.

Table 7.—Potash feldspar[1] sold or used by producers in the United States, by use

Use	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Pottery	42,100	$2,935	48,100	$3,508
Other[2]	23,100	1,260	15,600	819
Total	65,200	4,195	63,700	4,327

[1]K_2O content of 8% or higher.
[2]Includes glass, enamel, etc.

PRICES

Engineering and Mining Journal, December 1984, listed the following prices for feldspar, per short ton, f.o.b. mine or mill, carload lots, bulk, depending on grade:

	1983	1984
Connecticut:		
20 mesh, granular	$39.00	$39.00
200 mesh	53.25	53.25
Georgia:		
40 mesh, granular	51.00	54.00
200 mesh	69.25	73.50
North Carolina:		
20 mesh, flotation	29.25	29.25
40 mesh, flotation	51.00	54.00
200 mesh, flotation	$44.00- 70.25	44.00

Source: Engineering and Mining Journal, Dec. 1984, v. 185, No. 12, p. 27.

FOREIGN TRADE

U.S. exports in 1984 classified as feldspar, leucite, and nepheline syenite, but presumably mostly feldspar, increased 8% to 10,080 tons valued at $920,000. Chief recipients were Canada, 60%; Mexico, 12%; the Dominican Republic, 10%; and Taiwan, 6%. The remaining 12% was shared among 15 other countries.

In addition to feldspar and nepheline syenite, the United States imported 1,400 tons of "Other mineral fluxes, crushed" with a value of $474,800 and 98,300 tons of "Other crude natural mineral fluxes" with a value of about $6.6 million.

The tariff schedule in force throughout the year for most favored nations provided for a 3.1% ad valorem duty on ground feldspar; imports of unground feldspar were admitted duty free.

Table 8.—U.S. exports of feldspar, by country

Country	1983		1984	
	Short tons	Value	Short tons	Value
Canada	5,370	$338,900	6,040	$378,100
Dominican Republic	330	113,600	1,020	107,400
Mexico	1,240	78,600	1,180	179,400
Philippines	640	38,400	270	27,100
Taiwan	670	177,900	600	112,000
Venezuela	300	30,800	490	38,300
Other	810	77,600	480	77,400
Total	9,360	855,800	10,080	919,700

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of feldspar, by type and country

Type and country	1983		1984	
	Short tons	Value	Short tons	Value
Crude:				
Germany, Federal Republic of	--	--	1	$361
Japan	3	$578	--	--
Mexico	15	5,650	--	--
United Kingdom	--	--	1	561
Ground, crushed, or pulverized:				
Canada	3	1,320	--	--
France	9	9,839	11	9,800
Germany, Federal Republic of	--	--	2	227
Japan	34	13,406	--	--
United Kingdom	--	--	10	3,595
Total	64	30,793	25	14,544

Source: Bureau of the Census.

WORLD REVIEW

Production and producing companies of feldspathic minerals in Finland, France, the Federal Republic of Germany, Italy, Norway, and Sweden were described as part of a journal article on raw materials for ceramic whiteware.[4]

Canada.—Although Canada is a large producer of aluminum, it has no domestic source of bauxite and must rely on imported bauxite for producing the metal. Anorthosite, a lime-soda feldspar rock, was investigated as an alternative source of alumina for the production of aluminum. If technology for the extraction of alumina from anorthosite should ever prove feasible, the largest deposit, the Lac St. Jean anorthosite in Quebec, is located near the largest Canadian aluminum smelter.[5]

Nigeria.—Feldspar was being supplied to the ceramics and glass industries by Intermediate Technology Industrial Services, which hoped to expand into export markets. The specifications of the feldspar being supplied were K_2O plus Na_2O, 15%; alumina, 18%; silica, 65%; and less than 0.1% iron oxide.[6]

United Kingdom.—Feldspar imports in 1982 were about 92,000 tons. Principal countries of origin were Norway, 46%; Finland, 35%; and Sweden, 16%. In 1983, imports were about 61,000 tons, with principal countries of origin being Norway, 46%; Finland, 30%; and Sweden, 19%.[7]

Yugoslavia.—A processing plant for treating several minerals, including zeolites, quartz, feldspar, and white granite, was to be built at Bujanovac in Serbia. Expected production capacity was 33,000 tons per year.[8]

Table 10.—Feldspar: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina	36	29	17	22	22
Australia	4	4	5	[e]3	4
Austria	12	11	3	1	1
Brazil[3]	[r]136	[r]131	145	[r e]165	165
Burma	2	5	3	3	3
Chile	2	3	1	4	3
Colombia	30	30	33	35	35
Egypt	4	4	9	7	6
Finland	82	70	77	57	61
France	231	211	191	193	193
Germany, Federal Republic of	420	377	365	364	369
Guatemala	24	11	[e]13	[r e]7	7
Hong Kong	18	4	36	62	44
India	65	65	49	46	50
Iran[e]	3	2	3	3	3
Italy	380	472	864	951	959
Japan[4]	33	[r]28	33	34	37
Kenya	([5])	([5])	--	1	1
Korea, Republic of	79	114	94	121	99
Mexico	129	144	127	130	132
Morocco	2	2	1	[e]1	1
Nigeria[e]	6	6	6	6	6
Norway[6]	74	[r e]77	[r e]77	82	77
Pakistan	12	12	10	7	9
Peru	17	24	[e]28	[e]28	28
Philippines	18	[r]18	17	[e]17	17
Poland[e]	44	90	88	88	88
Portugal	[r]45	49	[e]47	[r e]46	44
Romania[e]	[r]66	[r]66	[r]66	[r]66	66
South Africa, Republic of	58	63	53	49	42
Spain[7]	114	143	144	128	127
Sri Lanka	4	[e]4	3	3	3
Sweden	64	44	60	61	61
Taiwan	28	19	12	13	17
Thailand	27	27	21	53	44
Turkey[e]	80	[r]77	[r]77	[8]10	11
U.S.S.R.[e]	340	350	360	360	360
United Kingdom (china stone)[e]	55	55	55	55	55
United States	710	665	615	710	[8]710
Uruguay	3	3	1	[r e]1	1
Venezuela	7	24	8	41	3
Yugoslavia	64	59	47	[e]47	46
Zambia	1	([5])	([5])	([5])	([5])
Zimbabwe	1	3	1	[e]1	1
Total	[r]3,530	[r]3,595	3,865	4,082	4,011

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

[1]Table includes data available through Apr. 30, 1985.

[2]In addition to the countries listed, Czechoslovakia, Romania, Madagascar, Namibia produced 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: 1980—150; 1981—133; 1982—87; 1983—17; and 1984—not available.

[4]In addition, the following quantities of aplite were produced, in thousand short tons: 1980—334; 1981—386; 1982—385; 1983—455; and 1984—466 (estimated).

[5]Less than 1/2 unit.

[6]Described in source as lump feldspar; does not include nepheline syenite.

[7]Includes pegmatite.

[8]Reported figure.

TECHNOLOGY

In its continuing effort to increase efficiency and conserve energy, the glass container industry was moving toward more finely ground feldspar and feldspathic sand, such as minus 30- or minus 40-mesh material.[9]

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.

In Canada, Indusmin Ltd. and International Minerals & Chemical Corp. (Canada) Ltd. continued to mine nepheline syenite from the deposit at Blue Mountain, Ontario. Norway and the U.S.S.R. were the only other known producing countries of significant quantities of nepheline syenite. In the U.S.S.R., nepheline concentrates from the Siberian Kija Shaltyrsk deposit, and as a byproduct from apatite mining in the Kola Peninsula, were used in the production of alumina, portland cement, and alkali carbonates. There was some use of nepheline concentrates in ceramics and colored container glass.[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 1984.

Table 11.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1982	316	$16	455,280	$13,735
1983	212	13	407,139	13,984
1984	410	17	377,535	14,201

Source: Bureau of the Census.

APLITE

Aplite is another rock of granitic texture containing quartz mixed with varying proportions of soda or lime-soda feldspar. Aplite, usually unsuitable for use in ceramics, has been used in the manufacture of glass, especially container glass, when sufficiently low in iron. Japan, with an annual production of approximately 400,000 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 was approximately the same as in 1983. The data are company proprietary and cannot be released for publication. Aplite traditionally has a somewhat lower price than feldspar. Industrial Minerals (London), December 1984, 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]Ceramic Industry. Industry News. V. 123, No. 6, Nov. 1984, p. 9.
[3]Chemical Week. It's an Open Road for Glass Fiber Reinforced Plastics. V. 135, No. 20, Nov. 14, 1985, pp. 11-12.
[4]Robbins, J. Ceramic Whiteware—An Overview of Raw Materials Supply. Ind. Miner. (London), No. 204, Sept. 1984, pp. 55, 59.
[5]Buchanan, R. M. Anorthosite in Canada. Ch. in The Geology of Industrial Minerals in Canada, ed. by G. R. Guillet and W. Martin. Can. Inst. Min. and Metall., Spec. v. 29, 1984, pp. 301-306.
[6]Industrial Minerals (London). Company News & Mineral Notes. No. 198, Mar. 1984, p. 71.
[7]———. United Kingdom Industrial Mineral Statistics. No. 199, Apr. 1984, p. 71.
[8]———. Company News & Mineral Notes. No. 196, Jan. 1984, p. 71.
[9]Kephart, W. W., and F. J. DeNapoli. Raw Materials Specifications to Tighten in the Glass Container Industry. Glass Ind., v. 65, No. 12, Dec. 1984, pp. 13-14.
[10]Ash, D. R. Nepheline Syenite. Min. Eng., v. 36, No. 5, May 1984, p. 525.

Ferroalloys

By Raymond E. Brown[1]

World demand for ferroalloys in 1984 continued to improve, owing to a moderate recovery by the world iron and steel industry, the major consumer of ferroalloys. Consequently, prices for most ferroalloys began to firm. Overcapacity and oversupply continued to be the major problems of world ferroalloy producers. However, the United States and Japan have begun aggressive programs to restructure their ferroalloy industry by cutting back capacity to bring it in line with the realities of the marketplace. Spain completed restructuring its ferroalloy industry in late 1984, resulting in an overall capacity reduction of 50%. U.S. ferroalloy producers continued to find it difficult to compete in the world market, a situation that was exacerbated by the high value of the U.S. dollar in relation to other foreign currencies.

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 52 operations to which a survey was sent, 45 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.—Several significant Government actions relative to ferroalloys occurred. Late in 1984, for the second consecutive year, the General Services Administration (GSA) 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 $26 million contract called for converting 141,601 short tons of chromium ore into about 57,000 tons of high-carbon ferrochromium (H-C FeCr), and Elkem's $18 million contract called for converting 80,039 tons of manganese ore into about 40,000 tons of high-carbon ferromanganese (H-C FeMn) in 1985. The contracts also included an option for the third year of the National Defense Stockpile 10-year upgrading program. The GSA contract is critical to Macalloy's chapter 11 bankruptcy plan. In 1984, the first year of the upgrading program, Macalloy's $23 million contract involved converting 121,753 tons of chromium ore into about 49,000 tons of H-C FeCr, and Elkem's $10 million contract involved converting 48,476 tons of manganese ore into about 24,000 tons of H-C FeMn. GSA also announced that it would purchase 1,000 tons of electrolytic chromium metal for the National Defense Stockpile. Defense contractors are now required to buy high-carbon ferrochromium only from U.S. producers under a new Government procurement policy implemented on February 25.

The U.S. Department of Commerce published the final results of its administrative review under the Tariff Act of 1930, of the countervailing duty order on ferroalloys imported into the United States from Spain during 1982. Commerce instructed the U.S. Customs Service to assess countervailing duties on imports of ferrochromium, ferromanganese, ferrosilicon manganese, and ferrosilicon. On January 24, 1984, the U.S. International Trade Commission (ITC) found that imports of Soviet origin 50% ferrosilicon during the second half of 1983, did not significantly harm the domestic ferroalloy industry. The ITC had been requested by the U.S. Trade Representative to conduct an investigation under section 406 of the Trade Act of 1974 to determine whether the Soviet ferrosilicon imports had caused market disruptions. Commerce released a statement on May 10, announcing that the President had determined that imports of ferroalloys do not threaten the national security.

The Ferroalloys Association petitioned the Government in August 1981 for import relief under the National Security Clause (Sec. 232) of the Trade Act of 1962. Additionally, higher U.S. import duties for seven ferroalloy classes were deleted from the Omnibus Trade Bill on October 5, 1984, by House-Senate conferees. An amendment (No. 4291) to the Senate version of the bill (S. 3398) that would have imposed a minimum "fair price" or "breakpoint" was struck out.

The U.S. Department of Defense (DOD) plans to use some 1985 Defense Production Act title III funds to support the domestic production capability of high-purity silicon. DOD presently purchases high-purity silicon from a West German producer. There is reportedly no domestic capacity for producing high-purity silicon for military applications. The decision reflects a new approach by DOD on use of title III funds. In its first allocation of such funding since the 1950's, DOD is also planning to guarantee purchase levels of several other materials and products considered critical to domestic defense, rather than follow its previous policy of creating domestic capacity through direct investments in industries.

The National Research Council, National Materials Advisory Board, released a study of 44 nonfuel materials in the National Defense Stockpile. Eight materials, including chromium and low-carbon ferrochromium, were found to be in need of immediate quality assessment because of their critical role in the national defense. The study recommends that a detailed analysis of the entire stockpile should focus on the likelihood of deterioration or contamination, technological changes in specifications, deficiency in analyses, quality data, end-use tests, inability to expeditiously use the material in an emergency, and the costs involved.[2]

The U.S. Office of Technology Assessment (OTA) released a study that called for a concerted effort to reduce U.S. dependence on the Republic of South Africa and the U.S.S.R. for critical and strategic metals. The OTA study concentrated on U.S. dependency on imports of chromium, cobalt, manganese, and platinum-group metals. OTA recommended five areas for Government action.[3]

Table 1.—Government inventory of ferroalloys, December 31, 1984

(Thousand short tons)

Alloy	Stockpile grade	Nonstockpile grade	Total
Ferrochromium:			
High-carbon	[1]402	1	403
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 does not reflect the estimated 49,000 tons of high-carbon ferrochromium produced under the National Defense Stockpile chromium ore conversion program in 1984.

[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.

DOMESTIC PRODUCTION

Domestic production of ferroalloys was up by about one-half overall from that of 1983. Producers of the bulk ferroalloys of chromium, manganese, and silicon, and their respective metals operated their plants at an average rate of about two-fifths of capacity, compared with about three-tenths in 1983. Domestic shipments of silicon materials rose by about three-tenths, while those of chromium materials more than doubled. Domestic shipments of manganese materials were essentially unchanged, compared with those of 1983. The overall increase in both production and shipments of ferroalloys and their respective metals was mainly the result of stronger demand for ferroalloys by the iron and steel industries and for silicon metal by the secondary aluminum and chemical industries.

Domestic data for production and shipments of ferroalloys for 1984 shown in tables 2 and 9 include an estimated 49,000 tons of high-carbon ferrochromium and an estimated 24,000 tons of high-carbon ferromanganese resulting from the GSA stockpile upgrading program. (See section on "Legislation and Government Programs" for details.)

Since January 1, 1980, Alabama Alloys Co. Inc., Autlan Manganese Corp., Chemstone Corp., Chromium Mining & Smelting Corp., The Pesses Co., Roane Ltd., and Satralloy Inc. permanently closed all 10 of their ferroalloy plants, and Union Carbide Corp. permanently closed 2 of its plants, 1 in Sheffield, AL, and the other in Portland, OR. These 12 plants employed an estimated 2,000 workers during peak periods and represent a combined loss of domestic annual capacity of about 490,000 tons. Additionally, Ohio Ferro-Alloys Corp. (OFA) ceased production of ferrosilicon at its Philo, OH, plant in September 1984 and silicon metal production at its Powhatan Point, OH, plant in October. The reasons cited for these actions were imports and higher domestic energy and labor costs. OFA continued to produce silicon metal at its third plant in Montgomery, AL.

Norway's Elkem A/S, one of the world's largest ferroalloy producers, raised its participation in Elkem Metals, Pittsburgh, PA, from 49% to 67%. The Globe Metallurgical Div. of Interlake Inc., a major producer of ferroalloys and silicon metal, was sold for $37 million to Pickands Mather & Co., a subsidiary of Moore McCormack Resources Inc. Pickands Mather had been sales agent for Globe products for nearly 30 years. Effective April 2, Union Carbide's chromium, tungsten, and vanadium businesses in Brazil, the Republic of South Africa, and the United States came under the management of Umetco Minerals Corp., a new wholly owned subsidiary. Additionally, Umetco began marketing a new vanadium oxide product under the trade name Vanox in May. This material was developed at the company's Niagara Falls research facility to compete against imported ferrovanadium. Vanox is currently being used as an addition agent to tool steel.

The Hanna Mining Co. negotiated with the Bonneville Power Administration (BPA) to obtain a low power rate through mid-1990. Without a longer term power contract from BPA, future operations at Hanna's ferronickel plant in Riddle, OR, are uncertain.

Estimated ferrous scrap consumption by the domestic ferroalloys industry was 340,000 tons in 1984, compared with 250,000 tons in 1983 and 230,000 tons in 1982.

The Ferroalloys Association reported that its member companies consumed 5.3 billion kilowatt hours of electricity, up from 4.1 billion in 1983. In addition, its member companies employed 4,000 workers and reported a profit amounting to $1 million before taxes, compared with 3,800 workers and reported losses amounting to $65 million in 1983.

Table 2.—Ferroalloys[1] produced and shipped from furnaces in the United States

	1983				1984			
	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]	85,930	81	108,889	$53,757	[3]171,129	77	[3]185,499	[3]$106,282
Silicomanganese	W	66	63,087	21,211	(4)	66	(4)	(4)
Manganese metal	W	100	W	W	(4)	100	(4)	(4)
Ferrosilicon[5]	r314,112	54	r361,028	r180,301	490,370	55	498,067	259,407
Silicon metal	121,890	r98	r123,072	r113,475	140,866	98	139,393	171,814
Chromium alloys:								
Ferrochromium	19,928	65	39,510	34,802	[6]95,400	62	[6]120,772	[6]102,101
Other alloys[6]	16,471	39	13,696	18,645	(7)	--	(7)	(7)
Total or average	36,399	53	53,206	53,447	95,400	62	120,772	102,101
Ferrocolumbium	W	64	W	W	W	65	W	9,809
Ferrophosphorus	74,992	25	62,077	7,010	91,117	24	113,504	18,123
Other[8]	142,037	XX	97,671	122,139	99,010	XX	96,683	92,959
Grand total	r775,360	XX	r869,030	r551,340	1,087,892	XX	1,153,918	760,495

rRevised. 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).
[3]Includes silicomanganese and manganese metal.
[4]Included with ferromanganese.
[5]Includes miscellaneous silicon alloys.
[6]Includes ferrochromium-silicon, chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.
[7]Included with ferrochromium.
[8]Includes ferroaluminum, ferroboron and other complex boron additive alloys, ferromolybdenum, ferronickel, ferrotitanium, ferrotungsten, ferrovanadium, ferrozirconium, silvery iron, and other miscellaneous alloys.

Table 3.—Producers of ferroalloys in the United States in 1984

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.
AMAX Inc., Climax Molybdenum Co. Div	Langeloth, PA	FeMo	Metallothermic.
Ashland Chemical Co	Columbus, OH	FeB, FeCb, FeMo, FeTi, FeW, NiCb.	Electric and metallothermic.
Cabot Corp., KBI Div., Penn Rare Metal Div	Revere, PA	FeCb	Metallothermic.
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 New Johnsonville, TN.	FeSi, FeV, Mn, silvery pig iron, other[2]	Do.
Hanna Mining Co., The:			
Hanna Nickel Smelting Co	Riddle, OR	FeNi, FeSi	Electric.
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.
A. Johnson & Co. Inc	Lionville, PA	FeAl, FeTi, FeZr	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, SiMn	Electric.
Ohio Ferro-Alloys Corp	Montgomery, AL Philo, OH Powhatan Point, OH	FeSi, Si	Do.
Pennzoil Co., Duval Corp	Sahuarita, AZ	FeMo	Metallothermic.
Reactive Metals & 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, FeMn, FeSi, SiMn.	Electric.
Teledyne Inc., Teledyne Wah Chang, Albany Div.	Albany, OR	FeCb	Metallothermic.
Union Carbide Corp., Metals Div	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			
Electro-Phos Corp	Pierce, FL	FeP	Electric.
FMC Corp., Industrial Chemical Div	Pocatello, ID	do	Do.
Monsanto Co., Monsanto Industrial Chemicals Co.	Columbia, TN Soda Springs, ID	do	Do.
Occidental Petroleum Corp., Hooker Chemical Co., Industrial Chemicals Group.	Columbia, TN	do	Do.
Stauffer Chemical Co., Industrial Chemical Div.	Mount Pleasant, TN Silver Bow, MT Tarpon Springs, FL	do	Do.

[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

Overall consumption of ferroalloys and their respective metals was substantially higher than in 1983, owing to an increase in production in the steel, ferrous foundry, and the aluminum and chemical industries. Increases in consumption corresponded to increased demand in major markets for ferroalloys. The steel industry and ferrous foundries, the major consumers of ferroalloys, experienced production increases of about one-tenth and one-sixth, respectively. The aluminum and chemical industries, the major consumers of silicon metal, also showed moderate production increases.

Of the bulk ferroalloys, demand for chromium ferroalloys increased by a greater percentage than that for manganese ferroalloys or silicon ferroalloys. Imports of bulk ferroalloys and their respective metals represented 55% of the domestic market, down slightly from 56% in 1983. High-carbon ferrochromium and high-carbon ferromanganese 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 1984, by end use[1]

(Short tons of alloys unless otherwise specified)

End use	FeMn	SiMn	FeSi	FeTi	FeP	FeB
Steel:						
Carbon	386,250	71,654	[2]75,298	659	9,924	274
Stainless and heat-resisting	14,584	4,683	[2]57,609	1,851	(3)	28
Other alloy	[2]79,049	[2]19,939	[2]39,412	677	1,627	247
Tool	[2]377	(3)	2,535	(3)	--	--
Unspecified	711	660	35,841	6	20	--
Total	480,971	96,936	210,695	3,193	11,571	549
Cast irons	[4]13,750	3,864	[4]217,512	62	2,108	W
Superalloys	426	25	[4]311	622	--	W
Alloys (excluding alloy steels and superalloys)	19,723	W	45,526	473	87	81
Miscellaneous and unspecified	5,187	2,029	86,430	12	2,051	406
Total consumption	520,057	102,854	560,474	4,362	15,817	1,036
Percent of 1983	112	123	123	125	102	208

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 1984, by end use[1]

(Short tons of contained elements unless otherwise specified)

End use	FeCr	FeMo	FeW	FeV	FeCb	FeNi
Steel:						
Carbon	[2]5,549	50	--	683	732	--
Stainless and heat-resisting	177,328	281	53	20	475	16,183
Other alloy	[2]29,365	683	42	2,452	847	1,189
Tool	[2]2,940	285	195	610	(3)	(4)
Unspecified	(5)	(5)	--	10	14	--
Total[2]	215,182	1,299	290	3,775	2,068	17,372
Cast irons	[2]3,725	604	--	18	--	126
Superalloys	8,585	78	W	8	620	64
Alloys (excluding alloy steels and superalloys)	[2]2,621	156	W	24	10	855
Miscellaneous and unspecified	1,846	44	19	1	2	2
Total consumption	231,959	2,181	309	3,826	2,700	18,419
Percent of 1983	101	128	264	140	125	118

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 "Steel: Other alloy."
[5]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	
	1983 (gross weight)	1984 (gross weight)	1983 (gross weight)	1984 (gross weight)	1983 (gross weight)	1984 (gross weight)
Manganese ferroalloys[1]	[2]61,143	30,806	157,350	145,442	218,493	176,248
Silicon alloys[3]	79,934	91,110	28,053	27,261	107,987	118,371
Ferrochromium[4]	33,293	19,414	26,670	26,302	59,963	45,716
Ferroboron[5]	183	114	203	197	386	311
Ferrophosphorus	168,263	141,212	1,468	1,720	169,731	142,932
Ferrotitanium	W	W	431	548	431	548
Total	342,816	282,656	214,175	201,470	556,991	484,126
	1983 (contained element)	1984 (contained element)	1983 (contained element)	1984 (contained element)	1983 (contained element)	1984 (contained element)
Ferrocolumbium[6]	W	W	W	W	399	476
Ferromolybdenum[7]	[r]1,310	1,226	285	361	[r]1,595	1,587
Ferronickel	W	W	756	692	756	692
Ferrotungsten	W	W	35	41	35	41
Ferrovanadium[8]	1,345	946	313	334	1,658	1,280
Total	[r]2,655	2,172	1,389	1,428	[r]4,443	4,076

[r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Includes ferromanganese, silicomanganese, and manganese metal.
[2]Part being withheld.
[3]Includes ferrosilicon, miscellaneous silicon alloys, and silicon metal.
[4]Includes other chromium alloys and chromium metal.
[5]Consumer totals include other boron materials.
[6]Consumer totals include nickel columbium.
[7]Consumer totals include calcium molybdate.
[8]Includes other vanadium-iron-carbon ferroalloys.

PRICES

Posted prices for most ferroalloys continued to firm because of stronger demand by major consuming industries; for example, the average posted price of imported bulk ferroalloys increased, compared with those of 1983, by 10% to $0.44 per pound of chromium for 60% to 65% high-carbon ferrochromium, by 2% to $325.33 per long ton of alloy for high-carbon ferromanganese, by 4% to $0.34 per pound of manganese for medium-carbon ferromanganese, by 12% to $0.19 per pound of alloy for silicomanganese, by 15% to $0.41 per pound of silicon for 75% ferrosilicon, and by 13% to $0.60 per pound of silicon for silicon metal containing 1% iron. Average listed prices for comparable domestically produced materials were higher than imports by 5%, 51%, 21%, 17%, 7%, and 5%, respectively.

Although demand for ferrocolumbium improved owing to increased production of high-strength, low-alloy steels, the average price of regular-grade ferrocolumbium was lowered by 5% to $5.72 per pound of columbium. It was reported that this action was taken by major suppliers of ferrocolumbium to stimulate long-term growth for the material. Average prices for other specialty ferroalloys that compete directly with ferrocolumbium as microalloying additives in the production of high-strength, low-alloy steels also were lowered. For instance, dealer export ferromolybdenum was reduced by 4% to $4.26 per pound of molybdenum and that of domestically produced ferrovanadium was reduced by 8% to $6.48 per pound of vanadium.

Domestic producers of ferroalloys continued their policy of discounting aggressively to compete with low-priced imports. For example, posted prices of domestically produced ferronickel remained unchanged at $3.16 per pound of nickel, but actual transaction prices were reportedly close to $2.15 per pound. Prices for selected ferroalloys are shown in the following tabulation:

Alloy	Yearend price[1]	
	1983	1984
Charge chromium (66% to 70%)	$0.42	$0.54
Low-carbon ferrochromium, 0.02% maximum carbon (Simplex)	1.00	1.00
Standard 78% ferromanganese, per long ton of alloy	490.00	490.00
Ferromolybdenum, dealer export	4.45	3.55
Ferronickel	3.16	3.16
Ferrosilicon, 50%	.4300	.4500
Ferrosilicon, 75%	.4300	.4700

[1]Per pound contained, except as noted otherwise. If range of prices was quoted, the lowest price is shown.

FOREIGN TRADE

The trade deficit for ferroalloys increased from $361 million in 1983 to $470 million in 1984. However, a surplus of $14 million for ferroalloy metals in 1983 increased to $35 million in 1984.

The quantity, on a gross weight basis, and value of exported ferroalloys and ferroalloy metals increased 77% to 134,000 tons and 64% to $165 million, respectively. The quantity and value of exported ferroalloys and ferroalloy metals were 11% and 27% of the quantity and value of imports, respectively, compared with 7% and 22%, respectively, in 1983.

Total imports for consumption of ferroalloys and ferroalloy metals increased 21% in quantity to about 1.2 million tons and 34% in value to $601 million, compared with those of 1983. Of the imported bulk ferroalloys, the quantity of chromium ferroalloys and manganese ferroalloys increased by 54% and 14%, respectively, while that of silicon ferroalloys declined by 10%. Imports of silicon metal were also down by about 10%, but imports of both manganese and chromium metal increased, manganese by a greater percentage than chromium. Ferronickel imports declined by 5%, but overall imports of all other ferroalloys were up by 55%. Ferroalloy and ferroalloy metal imports were equal to 73% of reported consumption, up from 69% in 1983.

The strong U.S. dollar, relative to other foreign currencies, and the availability of low-priced imports continued to be a major problem confronting domestic ferroalloy producers' efforts to achieve profitability.

Imports of ferroalloys and ferroalloy metals to the United States were supplied by 40 countries. The geographic sources were Africa, 40%; Europe, 31%; Western Hemisphere, 21%; Middle East, 4%; Oceania, 3%; and Asia, 2%. The four principal suppliers were the Republic of South Africa (36%), France (11%), Brazil (9%), and Norway (7%). Combined imports of chromium ferroalloys from the Republic of South Africa and Zimbabwe amounted to 73% of total chromium ferroalloys, the same as that of 1983. Major sources for imported manganese ferroalloys were the Republic of South Africa (29%), France (23%), Brazil (10%), Mexico (10%), and Norway (9%). The leading suppliers of ferrosilicon were Brazil (24%), Norway (20%), Venezuela (18%), Canada (11%), and the U.S.S.R. (8%). The principal sources of ferronickel imports were the Dominican Republic (46%), New Caledonia (26%), Colombia (16%), Japan (8%), and Brazil (3%). The main suppliers of all other ferroalloys were Brazil (41%), Canada (13%), and France (12%). Major suppliers of ferroalloy metal imports were the United Kingdom, Japan, China, and France, with 41%, 31%, 16%, and 9%, respectively, of the chromium metal; the Republic of South Africa with close to 100% of the manganese metal; and Canada, France, Yugoslavia, and Brazil with 34%, 17%, 14%, and 11%, respectively, of the silicon metal.

Table 7.—U.S. exports of ferroalloys and ferroalloy metals

Alloy	1982		1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ferroalloys:						
Ferrocerium and alloys	27	$264	41	$372	29	$304
Ferrochromium and ferrochromium-silicon	4,943	5,081	4,247	4,822	15,388	10,542
Ferromanganese	10,311	7,517	8,433	5,765	6,764	4,397
Silicomanganese	2,952	1,532	6,426	1,746	5,333	2,237
Ferromolybdenum	128	675	85	687	325	1,567
Ferrophosphorus	4,031	1,402	26,933	3,716	39,603	5,279
Ferrosilicon	14,932	11,996	13,338	10,712	29,364	21,185
Ferrovanadium	326	3,436	775	6,144	469	5,205
Ferroalloys, n.e.c	4,980	8,481	5,775	7,965	27,485	16,158
Total ferroalloys[1]	42,630	40,388	66,053	41,929	124,761	66,875
Metals:						
Manganese	2,948	3,861	6,391	8,531	4,082	5,915
Silicon	2,411	34,335	2,767	47,826	4,420	88,543
Chromium	213	2,685	238	2,555	259	3,627
Total ferroalloy metals[1]	5,572	40,881	9,396	58,912	8,761	98,084
Grand total	48,202	81,269	75,449	100,841	133,522	164,959

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

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1983			1984		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Manganese alloys:						
Ferromanganese containing 1% or less carbon	6,967	5,957	$5,410	5,020	4,431	$4,554
Ferromanganese containing more than 1% to 4% carbon	29,442	23,735	13,952	53,509	43,419	25,674
Ferromanganese containing more than 4% carbon	305,199	236,668	73,721	350,781	273,849	87,450
Ferrosilicon-manganese	139,657	[1]91,992	40,117	138,494	[1]91,339	44,746
Spiegeleisen	157	([2])	91	220	([2])	73
Total manganese alloys[3]	481,421	358,352	133,290	548,023	413,039	162,496
Ferrosilicon:						
8% to 30% silicon	29	6	11	46	7	13
30% to 60% silicon, over 2% magnesium	13,575	6,372	8,308	10,912	5,030	7,252
30% to 60% silicon, n.e.c	34,108	16,449	9,267	31,607	15,668	12,879
60% to 80% silicon, over 3% calcium	5,671	3,658	5,094	6,798	4,300	6,206
60% to 80% silicon, n.e.c	106,041	79,512	44,752	93,125	70,005	45,829
80% to 90% silicon	20	15	13	1,063	923	619
Over 90% silicon	--	--	--	100	94	76
Total ferrosilicon[3]	159,443	106,012	67,445	143,651	96,027	72,874
Chromium alloys:						
Ferrochromium containing 3% or more carbon	263,546	151,285	93,738	400,676	225,488	160,054
Ferrochromium containing less than 3% carbon	16,757	11,713	15,274	25,132	17,236	23,397
Ferrosilicon-chromium	1,438	579	670	7,942	3,032	3,736
Total chromium alloys	281,741	163,577	109,682	433,750	245,756	187,187
Ferronickel	45,134	16,696	65,264	43,048	15,847	68,429
Other ferroalloys:						
Ferrocerium and other cerium alloys	115	([2])	1,185	152	([2])	1,651
Ferromolybdenum	579	399	3,189	1,043	772	4,438
Ferrophosphorus	6	([2])	10	--	--	--
Ferrotitanium and ferrosilicon-titanium	893	([2])	1,288	579	[2]	861
Ferrotungsten and ferrosilicon-tungsten	66	53	604	393	315	3,420
Ferrovanadium	847	681	6,259	1,450	1,170	11,839
Ferrozirconium	551	([2])	696	759	([2])	932

See footnotes at end of table.

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals —Continued

Alloy	1983 Gross weight (short tons)	1983 Content (short tons)	1983 Value (thousands)	1984 Gross weight (short tons)	1984 Content (short tons)	1984 Value (thousands)
Other ferroalloys —Continued						
Ferroalloys, n.e.c.[4]	2,318	(2)	$14,400	3,949	(2)	$22,876
Total other ferroalloys	5,375	XX	27,631	8,325	XX	46,017
Total ferroalloys	973,114	XX	403,312	1,176,797	XX	537,003
Metals:						
Manganese	5,950	(2)	5,323	13,314	(2)	12,978
Silicon (96% to 99% silicon)	7,535	(2)	6,665	6,753	(2)	7,113
Silicon (99% to 99.7% silicon)	19,953	19,418	19,699	17,588	17,408	19,361
Chromium	3,092	(2)	13,687	4,677	(2)	24,073
Total ferroalloy metals[3]	36,530	XX	45,374	42,331	XX	63,526
Grand total[3]	1,009,644	XX	448,686	1,219,129	XX	600,529

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.

WORLD REVIEW

World demand for ferroalloys increased moderately compared with those levels of 1983, owing to increased production by world steel producers, the major consumers of ferroalloys. Overcapacity and oversupply continued to be the principal problems facing the world ferroalloy industry. A major gain in ferrosilicon capacity in Brazil was offset by reductions in the United States and Japan. Other countries that have recently installed new ferroalloy capacity or plan to do so are Egypt, Finland, Greece, Iceland, India, the Philippines, the Republic of South Africa, Sweden, and Turkey. The world ferroalloy industry is closely tied to the fortunes of the steel industry, which is still a long way from full recovery following the recent, severe recession.

The European Economic Community (EEC) rejected attempts by a group of high-carbon ferromanganese producers, Euromang, to set up a cartel to restrict supplies to European consumers. Euromang members reportedly included all EEC high-carbon ferromanganese producers, Elkem A/S, Norway; Eurominas Electro Metalurgia S.A.R.L., Portugal; and South African Manganese Amcor Ltd. (Samancor). The EEC ruled that the cartel was unacceptable under article 65 of the Treaty of Paris. In November, the EEC increased its duty-free community tariff import quotas for two grades of ferrochromium. Quotas for material containing 4% or more carbon were increased by 926 tons for France and 1,279 tons for the United Kingdom. Quotas for material containing 6% or more carbon were raised by 973 tons for both Belgium-Luxembourg and the Federal Republic of Germany, and 18,372 tons for both France and Italy. The EEC initiated an investigation of silicon carbide dumping in response to a complaint filed by the European Council of Chemical Manufacturers' Federations (Cefic). The countries involved are China, Czechoslovakia, Norway, Poland, Spain, the U.S.S.R., and Yugoslavia. Cefic claims that these exporters have taken 41% of the EEC's $100 million market. In August, the EEC called on Community producers of high-carbon ferromanganese to submit plans for cutting total EEC capacity by 20%. Demand for ferromanganese has been steadily declining owing to worldwide reduction in steelmaking and improved steel production techniques. The EEC also sought restriction of ferromanganese imports from Norway, Portugal, and the Republic of South Africa to prevent these countries from taking advantage of European capacity cutbacks by increasing exports into the EEC. These countries account for 25% of the total EEC market.

In 1984, many developing countries were able to arrange restructure of their large debts by adhering to the International Monetary Fund's (IMF) stringent program of strict monetary policy, curtailed Government spending, and fewer imports. However, these countries have not yet begun to reduce their debts. The largest debtor countries, such as Brazil and Mexico, made substantial economic progress, achieving large trade surpluses. Debtor countries and their lending institutions began to work out realistic long-term schedules for repaying huge loans. Argentina, which initially had objected strenuously to strict IMF conditions in connection with its debt-restructuring, eventually accepted the IMF's austerity program.

Australia.—Tasmanian Electro Metallurgical Co. Pty. Ltd., a wholly owned subsidiary of The Broken Hill Pty. Co. Ltd. (BHP), planned to increase capacity at its Bell Bay, Tasmania, manganese alloy plant by 40% to about 210,000 tons over a 3-year period. The company produces ferromanganese, silicomanganese, and ferrosilicon. Most of this additional production will be exported. Feed ore for the Bell Bay plant will continue to be supplied from BHP's manganese mine at Groote Eylandt in Australia's Northern Territory.[4] BHP was reportedly considering constructing a ferroalloy plant in China. The project would be a joint venture with the Chinese metals industry.

Brazil.—Alcan Alumínio do Brasil S.A., a subsidiary of Alcan Alumínio da America Latina Ltda., held talks with parties concerned with the sale of its ferroalloy plant in the State of Minas Gerais. Alcan put the plant up for sale in order to raise funds to cover the cost of expanding its aluminum facility. Also, Alcan's special power contract with the Brazilian Government was due to expire, and the new power rates were expected to increase. The plant consists of two ferrosilicon furnaces with a total transformer capacity of 21,300 kilovolt amperes (kV•A) and six silicomanganese furnaces with a total transformer capacity of 16,300 kV•A. Brazil's state-owned Cia. Vale do Rio Doce (CVRD) and Eletrometalur S.A. Indústria e Comércio, a major ferroalloy producer, formed a new ferrosilicon company, Eletrovale, to transform the Picarro iron ore minesite into a ferroalloy plant, with a production capacity of about 27,000 tons per year of 75% ferrosilicon with low calcium content. The minesite, which is expected to be exhausted in early 1985, was chosen for the new facility to take advantage of existing infrastructure. Ownership was divided on a 60% to 40% basis between the Brazilian companies and Japan's Kawasaki Steel Corp. and Mitsubishi Metal Corp. The plant will either be equipped with two Brazilian 15,000-kV•A electric furnaces or one 35,000-kV•A furnace procured from Elkem A/S, Norway, or Mannesmann Demag Hüttentechnik, the Federal Republic of Germany. About 40% of the annual production is expected to go to the Japanese steel producers.[5] Italmagnésio S.A. Indústria e Comércio brought a new 24,000-kV•A furnace on-line in November at its Bragança plant in Minas Gerais for production of ferrosilicon or silicon metal. The furnace is reportedly capable of producing 13,000 tons of silicon metal per year. The company also planned to install three additional furnaces by the end of 1986, which would produce ferrosilicon or silicon metal.

Italmagnésio reached a basic long-range agreement with C. Itoh & Co. Ltd. to act as its Japanese sales agent. In return, C. Itoh is to make available a large amount of funds to Italmagnésio. Cia. de Ferroligas Minas Gerais brought a second ferrosilicon furnace, with a capacity of 1,100 tons per month, on-stream at its plant in Pirapora early in the year. The company planned to bring another furnace on-line in October.[6]

Cia. de Ferro-Ligas da Bahia S.A. (Ferbasa) planned to expand its ferrochromium facility by about 60% by the first half of 1986. The expansion was necessary to enable the company to keep up with increased domestic demand. The increase in consumption forced the plant to restrict exports, with a consequent loss of currency. The plant can produce 13,000 tons per year of ferrochromium. Japan is the main buyer of Ferbasa's ferrochromium, with the United States the next largest purchaser.[7] Empresa de Desenvolvimento de Recursos Minerais S.A., which commissioned a second ferronickel furnace in August 1983, postponed further expansion plans in response to the poor current market conditions. Brazil was expected to produce about 25% more ferronickel in 1984, compared with that of 1983. CVRD reports that it expects to capture one-third of the world consumer market for naturally occurring manganese dioxide in 5 years with production from the Igarapé Azul Mine in Carajás. Tests on ore samples performed by major dry cell battery manufacturers have proved promising. The ore contains about 73% MnO_2 and has battery active properties, thus obviating the need for conversion to electrolytic manganese dioxide. CVRD has also started production of metallurgical manganese on an experimental scale at the Igarapé Azul Mine.[8]

Canada.—Elkem Metals Canada Inc.,

owned 90% by Elkem A/S and 10% by the Jebsen Group of Norway, purchased Union Carbide Canada Ltd.'s silicon and manganese operations in Quebec, effective July 25. This acquisition completes the takeover, begun in 1981, of Union Carbide's ferroalloy operations in North America and Norway. The transaction included plants at Beauharnois and Chicoutimi, Quebec. The Beauharnois plant has been idle since May 1982.[9]

Colombia.—Cerro Matoso S.A.'s 52-megavolt-ampere (MV•A) ferronickel furnace reportedly operated at about 90% of capacity since August. However, the facility has suffered heavy financial losses the past 2 years. In October 1984, the Colombian Government urged that the contractual relationship of Econiquel Ltda., the state mining company, in Cerro Matoso should be revised. The Colombian Government recently was required to pay $10.2 million in debt-servicing fees to the International Bank for Reconstruction and Development for its share of the project. Cerro Matoso began producing ferronickel granules. Depending on future market demand, up to 100% of the facility's output can be produced in granular form. The annual capacity at Cerro Matoso was rated at 50 million pounds of contained nickel. The company plans to install a block-type cooling system, supplied by Outokumpu Oy of Finland, within the furnace in the first half of 1985.[10]

Dominican Republic.—Falconbridge Dominicana C. por A.'s ferronickel shipments increased 36% to 14 million pounds in the third quarter of 1984, compared with those for the same period of 1983. However, for the first 9 months of 1984, shipments fell by 1.5%, compared with those of 1983.

France.—The dispute between state-owned Pechiney and Compagnie Minière de l'Ogooue S.A. (COMILOG) concerning the ownership of Bozel Electrométallurgie, a ferroalloys producer and a subsidiary of Nobel Bozel, was resolved in October with COMILOG's decision not to appeal the French Commercial Tribunal's award of the company to Pechiney. Nobel Bozel had previously promised to sell Bozel Electrometallurgie to COMILOG. COMILOG received a commitment from Pechiney for increased purchases of manganese ore. COMILOG and Samancor will now supply the bulk of Pechiney's manganese ore requirement, reducing the company's dependence on smaller sources such as Australia, Brazil, Ghana, and Mexico.[11]

Pechiney confirmed that it would cease medium-carbon ferromanganese production at its St. Beron plant in 1985. The plant has an annual capacity of 39,000 to 44,000 tons per year. Pechiney also reduced its share of Hidro Nitro Españolas S.A. from 49% to 45% and held discussions with Samancor and COMILOG with respect to these companies increasing their respective shares of Eurominas. A new Chromium Association was established in 1984. The eight founding member companies included Samancor, the Republic of South Africa; Ferro Alloys Corp. Ltd. and Indian Metals and Ferro-Alloys Ltd., India; Ferroleghe S.p.A., Italy; Ferrochrome Philippines Inc., the Philippines; Ferroaleaciones Españolas S.A. (Fesa), Spain; Hellenic Ferroalloy S.A. (HFA), Greece; and Axel Johnson Ore and Metals AB, Sweden. The organization will serve to collect, evaluate, and distribute information on chromium; to promote the use of chromium; and to sponsor research and development for new applications of the metal. The new organization will operate under the auspices of the Paris-based Manganese Centre.[12]

Greece.—HFA, a subsidiary of the state-controlled Hellenic Industrial Mining & Investment Co. (HIMIC), reviewed the financial feasibility of increasing the annual capacity of its Tsingeli ferrochromium plant from its current 50,000 tons to 110,000 tons. HFA could either utilize part of the idle facilities at the Société Minière et Métallurgique de Larymna S.A. (LARCO) plant or build another smelting furnace at its Tsingeli operation. The first option would not require capital investment and the plant could be operated according to market demands. The second option would require substantial capital investment but would make it possible to use the company's excess stock of lumpy ore and would also include a captive 12-megawatt (MW) powerplant, thereby considerably reducing power costs. The additional ferrochromium output would most likely go to the Japanese market. HFA shipped its first batch of ferrochromium to Japan in July 1984. HFA began shipment of ferrochromium to EEC member states early in the year.[13]

Iceland.—Sumitomo Corp., a Japanese trader, signed an agreement with the Icelandic Government and Elkem A/S to buy 15% of Icelandic Alloys Ltd. The Japanese company bought 15% of Elkem's share. The Icelandic Government's and Elkem's shares of Icelandic Alloys now amount to 55% and

30%, respectively. Sumitomo will receive a long-term supply of 22,000 tons of ferrosilicon per year beginning in the third quarter of 1984. The Grundartangi facility, completed in 1980, is equipped with two 35,000-kV•A electric furnaces with a combined annual capacity of about 61,000 tons.[14]

The Icelandic Parliament approved plans for a new 27,000-ton-per-year silicon metal plant at Reydarfjordur. Icelandic Metal PLC, which had been given a Government mandate to proceed with the project, began a search for foreign and domestic partners to share the cost of the facility.

India.—Power shortages continued to be the principal problem of the Indian bulk ferroalloy industry. Exports of ferrosilicon were banned in July owing to acute power shortages in the States of Karnataka and Orissa where ferrosilicon capacity is concentrated. Ferrosilicon producers were most concerned with the continuous underutilization of capacity, even though confronted with high costs of energy and raw materials. The plant load factor of power stations in India was reported to be only 47.5% in 1983.

Owing to the power shortages in Karnataka and Orissa, the Indian Government tried to restrict exports of ferromanganese in 1984 despite the international price situation, which was a deterrent to exports. The export ceiling for the period April 1984-85 was set at 27,500 tons for both ferromanganese and silicomanganese. Indian ferromanganese producers indicated to the Government that some kind of export assistance is required to increase ferroalloy exports. In Orissa, the power shortages also hampered export efforts of two export-oriented charge chrome producers there. Manganese Ore India Ltd. planned to build its first ferromanganese plant in the State of Madhya Pradesh. The new facility will have a capacity of 66,000 tons per year. Orissa Mining Corp.'s first charge chrome plant, at Bamanipal in the Keonjhar District, was expected to go into production in February 1985. The plant is being built by Outokumpu Oy, Finland, and Voest-Alpine AG, Austria. The plant, equipped with a 30,000-kV•A furnace, was expected to produce 55,000 tons of low-phosphorus charge chrome per year. Ore fines will be supplied by Outokumpu's Sukhrangi Mine. The Government had already granted the company an import permit for 30,000 tons per year of coke.[15]

Iran.—Iran made its first offering of 1,100 tons of molybdenum sulfide concentrates from its Sar Chesmeh operations in October. The concentrates are reported to be very high in copper content, about 2%, and need to be blended with higher grade concentrates to be viable for acceptably graded ferromolybdenum production.

Italy.—The restructuring of Carlo Tassara Stabilimenti Elettrosiderurgici S.p.A. left COMILOG with a controlling share in the company's ferroalloys business through its subsidiary Elettrosiderurgica Italiana. The COMILOG subsidiary, in which Carlo Tassara will have a minority interest, will produce ferroalloys at the Cairo Montenotte, Savona, and Tassara Breno, Brescia, facilities. Output from the two plants in 1984 was expected to reach 33,000 tons of ferromanganese, 33,000 tons of silicomanganese, and 16,500 tons of low-carbon ferromanganese.

Japan.—In June, the Japan Ferroalloy Association's ferrosilicon producing members withdrew their dumping complaint against Brazil, France, and Norway. The complaint, which was filed with the Finance Ministry in March, charged France and Norway with dumping their ferrosilicon into Japan and Brazil with unfair competition through subsidizing their ferrosilicon exports to Japan. Imports from the three countries were expected to amount to about 153,000 tons. Japan's Ministry of International Trade and Industry (MITI) had received assurances from the Governments of the countries involved that there had been no dumping and that exports of ferrosilicon had been in accordance with the General Agreement on Tariffs and Trade (GATT) regulations. Equally important in the decision to drop the dumping suit was the price of ferrosilicon imported into Japan, which had reached a level approximately equal to that of Japanese-produced material. MITI formed a new commission in March that, similar to the ITC, will have powers to exclusively handle complaints of dumping and unfair competition filed by Japanese industries against foreign imports.

In January, the Japanese Government's Tariff Council recommended that the 5.3% GATT-based import duty and the 12% non-GATT duty imposed on imports of silicon metal should be abolished effective April 1. The duty, introduced to protect Japanese producers from cheap imports, became redundant when the last Japanese producer of silicon metal ceased production in December 1982.

Nippon Denko Co. Ltd. announced in October that it had constructed an electric furnace for production of high-carbon ferroboron at its Hokuriku plant. The 1,500-ton-per-year furnace was put into operation October 15. Ferroboron was expected to become an important raw material in the production of amorphous metals. Amorphous metals have a random structure achieved by rapid cooling.

In March 1984, the Japan Rare Metals Association, under the 1983 national stockpile program, purchased 12,859 tons of high-carbon ferromanganese and 146 tons of ferrovanadium, based on contained vanadium. Of the totals, 7,807 tons of ferromanganese will be stored in the national stockpile with the remaining 5,052 tons in the joint government-private stockpiles. The ferrovanadium will be split evenly between the two stockpiles. The Metal Mining Agency of Japan planned to borrow $26.7 million to expand the country's ferroalloy stockpile by 6 to 20 days' worth of consumption by 1985. The stockpiling program, begun in 1983, includes cobalt, ferrochromium, manganese, molybdenum, nickel, tungsten, and vanadium.

MITI planned to cut back Japan's ferronickel and ferrochromium capacity by 10% to 12% by March 1988. High energy costs coupled with rising imports were cited as the reasons for the prospective cutbacks. Japanese chromium ore consumers reported that problems that severely disrupted shipments from Albania and India in the second half of 1984 had not resulted in a shortage of material. Japan imported far larger tonnages of chromium ore from the Republic of South Africa.

The Japanese ferroalloy industry has steadily declined since 1979. Ferrosilicon has been hardest hit followed by ferrochromium and ferromanganese. A basic factor in the decline is rapidly rising energy and power costs, which are making it prohibitive to produce energy-intensive metals. Coincidentally, ferroalloy imports have soared, further exacerbating the problems of Japanese producers.

New Caledonia.—Société Métallurgique Le Nickel (SLN) planned to start up its third furnace at its Domiambo nickel plant during the second half of 1984, responding to an improvement in the nickel market. SLN had technical problems with one of its furnaces early in the year. The furnace suffered an unscheduled shutdown owing to development of a crack in the lining. Overall production is expected to reach 33,000 tons of contained nickel in 1984. SLN ceased nickel ore production at its Thio Mine in November, a result of harassment by separatists. However, ore deliveries from its larger mine at Kouaha to the company's smelter at Domiambo were reported not affected. SLN's New Caledonian operations are major suppliers of ore and ferronickel to the Japanese and West European markets.[16]

Norway.—Norwegian ferroalloys producers reportedly operated at near capacity. Hydroelectric power is cheap in Norway but is limited in supply. Although the country has plenty of hydro potential remaining to be developed, expansion of the available power base has been restricted by environmental pressures. A Government report on energy development was to be considered by the Norwegian Parliament late in the year. Several major ferroalloys producers would likely expand capacity if they were able to acquire additional power rights. Norway is the world's largest exporter of ferrosilicon and silicon metal, and the world's second largest exporter of ferromanganese and silicomanganese.

Elkem A/S announced in July that it planned to increase medium-carbon ferromanganese production from its current level of about 83,000 tons per year to 127,000. The company said the increase would take place over several months at existing plants, using new refining equipment. The additional production will be slated for the Japanese and European markets. Elkem also increased its ferroalloy interests in Canada and the United States. Elkem's purchase of Union Carbide's ferroalloy plants in 1981 included valuable technology in medium-carbon ferromanganese production. This technology was further improved at the company's research centers and plants in Norway and the United States.[17]

Tinfos Jernverk A/S restarted silicon metal production at its Notodden plant in December. The company's initial startup in midyear was unsuccessful owing to technical difficulties. The transfer of silicomanganese capacity to the Oye Smelteverk in Kvinesdal resulted in spare capacity in Notodden, which could be used for silicon metal production.

Pakistan.—The Baluchistan Development Authority (BDA) entered into agreement with Pakistan Chrome Mines Ltd., a joint venture between Pakistani and Canadian interests, to expand the chromite mining operation in the Muslim Bagh area. BDA was also considering the establishment of a chrome ore beneficiation plant as a first step toward the production of ferrochromium in Pakistan.[18]

Papua New Guinea.—Nord Resources Corp. announced that, owing to the depressed metals market, it had no current plans to develop its chromium-nickel-cobalt deposit along the Ramu River. The company estimated that project development costs would be about $1 billion. Exploratory work has indicated a deposit in the range of about 250 million tons of mineralized material.

Philippines.—Ferrochrome Philippines completed modification of its high-carbon ferrochromium furnace at its Tagoloan plant. The furnace's annual production capacity was increased from 55,000 tons to 66,000 tons. Most of the plant's production, which is low in sulfur, goes to Japan.[19]

Portugal.—Cia. Portuguesa de Fornos Eléctricos S.A.R.L. reportedly planned to convert one of its two 25,000-kV•A silicon metal furnaces to ferrosilicon production late in 1984. A pickup in world demand along with a firming of prices were cited as the reasons for this action.

South Africa, Republic of.—General Mining Union Corp. Ltd. (Gencor) planned to increase ferrochromium capacity at its Tubatse Ferrochrome (Pty.) Ltd. plant, Steelpoort, in 1987. The plant contains three 30,000-kV•A electric furnaces with a conbined production capacity of about 150,000 tons of charge chrome per year. Gencor may expand capacity either by constructing new electric furnaces or by adding ore-pretreatment facilities. Adoption of ore-pretreatment technology would increase capacity to 220,000 tons per year while also substantially reducing power consumption per unit. Gencor earlier had decided to increase chrome ore production capacity at the Tweefontein Mine, Transvaal.[20]

About midyear, Gencor acquired Gesellschaft für Elektrometallurgie mbH's Waterkloof chrome ore mine at Rustenburg. The mine was operating at a production capacity of about 170,000 tons per year. Gencor will use the mine's lumpy ore production in its domestic ferrochromium production. Gencor also acquired outright control of Samancor by buying South African Iron and Steel Industrial Corp. Ltd.'s 44% holding in African Metals.

Samancor switched its ferromanganese furnaces over to ferrochromium production and at midyear was operating at about its capacity of 330,000 to 390,000 tons per year of 50% to 55% charge chrome.

Spain.—The Spanish ferroalloy industry completed its restructuring plan for ferrosilicon and ferromanganese producers in the latter part of the year. Overall capacity was cut back 50% in return for concessionary power rates by the Government. Production of the various alloys has been divided among the producers. Under the rationalization plan, the Government designates which companies are allowed to export and sets production levels. The ferroalloy industry's main purpose now is to supply that country's steel industry, with only Hidro Nitro Españolas able to export a significant amount of its production, about 50%.

Because of Government restrictions on production, only about 17,000 tons of ferrosilicon was expected to be exported. Once Spain obtains full membership to the EEC, certain export incentives and Spain's protective high import tariffs will be phased out. In late 1984, Fesa, a ferrochromium producer that was not included in the restructuring program, applied for the same favorable power rates as those awarded to the country's ferrosilicon and ferromanganese producers. The company, which produces about 26,000 tons of ferrochromium per year, maintains that the preferential power rate was vital if it was to remain competitive in the European market.

Sweden.—Swedechrome, a consortium of nine Swedish companies and a Government pension fund, announced a contract for construction of an approximately 86,000-ton-per-year ferrochromium plant in Malmo, southern Sweden, late in 1984. The Swedish Government had given its approval for construction of the plant in July. The plant was designed and will be built on a turnkey-basis by SKF Steel Engineering AB (SKF) and was scheduled for completion by the end of 1986. The facility will make use of the plasma arc technology developed by SKF, using the company's 6-MW plasma arc generator. When operating at full capacity, the plant will also supply large quantities of surplus energy to the city of Malmo's district heating system. An important advantage of the plasma process is its ability to process fines. Such fines are generally cheaper than the lump ore used in most other ferrochromium plants. The Malmo plant will be the second plasma arc furnace to be put into operation in Sweden.

Scan Dust AB began operation of its

plasma process plant at Landskrona in September 1984. The plant, also built by SKF, was expected to handle about 80,000 tons of steel mill baghouse dust per year. The Landskrona plant uses three 6-MW plasma generators, built by SKF, to generate up to 9,000° F of heat during the process. Excess heat from the Scan Dust plant is used by the Landskrona municipality for district heating purposes.[21]

Gullspongs Elektrokemiska AB shifted its three ferrotungsten furnaces to the production of high-speed steel ingot. Strong competition from Chinese ferrotungsten was cited as a principal reason for the switch. The company also began producing a ferronickel-type material containing 35% nickel and 15% chromium. The plant has a capacity to produce 22,000 tons per year of ferronickel.

Turkey.—The Turkish Government began to actively seek participation of foreign companies in development of metal ore deposits in Turkey. The country's previous policy discouraged foreign investment. Turkey was reportedly particularly interested in joint ventures with U.S. mining and energy companies. Since local economic problems have forced the country to borrow heavily from the IMF, Turkey has actively encouraged foreign investment. The main metals under consideration are chromium, nickel, molybdenum, and vanadium. Turkey has substantial reserves of chromite ore. The country was a major world supplier of low-carbon ferrochromium before the advent of the argon-oxygen decarburization (AOD) process, which utilizes high-carbon ferrochromium directly in steelmaking.

U.S.S.R.—Future production of manganese ore and ferromanganese was being planned for East Siberia in the vicinity of Krasnoyarsk. An East Siberian ferroalloys plant was to be located near the Sredneyeniseyskaya hydropower plant to be built on the Yenisey River. It had been thought that ore feed for the smelter would have to come from the distant Nikopol' Basin. It was now considered feasible to obtain at least part of the ore through development of the Porozhinskoye deposit in the region.

United Kingdom.—The British Government announced in November that it had decided to dismantle its strategic stockpile. The British Department of Trade and Industry said that the stockpile materials will be disposed of over a period of years. The principal contents of the British stockpile were reported to be manganese and chromium materials.

Venezuela.—Ferrosilicio de Venezuela S.A. (FESILVEN) lost its entire production owing to an explosion in one of its two 52,000-kV•A furnaces at the end of April. The explosion resulted in one fatality, with injuries to others. The plant's other furnace was down for scheduled repairs. Both furnaces were reported to be operating at 80% of capacity by the end of August. FESILVEN exports the majority of its production and expected to begin shipments to the United States and Europe in September.[22]

Yugoslavia.—Feronikl's new ferronickel plant in the Kosovo region began operations on May 23. The facility has a production capacity of about 13,000 tons of contained nickel per year. Production was expected to be 3,300 to 4,400 tons in 1984, with most of the output destined for export. The Macedonian regional government officially closed the new Rudnici i Industrija za Nikel, Celik i Antimon ferronickel plant at Kavadarci in July. The plant, which had temporarily shut down in March, will be maintained at a level where rapid reopening will be possible if market conditions warrant it.[23]

Zimbabwe.—The Zimbabwe Mining and Smelting Co., a Union Carbide subsidiary, expected to produce about 170,000 tons of ferrochromium in 1984. The plant operated five of its six furnaces concurrently. One of the plant's six furnaces was kept available as a standby replacement.

Table 9.—Ferroalloys: World production, by country, furnace type, and alloy type[1]

(Thousand short tons)

Country, furnace type,[2] and alloy type[3]	1980	1981	1982	1983[p]	1984[e]
Albania: Electric furnace, ferrochromium[e]	4	31	33	39	44
Argentina: Electric furnace:					
Ferromanganese	26	25	27	28	27
Silicomanganese	13	14	17	15	15
Ferrosilicon	13	11	19	17	17
Other	2	3	5	4	4
Total[4]	54	53	67	64	63
Australia: Electric furnace:[5]					
Ferromanganese	104	[r]74	60	54	[6]83
Silicomanganese	20	32	33	24	[6]34
Ferrosilicon	20	[r]20	22	[e]24	28
Total[4]	144	127	115	103	145
Austria: Electric furnace, undistributed	11	13	15	15	15
Belgium: Electric furnace, ferromanganese[7]	94	99	[e]99	[e]99	105
Brazil: Electric furnace:					
Ferromanganese	155	119	133	114	[6]117
Silicomanganese	148	157	190	184	193
Ferrosilicon	120	133	127	173	[6]174
Silicon metal	15	21	20	23	[6]30
Ferrochromium	103	131	107	85	[6]138
Ferrochromium-silicon	9	10	3	6	[6]8
Ferronickel	12	12	12	29	33
Other	47	41	39	34	60
Total[4]	609	[r]623	630	648	753
Bulgaria: Electric furnace:[e]					
Ferromanganese[8]	31	37	37	37	37
Ferrosilicon	18	22	22	22	22
Other	1	1	1	1	1
Total	50	60	60	60	60
Canada: Electric furnace:					
Ferromanganese[e 8]	95	120	[r]152	118	128
Ferrosilicon	153	[r]128	[e]116	94	88
Silicon metal	43	31	[e]30	28	28
Other[e 9]	28	[r]31	([10])	([10])	--
Total[4]	319	310	[e]298	239	244
Chile: Electric furnace:					
Ferromanganese	6	[r]6	3	6	6
Silicomanganese	([11])	([11])	NA	NA	([11])
Ferrosilicon	6	3	2	5	5
Other	1	1	2	2	2
Total[4]	13	9	6	13	13
China: Furnace type unspecified:[e 12]					
Ferromanganese[8]	650	580	520	540	540
Ferrosilicon	[r]215	[r]215	215	215	215
Silicon metal	[r]24	[r]24	[r]24	[r]24	24
Ferrochromium[13]	130	130	130	130	130
Other[9]	80	80	80	80	80
Total[4]	[r]1,102	[r]1,029	970	[r]992	989
Colombia: Electric furnace, ferrosilicon[e 14]	1	1	1	1	1
Czechoslovakia: Electric furnace:					
Ferromanganese[e 8]	110	110	110	110	110
Ferrosilicon[e]	35	35	35	35	35
Silicon metal[e]	6	6	6	6	6
Ferrochromium[e]	30	30	30	30	30
Other[e 9]	10	10	10	10	10
Total[15]	191	191	191	191	191
Dominican Republic: Electric furnace, ferronickel	51	54	16	[e]60	[6]71
Egypt: Electric furnace, ferrosilicon[e]	[r]5	[r]5	[r]6	[r]6	7
Finland: Electric furnace, ferrochromium	58	57	60	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]	1980	1981	1982	1983[p]	1984[e]
France:					
Blast furnace:					
Spiegeleisen	--	1	1	1	1
Ferromanganese	529	344	365	[r] [e]303	302
Electric furnace:					
Silicomanganese[16]	22	11	32	32	33
Ferrosilicon	283	208	186	212	220
Silicon metal	66	66	63	62	55
Ferrochromium[13]	49	30	16	20	22
Other[17]	137	131	115	148	143
Total[4]	[r]1,087	791	778	778	776
German Democratic Republic: Electric furnace:					
Ferromanganese[e] [8]	77	[r]74	[r]69	[r]69	72
Ferrosilicon[e]	[r]29	[r]28	26	[r]26	28
Silicon metal[e]	4	4	3	[r]4	4
Ferrochromium[e]	[r]21	[r]22	22	[r]19	23
Other[e] [9]	20	[r]21	17	[r]20	18
Total[4] [15]	151	149	138	141	145
Germany, Federal Republic of:					
Blast furnace:					
Ferromanganese	220	236	220	148	160
Ferrosilicon[e]	71	55	46	[r]44	50
Electric furnace:[e]					
Ferromanganese[8]	[r]26	21	21	[r]19	28
Ferrosilicon	55	46	37	[r]34	66
Ferrochromium	[r]64	55	46	[r]42	77
Other[9]	55	47	40	[r]36	72
Total[4]	[r]491	[r]461	411	323	453
Greece: Electric furnace:					
Ferrochromium	--	--	--	20	22
Ferronickel	57	56	[e]56	[e]55	55
Total	57	56	[e]56	75	77
Hungary: Electric furnace:					
Ferrosilicon	11	12	[e]12	11	10
Silicon metal[e]	2	2	2	2	2
Other	3	3	[e]3	2	2
Total[15]	16	17	17	15	14
Iceland: Electric furnace, ferrosilicon	[r]28	37	47	56	61
India: Electric furnace:					
Ferromanganese	[r]174	[r]227	166	138	138
Silicomaganese	14	18	15	[e]15	11
Ferrosilicon	[r]60	[r]67	40	45	44
Silicon metal	3	4	[e]4	[e]4	3
Ferrochromium	18	[r]35	44	34	44
Ferrochromium-silicon	4	5	[e]4	([11])	([11])
Other	1	[r]10	15	[r] [e]12	11
Total[4]	[r]274	[r]365	290	250	251
Indonesia: Electric furnace, ferronickel	20	22	24	23	22
Italy:					
Blast furnace:					
Spiegeleisen	6	1	1	1	1
Ferromanganese	[e]67	65	63	54	55
Electric furnace:					
Ferromanganese	24	14	18	14	14
Silicomanganese	[r]49	60	64	41	44
Ferrosilicon	79	61	70	57	55
Silicon metal[e]	17	17	17	15	15
Ferrochromium	45	11	40	13	13
Other[18]	16	14	13	37	39
Total[4] [18]	304	[r]242	286	232	236

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]	1980	1981	1982	1983[p]	1984[e]
Japan: Electric furnace:					
Ferromanganese	627	626	593	429	[6]535
Silicomanganese	[r]343	312	297	245	[6]257
Ferrosilicon	335	259	212	174	[6]169
Silicon metal	17	13	9	--	--
Ferrochromium	444	337	362	335	[6]357
Ferrochromium-silicon[19]	NA	NA	NA	NA	NA
Ferronickel	305	269	236	199	[6]239
Other[e]	[r]4	[r]4	[r]7	[r]5	7
Total	[r]2,075	[r]1,820	1,716	1,387	[6]1,564
Korea, North: Furnace type unspecified:[e 12]					
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	60	[r]75	66	58	66
Ferrosilicon	33	[r]35	35	36	39
Other	28	[r]30	37	48	54
Total[4]	[r]120	141	139	142	159
Mexico: Electric furnace:					
Ferromanganese	[r]135	[r]145	155	153	176
Silicomanganese	34	[r]28	34	46	47
Ferrosilicon	30	[r]25	32	26	25
Ferrochromium	--	[r]3	7	3	8
Other	[r]([11])	2	([11])	1	2
Total[4]	[r]199	[r]204	227	229	258
New Caledonia: Electric furnace, ferronickel	145	121	120	77	101
Norway: Electric furnace:					
Ferromanganese	326	257	224	247	276
Silicomanganese	185	236	238	199	220
Ferrosilicon	353	346	326	381	[6]452
Silicon metal[e]	94	61	[r]61	[r]74	77
Ferrochromium	12	13	[e]13	[r e]11	11
Ferrochromium-silicon	([11])	1	[e]1	1	1
Other	22	5	[e]13	17	20
Total[4 15]	992	919	876	930	1,057
Peru: Electric furnace:					
Ferromanganese	--	([11])	--	([11])	([11])
Ferrosilicon	1	--	--	([11])	([11])
Total	1	([11])	--	([11])	([11])
Philippines: Electric furnace:[e]					
Ferrosilicon	22	25	30	22	20
Ferrochromium	11	11	13	24	36
Total	33	36	43	46	56
Poland:[e]					
Blast furnace:					
Spiegeleisen	8	8	8	8	8
Ferromanganese	131	131	131	131	131
Electric furnace:					
Ferromanganese[8]	52	52	52	52	52
Ferrosilicon	55	55	55	55	55
Silicon metal	11	11	11	11	11
Ferrochromium	52	52	52	52	52
Other[9]	17	17	17	17	17
Total[15]	326	326	326	326	326
Portugal: Electric furnace:					
Ferromanganese[e 20]	82	72	30	[r]37	33
Silicomanganese[e 20]	19	20	[r]18	18	17
Ferrosilicon[e]	28	26	[r]23	[r]24	22
Silicon metal[e]	36	35	35	[r]35	33
Other[e]	([11])	([11])	([11])	([11])	([11])
Total[4 15]	[r]164	153	106	115	105

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]	1980	1981	1982	1983[p]	1984[e]
Romania: Electric furnace:[e]					
Ferromanganese	72	77	83	88	96
Silicomanganese	34	36	39	42	45
Ferrosilicon	43	46	50	53	57
Silicon metal	3	4	4	4	5
Ferrochromium	38	40	43	46	50
Total[4]	190	203	218	234	253
South Africa, Republic of: Furnace type unspecified:[e 12]					
Ferromanganese	573	496	485	[r]386	422
Silicomanganese	77	55	44	33	39
Ferrosilicon	179	121	110	110	121
Silicon metal	33	33	33	[r]24	28
Ferrochromium	882	827	[r]507	[r]794	977
Ferrosilicochromium	42	22	22	20	29
Other[21]	[r]1	[r]1	[r]1	[r]1	1
Total	[r]1,787	[r]1,555	[r]1,202	[r]1,368	1,617
Spain: Electric furnace:					
Ferromanganese	135	106	96	94	94
Silicomanganese	104	77	78	77	77
Ferrosilicon	136	94	70	68	66
Silicon metal[e]	22	20	20	[r]19	17
Ferrochromium	18	19	17	15	15
Other	7	7	6	6	6
Total[4 15]	422	323	286	279	275
Sweden: Electric furnace:					
Ferrosilicon	9	21	16	17	17
Silicon metal	20	[r]16	[e]18	[e]18	18
Ferrochromium	159	[r]161	129	[r e]138	138
Ferrochromium-silicon	9	[r]25	22	[e]22	22
Other	2	[r]1	1	1	1
Total[4 15]	[r]199	[r]223	185	195	196
Switzerland: Electric furnace:[e]					
Ferrosilicon	3	3	3	[r]2	3
Silicon metal	2	2	[r]2	[r]2	2
Total	5	5	[r]5	[r]4	5
Taiwan: Electric furnace:					
Ferromanganese	23	[r]21	21	24	[e]22
Ferrosilicomanganese	25	16	23	20	[e]25
Ferrosilicon	31	[r]19	19	20	[e]26
Total[4]	79	[r]56	63	65	[e]73
Thailand: Electric furnace:					
Ferromanganese	([11])	([11])	--	--	--
Ferrosilicon	([11])	[r]([11])	--	--	--
Total	([11])	[r]([11])	--	--	--
Turkey: Electric furnace:					
Ferrosilicon	--	--	[e]5	[e]5	[e]8
Ferrochromium	[e]35	45	44	33	[e]53
Total	[e]35	45	49	38	[e]61
U.S.S.R.:					
Blast furnace:					
Spiegeleisen[e]	55	55	55	55	55
Ferromanganese[e]	606	606	606	[r]606	606
Other	110	--	--	--	--
Electric furnace:[22]					
Ferromanganese[e]	1,070	1,140	1,200	1,270	1,320
Silicomanganese[e]	35	35	35	[r]37	39
Ferrosilicon[e]	694	717	750	[r]794	827
Silicon metal[e]	65	70	70	70	70
Ferrochromium[e]	[r]430	[r]441	[r]457	[r]457	463
Ferrochromium-silicon[e]	11	11	11	[r]13	13
Other[17]	220	230	248	250	250
Total[4]	[r]3,297	3,305	3,432	3,551	3,643

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]	1980	1981	1982	1983[p]	1984[e]
United Kingdom:					
Blast furnace, ferromanganese	57	93	e67	r e91	83
Electric furnace, undistributed[e]	13	14	12	r14	14
Total[4]	r71	107	e79	e106	97
United States: Electric furnace:[23]					
Ferromanganese	189	193	119	86	[24]171
Silicomanganese	188	173	69	W	([25])
Ferrosilicon	559	580	299	r314	490
Silicon metal	127	130	77	122	141
Ferrochromium	184	164	92	20	[26]95
Ferrochromium-silicon[27]	54	62	27	16	([28])
Other[29]	245	219	136	r198	190
Total[4]	1,547	1,521	819	r757	[6]1,088
Uruguay: Electric furnace, ferrosilicon	([11])	([11])	([10])	([11])	([11])
Venezuela: Electric furnace:					
Ferromanganese	2	2	2	2	2
Silicomanganese	r1	r11	10	10	10
Ferrosilicon	r65	r49	46	51	49
Total	r68	r62	58	63	61
Yugoslavia: Electric furnace:					
Ferromanganese	37	56	43	e43	46
Silicomanganese	36	32	22	e26	28
Ferrosilicon	73	88	78	e90	110
Silicon metal	33	31	33	e40	50
Ferrochromium	76	76	56	e65	88
Ferrochromium-silicon	11	6	7	e7	8
Other	1	1	4	e5	6
Total[4]	267	r291	243	e276	[6]335
Zimbabwe: Electric furnace:					
Ferromanganese	e3	e2	2	2	2
Ferrosilicon	NA	NA	14	30	31
Ferrochromium	e287	230	198	174	187
Total	e290	233	215	206	220
Grand total[4]	r17,578	r16,583	15,153	15,014	16,484
Of which:					
Blast furnace:					
Spiegeleisen[30]	69	65	65	65	65
Ferromanganese[30]	1,610	1,475	1,452	1,333	1,337
Other[31]	181	55	46	44	50
Total blast furnace	1,860	1,595	1,563	1,442	1,452
Electric furnace:[12]					
Ferromanganese[32]	r3,734	r3,750	3,581	3,391	3,756
Silicomanganese[32 33]	r1,347	r1,323	1,258	1,064	1,134
Ferrosilicon	r3,813	r3,575	3,189	3,338	3,696
Silicon metal	r643	r601	542	587	619
Ferrochromium[34]	r3,157	r2,951	2,518	2,675	3,139
Ferrochromium-silicon[27 34]	r140	r142	97	85	81
Ferronickel[35]	590	534	464	443	521
Other[35]	r970	r932	832	957	1,018
Undistributed	24	27	27	29	29

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]	1980	1981	1982	1983[p]	1984[e]
Total electric furnace	[r]14,418	[r]13,835	12,508	12,569	13,993
Furnace type unspecified:					
Ferromanganese[12]	1,300	1,153	1,082	1,003	1,039

[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 June 9, 1985.

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

[5]Data for year ending Nov. 30 of that stated.

[6]Reported figure.

[7]Reported as blast furnace ferromanganese and spiegeleisen but believed to be electric-furnace output.

[8]Includes silicomanganese.

[9]Includes ferrochromium-silicon and ferronickel, if any was produced.

[10]Revised to zero.

[11]Less than 1/2 unit.

[12]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.

[13]Includes ferrochromium-silicon, if any was produced.

[14]Colombia is reported to produce ferromanganese also, but output is not reported quantitatively, and no basis is available for estimation.

[15]Totals for 1980-84 represent estimates for silicon metal plus reported totals for all other types.

[16]Includes silicospiegeleisen.

[17]Includes ferronickel, if any was produced.

[18]Series excludes calcium silicide.

[19]Data revised; not available owing to reporting procedure by Japan.

[20]Estimated figures based on reported exports and an allowance for domestic use.

[21]Ferrovanadium only; other minor ferroalloys may be produced, but no basis is available for estimation.

[22]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.

[23]U.S. production of ferronickel cannot be reported separately in order to conceal corporate proprietary data.

[24]U.S. output of ferromanganese for 1984 includes silicomanganese and manganese metal.

[25]U.S. output of silicomanganese for 1984 included with ferromanganese.

[26]U.S. output of ferrochromium for 1984 includes ferrochromium-silicon, chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.

[27]U.S. output of ferrochromium-silicon includes chromium briquets, exothermic chromium additives, other miscellaneous chromium alloys, and chromium metal.

[28]U.S. output of ferrochromium-silicon for 1984 included with "Ferrochromium."

[29]Includes ferronickel.

[30]Spiegeleisen for the Federal Republic of Germany is included with "Blast furnace: Ferromanganese."

[31]Includes the following quantities specifically identified as "Ferrosilicon," in thousand short tons: 1980—71; 1981—55; 1982—46; 1983—44 (revised); and 1984—50. The remainders are not identified except that they are not spiegeleisen or ferromanganese.

[32]Includes silicomanganese (if any was produced) for countries carrying footnote 8 on "Ferromanganese" data line.

[33]Includes silicospiegeleisen for France.

[34]Includes ferrochromium-silicon (if any was produced) for countries carrying footnote 13 on "Ferrochromium" data line.

[35]Includes ferronickel production for France, Norway, the U.S.S.R., and the United States.

TECHNOLOGY

Plasma technology was evaluated as an alternate method to the conventional submerged arc electric furnace for ferroalloy production. The three basic types of thermal plasma reactors currently in use for materials processing use direct current (dc), alternating current (ac), or radio frequency (rf) as the primary power sources. An ac or dc plasma is generated by ohmic heating of a neutral or chemically reactive gas by means of an electrical discharge (arc) struck between two electrodes. However, the plasma in an rf reactor is produced by inductive coupling. The dc plasma arc furnace is most commonly used in ferroalloy production. In the dc arc furnace, there are two different modes by which the arc may be formed and heat transferred to the charge: (1) transferred-arc mode, in which the material being processed is one of the electrodes, and (2) nontransferred-arc mode, in which both electrodes are confined in a single device, from which the plasma is blown into a reactor by passing a flow of gas through the device.

The most important feature of the plasma furnace in metallurgical applications is that it can process ore fines directly without prior briquetting or pelletizing, a costly process normally required for conventional submerged arc electric furnaces. Further, plasma reactors can be used to recycle and refine materials such as ironworks and steelworks baghouse dusts and ferroalloy plant fines to recover critical and strategic materials. Other advantages claimed for the dc arc plasma furnace include use of low-cost coal in place of more expensive coke, less noise pollution, and lower electrode consumption.

In market economy countries, the three companies currently most actively involved in plasma technology are SKF, Sweden; Tetronics Research and Development Co. Ltd., United Kingdom; and Westinghouse Corp., United States. SKF licensed its gas plasma technology from Westinghouse. Westinghouse developed its nontransferred arc plasma process for the U.S. National Aeronautics and Space Administration to simulate conditions that a spacecraft would experience on a reentry into the Earth's atmosphere. In this system, a gas is ionized as it passes through the space between two concentric copper electrodes. Ionization strips the gas of electrons, giving the gas an electric charge. Also, most of the energy applied to the electrodes is passed to the gas stream in the form of heat.

In September 1984, SKF completed the construction of a new plant for Scan Dust at Landskrona, in southern Sweden, for the recovery of metals from steel mill baghouse dust. The Landskrona plant uses three 6-MW plasma generators built by SKF, to generate up to 9,000° F of heat. The plant is expected to process about 55,000 tons of waste per year. Late in 1984, Swedechrome, a consortium of nine Swedish companies and a Government pension plan, announced a contract for construction of a 86,000-ton-per-year ferrochromium plant in Malmo, southern Sweden. The plant is scheduled to begin production in 1986.

The most extensive investigation in the possible commercialization of plasma furnaces for ferroalloy production in market economy countries is being conducted by the Council for Mineral Technology in the Republic of South Africa in conjunction with the Middelburg Steel & Alloys Holdings (Pty.) Ltd. (MSA). Their experiments were conducted at Tetronics, Faringdom, Oxon, England, using the Tetronics plasma system (TPS) with a 1.4-MW transferred arc plasma furnace and a precessing cathodic electrode and liquid metal anode.

The TPS system uses one electrode through which the gas passes, while the second electrode is at the base of the furnace. This means that the gas is ionized within the reaction zone of the furnace. Experiments have been conducted on the production of both ferromanganese and ferrochromium. Tetronics also has built an 11,000-ton-per-year plant for Texasgulf Corp. in the United States, near Atlanta, GA, to recover platinum from spent automobile catalysts.

ASEA AB, Sweden, has built a 20-MV•A plasma arc furnace for commercial scale ferrochromium production at MSA's Krugersdorp plant, Transvaal, Republic of South Africa. Chromite ore fines are charged directly into the dc arc. Initial production of the 44,000-ton-per-year furnace began in late 1984.

Application of high-temperature plasma reactors for the production of other ferroalloys such as ferromolybdenum and ferrovanadium from lean ores, concentrates, and scrap materials is still under laboratory or pilot plant development.[24]

The Idaho National Engineering Laboratory was conducting research for the Bureau of Mines on metal-gas reactions in thermal plasmas. The objective of this ongoing research program is to obtain a better understanding of physical and chemical phenomena in thermal plasmas.[25]

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[1]Physical scientist, Division of Ferrous Metals.

[2]National Materials Advisory Board. Priorities for Detailed Quality Assessments of the National Defense Stockpile Non-Fuel Materials. Natl. Acad. Sci., Washington, DC, NMAB-403, 1984, 66 pp.

[3]U.S. Congress, Office of Technology Assessment. Strategic Materials: Technologies To Reduce U.S. Import Vulnerability. OTA-ITE-249, Jan. 1985, 56 pp.

[4]Metals Week. V. 55, No. 49, Dec. 3, 1984, p. 8.

[5]Mining Journal. V. 303, No. 7780, Sept. 28, 1984, p. 223.

[6]Metal Bulletin (London). No. 6883, May 1, 1984, p. 19.

[7]———. No. 6943, Dec. 4, 1984, p. 15.

[8]———. No. 6945, Dec. 11, 1984, p. 15.

[9]Iron Age. V. 227, No. 20, Oct. 15, 1984, p. 21.

[10]Metals Week. V. 55, No. 45, Nov. 5, 1984, p. 7.

[11]Metal Bulletin (London). No. 6933, Oct. 30, 1984, p. 21.

[12]American Metal Market. V. 92, No. 98, May 5, 1984, p. 7.
[13]The Tex Report. V. 16, No. 3746, July 6, 1984, p. 10.
[14]Metal Bulletin (London). No. 6924, Sept. 28, 1984, p. 17.
[15]———. No. 6919, Sept. 11, 1984, p. 23.
[16]Work cited in footnote 4.
[17]The Tex Report. V. 16, No. 3751, July 13, 1984, p. 6.
[18]Mining Journal. V. 302, No. 7766, June 22, 1984, p. 422.
[19]The Tex Report. V. 16, No. 3810, Oct. 8, 1984, p. 2.
[20]———. V. 16, No. 3782, Aug. 1984, p. 17.
[21]Scrap Age. V. 42, No. 1, Jan. 1985, p. 46.
[22]Metals Week. V. 55, No. 34, Aug. 20, 1984, p. 7.
[23]Metal Bulletin (London). No. 6900, July 3, 1984, p. 7.
[24]National Materials Advisory Board. Plasma Processing of Materials. Natl. Acad. Sci., Washington, DC, NMAB-415, 1985, 172 pp.

Schoukens, A. F. S., and T. R. Curr. The Production of Manganese Ferro-Alloys in Transferred-Arc Plasma Systems. Proc. 42d Electr. Furnace Conf. Iron and Steel Soc. AIME, Warrendale, PA, 1985, pp. 161-171.

Sommerville, I. D., A. Mclean, and C. B. Alcock. Smelting and Refining of Ferroalloys in a Plasma Reactor. Proc. 41st Electr. Furnace Conf. Iron and Steel Soc. AIME, Warrendale, PA, 1984, pp. 31-36.

[25]Idaho National Engineering Laboratory (Dep. Energy). Strategic and Critical Materials Program Annual Report (contract J0134035). BuMines OFR 79-85, May 1984, pp. 51-104; NTIS PB 85-216026.

Fluorspar

By Lawrence Pelham[1]

Fluorspar was recovered by one major producer and one small producer. Two other small producers shipped fluorspar from their mine stocks. Domestic fluosilicic acid (H_2SiF_6) recovery, a byproduct of some phosphoric acid and hydrofluoric acid (HF) plants, decreased. In the chemical industry, fluosilicic acid continued to augment fluorspar as a source of fluorine.

The United States depended on foreign sources for more than 90% of its fluorspar requirements. Imports increased by 55%.

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 4 fluorspar mining operations, 18 fluosilicic acid producers, and 4 briquet producers to which a survey request was sent for the 3 production surveys, all responded, representing 100% of the production data shown in table 1. The consumption survey was sent to approximately 130 operations quarterly and 30 additional operations annually. Of the operations surveyed quarterly, 67% responded for the first quarter; 70% responded for the second quarter; 65% responded for the third quarter; and 68% responded for the fourth quarter. Of the 30 operations surveyed annually, 77% responded. Together, quarterly and annual responses represented 100% of the apparent consumption data shown in table 1.

Table 1.—Salient fluorspar statistics[1]

	1980	1981	1982	1983	1984
United States:					
Production:					
Mine production ________ short tons __	372,092	415,862	199,714	W	W
Material beneficiated ________ do ____	321,219	419,058	231,726	W	W
Material recovered ________ do ____	88,831	111,281	76,316	W	W
Finished (shipments) ________ do ____	92,635	115,404	77,017	e61,000	e72,000
Value, f.o.b. mine ____ thousands __	$12,611	$18,412	$13,293	e$10,000	W
Exports ________ short tons __	17,865	11,261	10,573	9,236	12,266
Value ________ thousands __	$1,660	$1,194	$1,084	$962	$1,292
Imports for consumption _____ short tons __	899,219	826,783	543,723	453,314	703,711
Value[2] ________ thousands __	$94,103	$104,938	$67,665	$47,032	$65,241
Consumption (reported) ______ short tons __	976,644	932,855	530,565	564,187	752,581
Consumption (apparent)[3] ________ do ____	1,017,559	897,572	618,493	613,705	743,431
Stocks, Dec. 31:					
Domestic mines:					
Crude ________ do ____	213,204	200,698	164,094	W	W
Finished ________ do ____	8,930	12,924	10,816	W	W
Consumer ________ do ____	182,853	216,207	207,880	99,253	120,267
World: Production ________ do ____	r5,518,529	r5,463,153	4,840,511	p4,738,286	e5,070,012

eEstimated. pPreliminary. rRevised. 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]Apparent consumption includes finished shipments 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 1983 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. Fluorspar continued to be listed as a priority material to be acquired.

The national stockpile purchase specification for metallurgical-grade fluorspar, which was published by the U.S. Department of Commerce with the approval of the Federal Emergency Management Agency, was revised effective May 10 and superseded Specification P-69b-R2 dated January 2, 1976.

The ban continued on the sale and manufacture of "nonessential" aerosol products containing chlorofluorocarbons (CFC). The ban was instituted in 1979 because of the uncertainty of the role of CFC in the depletion of stratospheric ozone.

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.

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. A bill, H.R. 2947, which had been introduced in the U.S. House of Representatives in 1983, to suspend the duty on all grades of imported fluorspar, was dropped from consideration after written comments from the public were accepted.

DOMESTIC PRODUCTION

Illinois remained the leading producing State, accounting for more than 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 mines and plants in Pope and Hardin Counties, IL. The Hastie Trucking and Mining Co. operated near Cave-In-Rock, IL. The Inverness Mining Co.'s mines near Cave-In-Rock remained closed, and after 2 years of maintenance pumping and ventilating, the underground equipment was removed and the mine allowed to flood. The drying facilities were operated using foreign fluorspar.

In the West, J. Irving Crowell, Jr. and Sons shipped metallurgical-grade fluorspar from the stocks of its Crowell-Daisy Mine in Nye County, NV, as did D & F Minerals Co. from its Paisano Mines, south of Alpine, TX.

Reported shipments of fluorspar briquets for use in steel furnaces decreased 8% to approximately 68,000 tons. Fluorspar briquets were produced by two plants owned by Cametco Inc., one plant owned by Mercier Corp., and one plant owned by Oglebay Norton Co.

Sixteen plants processing phosphate rock for the production of phosphoric acid and two plants producing HF sold or used 61,000 tons of byproduct fluosilicic acid, which was equivalent to 107,000 tons of fluorspar, valued at $3.5 million.

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 ceramics 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 increased 33% because of a large increase in the production of HF and iron and steel castings. The increase in consumption for welding rod coatings was a result of improved Bureau of Mines coverage of that end use. The HF and steel industries accounted for 70% and 27%, respectively, of reported consumption. According to the American Iron and Steel Institute (AISI), raw steel production increased 8% to 91.5 million tons. A comparison of 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 1982-84. 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)		
	1982	1983	1984
Open hearth	9.89	6.44	8.61
Basic oxygen	5.65	4.19	3.99
Electric	3.69	3.80	2.94
Industry average	5.43	4.30	4.06

Steel production in open-hearth furnaces showed an increasing rate of fluorspar consumption in 1984.

In the ceramics 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 HF "produced and withdrawn from the system" was approximately 168,100 tons, compared with 180,000 tons in 1983.

Allied Chemical Co. closed its acid plant in Nitro, WV, which had produced HF since 1958. The facility had an annual capacity of 12,700 tons anhydrous HF and 14,000 tons of 70% HF. It was continuing in use as a shipping terminal for HF. Allied's Gismar, LA, plant was expanded to a capacity of 95,000 tons anhydrous HF and 14,000 tons of 70% HF.

CFC production, by five companies, was a major end use of HF. According to U.S. International Trade Commission data, production of trichlorofluoromethane (F-11) increased 15% to 92,600 tons; dichlorodifluoromethane (F-12) output increased 15% to 169,900 tons; and chlorodifluoromethane (F-22) production increased 8% to 127,600 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. The U.S. Department of Commerce reported that aluminum fluoride production was 84,234 tons in 1982. Production data since then have been withheld to avoid disclosing company proprietary data.

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.

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	
	1983	1984	1983	1984	1983	1984
Hydrofluoric acid (HF)	360,832	530,527	--	--	360,832	530,527
Glass and fiberglass	4,063	4,952	1,628	846	5,691	5,798
Enamel and pottery	W	--	1,227	1,619	1,227	1,619
Welding rod coatings	475	8,414	1,282	2,600	1,757	11,014
Primary aluminum and magnesium	--	--	W	--	W	--
Iron and steel castings	--	924	16,882	15,591	16,882	16,515
Open-hearth furnaces	W	--	19,174	35,893	19,174	35,893
Basic oxygen furnaces	--	--	109,084	105,253	109,084	105,253
Electric furnaces	16,442	2,021	32,094	42,597	48,536	44,618
Other	114	--	890	1,344	1,004	1,344
Total	381,926	546,838	182,261	205,743	564,187	752,581
Stocks, Dec. 31	46,493	70,446	52,760	49,821	99,253	120,267

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

Table 3.—U.S. consumption (reported) of subacid grades of fluorspar in 1984, 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	2,600	--	--
Glass, ceramic, bricks:			
Glass	813	33	--
Other glass, clay products	1,619	--	--
Primary metals:			
Iron and steel foundries	38	15,003	550
Steel mills:			
Basic oxygen furnaces	2,576	57,360	45,317
Electric furnaces	931	41,335	331
Open-hearth furnaces	1,272	31,559	3,062
Other identified end uses	93	1,251	--
Total	9,942	146,541	49,260

Table 4.—U.S. consumption of fluorspar (domestic and foreign), by State

(Short tons)

State	1983	1984
Alabama, Kentucky, Tennessee	62,829	68,643
Arizona, Colorado, Utah	8,033	12,141
Arkansas, Kansas, Louisiana, Missouri	25,355	161,450
California	W	W
Connecticut, Massachusetts, New York, Rhode Island	9,577	6,540
Illinois	12,561	10,747
Indiana	31,608	37,919
Michigan	W	2,294
New Jersey	W	W
Ohio	54,088	72,723
Oregon and Washington	--	W
Pennsylvania	40,949	54,950
Texas	264,097	278,728
West Virginia	23,977	14,480
Other[1]	31,113	31,966
Total	564,187	752,581

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 increased 21% to about 120,000 tons.

PRICES

Domestic producer prices of metallurgical-grade and ceramic-grade fluorspar and fluorspar briquets reported in the Engineering and Mining Journal (E&MJ) remained at 1983 levels. Reported prices of acid-grade fluorspar decreased by 4%. 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.

Table 5.—Prices of domestic and imported fluorspar

(Dollars per short ton)

	1983	1984
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	180	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. 1983 and 1984.

FOREIGN TRADE

According to Bureau of the Census data, U.S. fluorspar exports of all grades increased 33% and had an average value of $105 per ton. Synthetic cryolite exports decreased 46% to 17,100 tons valued at $9.1 million.

Imports for consumption of fluorspar increased by 55%. Acid-grade imports increased by 35%, and imports of subacid-grade material increased by 167%. Imports from Mexico, the largest foreign supplier, were 49% of the combined fluorspar total. The Republic of South Africa supplied 28%; China, 9%; Italy, 9%; and Spain, 5%. Small quantities were also imported from Canada, France, and the Federal Republic of Germany.

Imports for consumption of HF increased 25% to a quantity equivalent to about 172,000 tons of fluorspar. Imports for consumption of natural and synthetic cryolite increased 216% and had an average value of $578 per ton. Cryolite imports represented 27,000 tons of equivalent fluorspar. Canada, the primary supplier, increased its share of the U.S. cryolite import market from 20% to 61%.

Table 6.—U.S. exports of fluorspar, by country

Country	1983		1984	
	Quantity (short tons)	Value	Quantity (short tons)	Value
Australia	26	$2,619	--	--
Canada	8,516	855,119	11,863	$1,188,601
Chile	16	3,264	--	--
Colombia	9	880	--	--
Dominican Republic	47	16,618	317	82,759
Germany, Federal Republic of	19	1,920	--	--
Ghana	31	7,370	--	--
Leeward and Windward Islands	9	873	--	--
Mexico	477	65,163	--	--
United Kingdom	15	1,480	--	--
Venezuela	71	7,028	86	21,066
Total	9,236	962,334	12,266	1,292,426

Table 7.—U.S. imports for consumption of fluorspar, by country and customs district

Country and customs district	1983 Quantity (short tons)	1983 Value (thousands) Customs	1983 Value (thousands) C.i.f.	1984 Quantity (short tons)	1984 Value (thousands) Customs	1984 Value (thousands) C.i.f.
CONTAINING MORE THAN 97% CALCIUM FLUORIDE (CaF_2)						
Canada:						
Detroit	--	--	--	259	$25	$25
Laredo	--	--	--	81	6	6
Total	--	--	--	340	31	31
China:						
Baltimore	--	--	--	39	6	11
Houston	5,953	$666	$710	--	--	--
Total	5,953	666	710	39	6	11
Denmark: Detroit	4,630	283	285	--	--	--
France: Houston	250	63	83	113	28	37
Italy: Houston	37,042	4,186	4,786	61,619	6,318	7,325
Mexico:						
El Paso	76,254	7,781	7,781	90,738	8,219	8,219
Laredo	83,386	7,783	7,783	120,437	11,125	11,125
New Orleans	15,476	1,673	1,804	15,612	1,509	1,646
Total	175,116	17,237	17,368	226,787	20,853	20,990
Morocco: New Orleans	19,761	2,910	3,129	--	--	--
South Africa, Republic of:						
Houston	21,302	1,341	1,504	44,675	3,344	3,656
New Orleans	87,312	8,675	10,132	140,096	12,675	14,833
Philadelphia	4,641	500	530	9,958	900	959
Total	113,255	10,516	12,166	194,729	16,919	19,448
Spain:						
Cleveland	18,749	1,672	1,917	20,648	1,667	2,211
El Paso	1	(1)	(1)	--	--	--
New Orleans	10,381	942	1,050	17,173	1,599	1,803
Total	29,131	2,614	2,967	37,821	3,266	4,014
Grand total	385,138	38,475	41,494	521,448	47,421	51,856
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE (CaF_2)						
Canada:						
Buffalo	--	--	--	425	39	39
Detroit	--	--	--	177	12	12
Total	--	--	--	602	51	51
China:						
Baltimore	7,737	462	745	30,473	2,064	2,460
New Orleans	16,639	925	1,020	20,602	1,052	1,409
San Francisco	--	--	--	11,453	753	966
Total	24,376	1,387	1,765	62,528	3,869	4,835
Germany, Federal Republic of: Houston	--	--	--	11	5	3
Italy: Los Angeles	--	--	--	23	7	9
Mexico:						
Buffalo	--	--	--	401	42	42
Detroit	--	--	--	2,544	202	202
El Paso	11,024	659	659	16,699	796	796
Laredo	12,010	1,086	1,086	39,097	3,067	3,067
New Orleans	20,546	1,606	2,005	50,120	3,136	3,425
Philadelphia	--	--	--	7,445	652	725
San Diego	220	23	23	--	--	--
Total	43,800	3,374	3,773	116,306	7,895	8,257
South Africa, Republic of: New Orleans	--	--	--	2,793	190	230
Grand total	68,176	4,761	5,538	182,263	12,017	13,385

[1]Less than 1/2 unit.

Table 8.—U.S. imports for consumption of hydrofluoric acid (HF), by country

Country	1983 Quantity (short tons)	1983 Value, c.i.f. (thousands)	1984 Quantity (short tons)	1984 Value, c.i.f. (thousands)
Canada	31,709	$31,512	43,441	$36,644
France	--	--	17	14
Germany, Federal Republic of	(1)	1	56	82
Japan	2,990	2,546	4,422	3,429
Korea, Republic of	17	14	--	--
Mexico	56,232	45,194	66,399	60,694
Spain	568	443	35	29
United Kingdom	50	43	61	48
Total	91,566	79,753	114,431	100,940

[1]Less than 1/2 unit.

Table 9.—U.S. imports for consumption of cryolite, by country

Country	1983 Quantity (short tons)	1983 Value, c.i.f. (thousands)	1984 Quantity (short tons)	1984 Value, c.i.f. (thousands)
Brazil	--	--	17	$12
Canada	1,437	$816	13,883	7,079
China	92	53	19	10
Denmark	2,390	1,756	2,724	2,018
France	--	--	256	295
Germany, Federal Republic of	62	25	444	377
Greenland	--	--	65	61
Japan	2,395	1,853	3,663	2,554
Netherlands	102	81	98	72
Norway	36	13	--	--
United Arab Emirates	--	--	830	446
United Kingdom	685	187	723	200
Total	7,199	4,784	22,722	13,124

WORLD REVIEW

Canada.—Feasibility and environmental studies were being conducted on Eaglet Mines Ltd.'s Quesnet Lake property in British Columbia as assessment and development continued on the large, low-grade deposit. The property reportedly contained recoverable fluorspar, lead, molybdenum, silver, and zinc.

Minworth Ltd., a British firm, continued development work to reopen the fluorspar mine near St. Lawrence, Newfoundland. The mine was last operated in 1977 by the St. Lawrence Corp. and Newfoundland Fluorspar Ltd., formerly a subsidiary of Aluminum Co. of Canada Ltd.

Mexico.—In March, Industrias Peñoles S.A. de C.V. (PEÑOLES) closed the El Refugio Mine and associated processing plant at Ciudad Fernandez. The operation was controlled by a PEÑOLES subsidiary, Cía. Minera Río Colorado S.A.

[1]Physical scientist, Division of Industrial Minerals.

Table 10.—Sales of Mexican fluorspar, by grade

(Short tons)

Grade	1980	1981	1982	1983	1984
Acid	564,608	532,765	338,732	339,740	507,250
Ceramic	96,167	100,511	27,202	49,182	54,518
Metallurgical	312,218	250,121	120,478	116,944	229,892
Submetallurgical	236,470	211,505	116,030	93,367	116,867

Source: Instituto Mexicano de la Fluorita A.C.

Table 11.—Fluorspar: World production, by country[1]

(Short tons)

Country[2] and grade[3]	1980	1981	1982	1983[p]	1984[e]
Argentina	17,050	22,878	26,155	31,950	31,000
Brazil (marketable):					
Acid grade	36,078	39,932	35,274	47,399	49,600
Metallurgical grade	24,956	19,184	20,944	28,660	33,000
Total	61,034	59,116	56,218	76,059	82,600
China:[e]					
Acid grade	88,000	88,000	88,000	[r]110,000	110,000
Metallurgical grade	440,000	440,000	440,000	440,000	606,000
Total	528,000	528,000	528,000	[r]550,000	716,000
Czechoslovakia[e]	106,000	106,000	106,000	106,000	106,000
Egypt	1,931	590	99	13	55
France:					
Acid and ceramic grade	178,133	185,960	177,725	155,957	154,000
Metallurgical grade	106,814	96,452	90,825	60,488	61,000
Total	284,947	282,412	268,550	216,445	215,000
German Democratic Republic[e]	110,000	110,000	110,000	110,000	110,000
Germany, Federal Republic of (marketable)	86,148	[r]79,155	86,685	88,964	89,000
Greece	440	[4]322	330	330	330
India:					
Acid grade	13,612	14,711	13,676	[r e]12,000	13,000
Metallurgical grade	5,301	5,924	6,294	[r e]5,000	6,000
Total	18,913	20,635	19,970	[r e]17,000	19,000
Italy:					
Acid grade	137,540	142,019	147,850	141,117	154,000
Ceramic grade	1,060	--	--	--	--
Metallurgical grade	28,912	39,018	36,180	54,691	55,000
Total	167,512	181,037	184,030	195,808	209,000
Kenya: Acid grade	102,932	105,849	97,804	65,129	55,000
Korea, North: Metallurgical grade[e]	44,000	44,000	44,000	44,000	44,000
Korea, Republic of: Metallurgical grade	7,619	7,125	4,042	7,012	4,400
Mexico:					
Acid grade	542,337	559,973	450,845	448,640	[4]379,725
Ceramic grade	114,640	119,049	59,525	50,706	[4]40,307
Metallurgical grade	330,693	338,409	182,983	80,469	[4]235,079
Submetallurgical grade[5]	231,485	212,746	116,845	87,082	[4]115,878
Total	[r]1,219,155	[r]1,230,177	810,198	666,897	770,989
Mongolia: Metallurgical grade[e]	666,000	656,000	739,000	[r]772,000	772,000
Morocco: Acid grade	70,989	73,524	55,336	66,469	66,000
Pakistan	1,305	391	903	434	550
Romania: Metallurgical grade[e]	22,000	22,000	22,000	22,000	22,000
South Africa, Republic of:					
Acid grade	517,735	497,819	323,882	[e]263,600	306,400
Ceramic grade	9,798	6,744	10,613	[e]7,300	5,000
Metallurgical grade	48,664	42,758	30,188	[e]31,200	43,000
Total	576,197	547,321	364,683	[e]302,100	354,400
Spain:					
Acid grade	225,528	235,471	173,289	210,265	215,000
Metallurgical grade	44,261	47,963	40,868	45,840	50,000
Total	269,789	283,434	214,157	256,105	265,000
Thailand:					
Acid grade	66,258	60,827	89,314	51,466	55,000
Metallurgical grade	190,461	173,405	194,099	176,324	187,000
Total	256,719	234,232	283,413	227,790	242,000
Tunisia: Acid grade	43,487	38,409	36,607	37,493	39,000
Turkey: Metallurgical grade	2,144	2,189	[e]2,200	[e]2,200	2,200
U.S.S.R.[e]	573,000	585,000	595,000	595,000	606,000

See footnotes at end of table.

Table 11.—Fluorspar: World production, by country[1] —Continued

(Short tons)

Country[2] and grade[3]	1980	1981	1982	1983[p]	1984[e]
United Kingdom:					
Acid grade	151,016	97,000	NA	NA	NA
Metallurgical grade	11,023	5,512	NA	NA	NA
Unspecified	26,455	25,353	NA	NA	NA
Total	188,494	127,865	108,026	220,000	176,400
United States (shipments)	92,635	115,404	77,017	[e]61,000	72,000
Uruguay[e]	89	[r]88	88	88	88
Grand total	[r]5,518,529	[r]5,463,153	4,840,511	4,738,286	5,070,012

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 7, 1985.
[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.

Gallium

By Deborah A. Kramer[1]

Gallium metal was used in the United States primarily to produce gallium compounds for use in solid-state electronic devices. The increase in domestic consumption of gallium was met by increased imports and withdrawals from consumer stocks.

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 40 operations to which a survey request was sent, 20 responded, representing 30% of the consumption shown in tables 1, 2, and 3. Consumption for the 20 nonrespondents was estimated using import data and information on production and domestic consumption trends.

Table 1.—Salient U.S. gallium statistics

(Kilograms unless otherwise specified)

	1980	1981	1982	1983	1984
Production	NA	NA	NA	NA	NA
Imports for consumption	6,175	5,536	5,199	7,294	9,669
Consumption	8,810	6,810	6,660	6,425	7,060
Price per kilogram	\$510-\$630	\$630	\$630	\$525	\$525

NA Not available.

DOMESTIC PRODUCTION

Eagle-Picher Industries Inc. was the sole U.S. producer of primary gallium metal. Gallium was recovered from residues from zinc production at the company's plant in Quapaw, OK.

Musto Explorations Ltd., a Canadian firm in Vancouver, British Columbia, continued to develop an abandoned copper mine near St. George, UT, for recovery of gallium and germanium. The plant was expected to produce 10,000 kilograms of 99.9%-pure gallium per year and was expected to come onstream in May 1985. Musto reported that it was stockpiling underground dump ore left by a previous owner. In addition, Musto announced that underground development and mine rehabilitation were started, and construction began on the tailings pond and processing buildings.[2]

CONSUMPTION

Domestic gallium consumption increased moderately from that of 1983. The increase in demand for gallium for light-emitting diodes (LED) and research and development was met in part by withdrawals from inventories.

Gallium arsenide continued to receive attention during the year from research and development because of its application in semiconductors. Rockwell International and Honeywell Inc. announced plans to construct new facilities for manufacturing gallium arsenide integrated circuits for space and other military applications. Rockwell's $15 million production facility reportedly will produce both digital circuits and monolithic microwave integrated circuits. Honeywell's $10 million plant will accommodate a pilot production line for gate arrays. Both companies operated gallium arsenide integrated circuit production facilities during the year.[3]

Table 2.—U.S. consumption of gallium, by end use

(Kilograms)

End use	1982	1983	1984
Specialty alloys	27	43	42
Electronics[1]	6,136	5,915	6,320
Research and development	440	410	641
Unspecified	57	57	57
Total	6,660	6,425	7,060

[1]Light-emitting diodes, semiconductors, and other electronic devices.

Table 3.—Stocks, receipts, and consumption of gallium[1]

(Kilograms)

Purity	Beginning stocks[2]	Receipts	Consumption	Ending stocks
1983:				
97.0% to 99.9%	106	48	45	109
99.99%	4	14	14	4
99.999%	5	19	20	4
99.9999% to 99.99999%	1,740	6,368	6,346	1,762
Total	1,855	6,449	6,425	1,879
1984:				
97.0% to 99.9%	110	39	44	105
99.99%	4	254	254	4
99.999%	4	20	20	4
99.9999% to 99.99999%	1,712	5,735	6,742	705
Total	1,830	6,048	7,060	818

[1]Consumers only.
[2]Ending stocks for 1983 do not equal 1984 beginning stocks because of reported beginning stock adjustments.

PRICES

Throughout the year, the American Metal Market (AMM) quoted a price of $525 per kilogram for 99.99999%-pure gallium metal in 100-kilogram lots. 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, $460 to $480; gallium oxide, 99.99% pure, imported, $380 to $400; and gallium oxide, 99.999% pure, $415.

FOREIGN TRADE

Export data on gallium 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 waste and scrap and metal increased significantly over those of 1983. Switzerland, France, and the Federal Republic of Germany, in declining order, were the primary import sources, accounting for over 80% of U.S. imports. The average value of imported gallium declined from $438 per kilogram in 1983 to $419 per kilogram in 1984.

Beginning January 1, 1984, import duties for gallium compounds and gallium metal (TSUS 423.00 and TSUS 632.24, respectively), were 4.2% 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	1983		1984	
	Kilograms	Value	Kilograms	Value
Canada	279	$130,640	1	$440
China	500	157,264	400	154,696
France	829	304,334	2,449	997,182
Germany, Federal Republic of	918	415,094	1,554	575,790
Hungary	--	--	168	61,430
Japan	146	62,465	89	40,317
Netherlands	--	--	131	49,120
New Zealand	--	--	132	53,030
Switzerland	4,154	1,956,778	4,088	1,938,711
United Kingdom	468	168,001	651	176,802
Other	--	--	6	2,513
Total	7,294	3,194,576	9,669	4,050,031

WORLD REVIEW

Data for world gallium production were not reported, but world production and consumption of gallium were believed to have increased from that of 1983.

Hungary.—The Hungarian Clay and Aluminum Works in Ajka was estimated to have produced 3,000 kilograms of gallium in 1984. Most of the gallium was exported to Japan for use in the electronics industry.[4]

Japan.—Production of gallium metal in Japan was estimated to be 19,000 to 20,000 kilograms, with 5,000 to 6,000 kilograms obtained from scrap. Reportedly, owing to increased demand for LED, demand exceeded production by Japan's two producing companies, Sumitomo Chemical Co. and Dowa Mining Co. Ltd. Sumitomo announced that test operations at its new Niihama plant on the island of Shikoku, which recovered gallium from bauxite, were completed early in the year, but the plant did not reach its full capacity of 8,000 kilograms until October. Dowa was believed to have produced about 6,000 kilograms of metal. Reportedly, metal imports from China, Czechoslovakia, France, and the Federal Republic of Germany supplied part of Japan's gallium demand.[5]

Sumitomo Electric Industries Ltd. announced that it had opened a new fully automated gallium arsenide manufacturing facility in Itami. The new facility, combined with existing facilities in Itami, was designed to produce 10,000 kilograms of gallium arsenide per year.

TECHNOLOGY

Harris Microwave Semiconductor Inc., a subsidiary of Harris Corp., announced the first commercially available gallium arsenide digital integrated circuits. The gallium arsenide integrated circuits, a shift register and a binary counter, reportedly operate five times faster than the fastest silicon equivalent. Applications for the new chips include test instrumentation and telecommunications equipment.[6]

Scientists at General Electric Co. announced the fabrication of an experimental gallium arsenide semiconductor power diode. The device dissipates less power and, consequently, requires a smaller heat sink because of its high switching speed. Accordingly, the size and weight of solid-state power supplies for computers would be less if the experimental device is used. A proprietary technique for preparation of the diode was developed that reduces contaminants to less than 10 parts per billion.[7]

A review of recent developments in gallium arsenide technology was published.[8]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]The Northern Miner. Musto Developing Apex Mine for 1985 Production Start. V. 70, No. 42, Dec. 27, 1984, pp. 1, 6.
[3]Solid State Technology. V. 27, No. 7, July 1984, p. 34.
[4]Mining Journal. V. 303, No. 7769, July 13, 1984, p. 27.
[5]Metal Bulletin. Gallium Demand Surges in Japan. No. 6945, Dec. 12, 1984, p. 13.
[6]American Metal Market. Harris has First Commercial ICs Based on Gallium Arsenide. V. 92, No. 35, Feb. 20, 1984, p. 21.
[7]Solid State Technology. Semiconductor Power Diode. V. 27, No. 5, May 1984, p. 62.
[8]Robinson, P. Gallium Arsenide Chips. Byte, v. 20, No. 12, Nov. 1984, pp. 211-227.

Gem Stones

By J. W. Pressler[1]

The value of gem stones and mineral specimens produced in the United States during 1984 was estimated to be $7.5 million, virtually the same as that of 1983. Turquoise and peridot production decreased while tourmaline, sapphire, and opal production increased. 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 52 operations to which a survey request was sent, 44% responded, representing an estimated 60% of the total production indicated in the text. 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, $500,000; Montana, $450,000; Maine and Oregon, $400,000 each; Wyoming, $225,000; and Arkansas, New Mexico, and Washington, $200,000 each. Estimated production increased 67% in California, 50% in Idaho and Montana, and 8% in Nevada, but decreased 33% in Oregon, 20% in Maine, 10% in Wyoming, and 4% in Arizona.

Park authorities at the Crater of Diamonds Park in Pike County, AR, reported that 85,000 people visited the park and recovered, by washing, screening, and panning, 1,339 diamonds, an 11% decrease from that of 1983, with a total weight of 202 carats. The largest was a 5.58-carat brown stone of good quality. The total diamonds recovered averaged 15 points (100 points equals 1 carat) compared with 21 points in 1983. More small stones were found because of improvements in panning and screening equipment, especially the hemispherical "suruka" screen. The "dig for fee" operations remained popular.

In Emerald Creek, ID, the U.S. Forest Service issued 753 permits to diggers and panners who found 1,800 kilograms of gem garnet, most of which was asteriated, with the balance faceting grade. The garnet area consisted of three gulches, with one being especially noted for large stones. The 15 largest stones reported during the season varied from 50 to 500 grams. Because of the cold weather, the area was opened for about 100 days from May to September.

Exploration for diamondiferous kimberlite in Wyoming was continued by Cominco American Incorporated and Superior Minerals Co., working independently with the Geological Survey of Wyoming and the University of Wyoming, using remote sensing techniques. The Geological Survey of Wyoming also discovered a new kimberlite district in the Pole Mountain region of the Laramie Range. Bulk sampling and testing of properties in the Colorado-Wyoming State line district indicated grades of 0.01 and 0.2 carat per short ton, with stones as large as 1 carat.

In upper Michigan and northwest Wisconsin, Dow Chemical Co., Exmin Corp., Anaconda Mining Co., and others conducted investigations and sampled kimberlites in Dickinson and Iron Counties, MI, and Florence, Forest, and Pierce Counties, WI. Three small diamonds were found by a prospector in the Antigo area, Langlade County, WI, in glacial deposits.

Alaska's first confirmed find of diamond occurred near Circle, AK, in 1982, while working a gold placer deposit.

Montana continued to be the largest producer of gem-quality corundum in the United States. Intergem Inc. of Denver, CO, produced over 100,000 carats of corundum in 1984 from test operations of its properties on Yogo Gulch, near Lewiston, Fergus County, MT. Some high-quality colored stones were recovered, including blue and alexandrite-like purple. Recoverable corundum content of the ore was less than 10 carats per ton. After cutting, some of the larger sapphires were as much as 4 carats, but average cut stones, done in Bangkok, were only 20 points. Intergem was vertically integrated with its Yogo Mine, cutting and polishing of stones, and marketing of jewelry. In addition to Intergem, three other pay-as-you-dig or fee placer operations were active in Montana: Eldorado Bar and Castle's Sapphire Mine near Helena, and Gem Mountain Sapphire Mine near Philipsburg.

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 (domestic production plus imports minus exports and reexports) increased 40% to $2,978 million.

The sales value of jewelry containing pearls and diamonds increased 19%, with the Christmas trade being particularly good. Demand for small, lower quality goods was high, and the demand for larger stones of good quality was better than that in 1983.

U.S. consumption of colored stones, led by emerald, ruby, and sapphire, increased significantly. 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, increased 28%, with other cut, set, and unset, principally cultured pearls, increasing 48%, followed by emerald with a 15% increase.

PRICES

The U.S. price of 1.0-carat, D-flawless, investment-grade diamond fluctuated between $11,000 and $14,000 per carat, and at yearend was $12,750 per carat, a decrease of 6% for the year. 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.

The unit value of Colombian and Zambian emeralds continued at a median price of $1,400 to $1,500 per carat.

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 1984	Median price per carat[3] December 1983	Median price per carat[3] November 1984
0.04-0.08	G-I	VS_1	$400- $613	$490	$490
.04- .08	G-I	SI_1	400- 520	450	450
.09- .16	G-I	VS_1	450- 770	560	560
.09- .16	G-I	SI_1	410- 610	475	475
.17- .22	G-I	VS_1	700- 1,300	835	835
.17- .22	G-I	SI_1	500- 1,195	690	690
.23- .28	G-I	VS_1	775- 1,470	965	965
.23- .28	G-I	SI_1	650- 1,350	770	770
.29- .35	G-I	VS_1	875- 1,700	1,260	1,260
.29- .35	G-I	SI_1	735- 1,570	1,050	1,050
.46- .55	G-I	VS_1	1,450- 2,350	2,000	2,000
.46- .55	G-I	SI_1	900- 1,845	1,545	1,545
.69- .79	G-I	VS_1	1,800- 3,010	2,500	2,500
.69- .79	G-I	SI_1	1,400- 2,465	1,950	1,950
1.00-1.15[4]	D	FL	11,000-14,000	13,500	12,750
1.00-1.15	E	VVS_1	6,800- 8,200	7,500	7,500
1.00-1.15	G	VS_1	3,500- 5,200	4,200	4,200
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. 155, No. 2, Feb. 1984, p. 124, and v. 155, No. 12, Dec. 1984, p. 42. 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. 1984.

Table 2.—Prices of U.S. cut colored gem stones

Gem stone	Carat weight	Price range per carat in 1984	Median price per carat[1 2] January 1984	Median price per carat[1 2] November 1984
Amethyst	10	$8- $24	$17	$17
Aquamarine	5	75- 210	150	150
Citrine	10	8- 18	10	10
Emerald:				
Colombian	1	900-1,800	1,500	1,500
Zambian	1	750-2,200	1,400	1,400
Commercial, 2d quality[3]		550-1,500	550	550
Garnet, tsavorite	1	350-1,100	725	725
Ruby:				
Medium to better	1	500-2,200	1,200	1,200
Commercial, 2d quality[3]	1	330- 660	330	330
Sapphire:				
Medium to better	1	150-1,500	700	700
Commercial, 2d quality[3]	1	220- 440	220	220
Tanzanite	5	500- 950	762	762
Topaz	5	80- 400	210	210
Tourmaline, green	5	60- 200	132	132
Tourmaline, pink	5	50- 225	137	137

[1]Medium to better quality.
[2]Jewelers' Circular-Keystone. V. 154, No. 2, Feb. 1983, p. 87, and v. 155, No. 12, Dec. 1984, p. 44. 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.

FOREIGN TRADE

The declared customs value of U.S. imports of rough and polished natural diamond, excluding industrial diamond, increased 28% to $2.9 billion. Total polished diamond imports, principally from Belgium, 32%; Israel, 26%; and India, 22%; were valued at $2.6 billion. Imports in the over-0.5-carat category, mostly from Belgium, 36%; Israel, 24%; and Switzerland, 13%; increased 43% in value to $1.1 billion. Imports in the less-than-0.5-carat group, mostly from India, 36%; Belgium, 29%; and

Israel, 26%; increased 22% in value to $1.5 billion. Imports of rough natural diamond, 79% from the Republic of South Africa, increased 6% in caratage and 11% in value. A 3% decrease in South African carat value, from $336 to $325, was indicated.

The total value of emerald imports increased 15% to $155 million. The total value of ruby imports increased 19% to $80 million, and sapphire imports decreased 3% to $83 million. Average carat value decreased 45% for emerald to $35, influenced by large imports of cheap cut emeralds from India. Average carat values decreased 31% for ruby to $16 and 8% for sapphire to $23, both impacted principally by imports of cheap goods from Thailand.

Export value of all gem materials other than diamond decreased 20% to $53.6 million. Of this total, other precious and semiprecious stones, cut but unset, were valued at $27.7 million; other natural precious and semiprecious stones, not set or cut, $12.8 million; synthetic gem stones and materials for jewelry, cut, $4.7 million; pearls, natural, cultured, and imitation, not strung or set, $2.6 million; and other, $5.8 million. Reexports of all gem materials, other than diamond, increased 25% to $52.8 million. Reexport categories were precious and semiprecious stones, cut but unset, $33.3 million, and other, $19.5 million.

Table 3.—U.S. exports and reexports of diamond (exclusive of industrial diamond), by country

Country	1983		1984	
	Quantity (carats)	Value (millions)	Quantity (carats)	Value (millions)
Exports:				
Belgium-Luxembourg	103,106	$50.5	128,521	$65.0
Canada	16,134	10.0	19,043	11.0
France	4,094	9.9	2,153	7.1
Germany, Federal Republic of	3,626	5.0	3,677	3.7
Hong Kong	58,851	87.0	63,320	64.8
Israel	75,092	39.2	101,532	53.0
Japan	30,911	62.3	29,043	54.2
Singapore	5,996	11.5	3,734	9.2
Sweden	1,198	1.1	9	(1)
Switzerland	12,473	76.8	20,113	73.9
Thailand	3,504	3.3	3,813	2.4
United Arab Emirates	1,035	.7	29	(1)
United Kingdom	5,441	9.5	5,707	14.2
Other	2,912	6.0	4,468	4.4
Total	324,373	372.8	385,162	362.9
Reexports:				
Belgium-Luxembourg	[2]1,317,578	84.6	[2]1,072,640	57.4
Canada	10,145	1.7	7,834	.6
China	10,613	.1	17,784	.7
Germany, Federal Republic of	25,919	2.2	32,530	1.5
Hong Kong	83,800	28.0	27,244	17.6
India	226,987	6.1	228,205	6.5
Israel	212,557	34.7	126,400	26.3
Japan	92,934	11.0	98,398	8.5
Netherlands	54,407	4.7	21,793	3.4
Switzerland	31,667	43.7	110,486	46.3
United Kingdom	73,474	26.9	93,442	32.6
Other	24,095	5.9	50,592	10.3
Total	2,164,176	249.6	1,887,348	211.7

[1]Less than 1/10 unit.
[2]Artificially inflated in 1983 by auction of approximately 1 million carats of U.S. Government stockpile diamond stones with subsequent reexports as gem stones to Belgium-Luxembourg. In 1984, 1 million carats was similarly auctioned and reexported to Belgium-Luxembourg and India.

Table 4.—U.S. imports for consumption of diamond, by kind and country

Kind and country	1983 Quantity (carats)	1983 Value (millions)	1984 Quantity (carats)	1984 Value (millions)
Rough or uncut, natural:[1]				
Belgium-Luxembourg	111,211	$14.7	160,100	$32.8
Brazil	2,290	.7	1,431	.3
Cape Verde	3,400	.1	--	--
Colombia	21,413	.1	216	.2
Congo	8,690	2.7	12,977	4.4
Dominican Republic	2,331	.1	--	--
Guyana	4,989	.3	2,475	.1
Israel	9,651	1.6	14,880	4.7
Netherlands	1,585	2.1	4,675	4.1
South Africa, Republic of	729,547	245.3	794,912	258.3
Switzerland	13,035	2.6	7,748	7.2
United Kingdom	41,234	13.4	22,125	4.6
Venezuela	65,908	3.2	34,811	2.3
Other	10,366	5.8	28,163	6.9
Total	1,025,650	292.7	1,084,513	325.9
Cut but unset, not over 0.5 carat:				
Belgium-Luxembourg	1,126,400	358.7	1,424,655	433.6
Brazil	5,530	.8	20,567	6.0
Canada	9,832	2.5	38,567	5.2
Hong Kong	29,957	8.9	100,017	20.3
India	2,153,148	440.8	3,107,794	544.8
Israel	1,047,471	342.4	1,113,127	399.5
Malaysia	5,215	1.8	21,949	7.8
Netherlands	19,802	8.6	56,924	23.5
South Africa, Republic of	45,187	24.3	38,301	23.8
Switzerland	44,864	18.0	56,670	23.8
United Kingdom	31,417	17.2	33,332	15.3
Other	[r]70,059	[r]17.4	44,030	16.0
Total	4,588,882	1,241.4	6,055,933	1,519.6
Cut but unset, over 0.5 carat:				
Belgium-Luxembourg	281,064	284.2	410,638	379.8
Hong Kong	9,135	23.8	13,697	22.5
India	58,871	18.1	83,415	23.2
Israel	165,641	132.1	342,221	259.5
Netherlands	10,841	18.8	32,846	33.6
South Africa, Republic of	33,936	47.4	61,595	89.8
Switzerland	27,364	111.1	56,618	134.0
United Kingdom	29,544	58.8	34,643	68.9
Other	33,501	47.0	51,200	48.6
Total	649,897	741.3	1,086,873	1,059.9

[r]Revised.
[1]Includes some natural advanced diamond.

Table 5.—U.S. imports for consumption of natural precious and semiprecious gem stones, other than diamond, by kind and country

Kind and country	1983 Quantity (carats)	1983 Value (millions)	1984 Quantity (carats)	1984 Value (millions)
Emerald:				
Argentina	550	([1])	12,474	$1.3
Belgium-Luxembourg	34,027	$1.6	10,092	2.8
Brazil	174,314	8.0	197,367	13.8
Colombia	203,485	44.1	271,559	48.9
France	7,806	2.2	11,456	2.5
Germany, Federal Republic of	28,293	3.7	52,883	2.4
Hong Kong	44,289	6.1	114,630	11.3
India	1,274,765	12.8	3,220,565	16.7
Israel	87,145	17.9	162,559	19.6
Japan	8,415	2.0	28,516	1.4
Paraguay	--	--	25,790	([1])
South Africa, Republic of	7,979	.3	3,118	.1
Switzerland	41,518	17.4	103,859	20.8
Taiwan	78,853	([1])	2,758	([1])
Thailand	64,590	2.2	116,812	4.5
United Kingdom	36,273	11.0	20,008	4.6
Other	[r]24,697	[r]4.8	55,709	3.9
Total	2,116,999	134.1	4,410,155	154.6

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	1983 Quantity (carats)	1983 Value (millions)	1984 Quantity (carats)	1984 Value (millions)
Ruby:				
Austria	163,361	$.2	75,977	$.1
Belgium-Luxembourg	6,930	.9	14,246	1.9
Brazil	6,594	.2	10,712	.1
Colombia	37,070	.2	948	.2
France	4,393	1.6	11,277	1.4
Germany, Federal Republic of	53,343	1.5	65,703	1.6
Hong Kong	125,447	4.9	71,857	5.5
India	230,186	3.3	226,782	1.8
Israel	28,376	1.2	99,663	2.1
Japan	4,168	.1	33,146	.6
Switzerland	221,416	8.8	81,943	12.6
Thailand	1,840,758	36.0	4,107,406	43.0
United Kingdom	19,472	4.1	21,208	6.1
Other	r45,158	r3.8	32,977	2.7
Total	2,786,672	66.8	4,853,845	79.7
Sapphire:				
Australia	43,493	.6	13,415	.4
Austria	44,945	.1	1,186	(1)
Belgium-Luxembourg	28,462	1.0	20,436	1.8
Brazil	11,080	(1)	13,209	.1
Canada	15,146	.6	9,260	.6
Colombia	14,656	.1	1,647	(1)
France	11,026	2.5	11,185	2.5
Germany, Federal Republic of	121,800	2.5	67,298	1.8
Hong Kong	167,305	9.9	98,180	3.8
India	130,481	2.7	175,855	1.7
Israel	48,966	.8	71,286	1.6
Japan	8,317	.3	45,737	1.3
Korea, Republic of	5,245	.1	22,478	.1
Singapore	12,106	.1	22,955	.8
Sri Lanka	48,377	4.3	28,999	2.7
Switzerland	244,025	11.8	87,879	15.7
Thailand	2,456,096	32.7	2,917,584	39.2
United Kingdom	33,959	8.3	36,973	6.6
Other	r25,068	r6.8	32,816	2.3
Total	3,470,553	85.2	3,678,378	83.0
Other:				
Rough, uncut:				
Australia	NA	1.0	NA	1.9
Belgium-Luxembourg		.4		.4
Brazil		11.1		14.0
Canada		1.4		.1
Colombia		7.3		10.3
Hong Kong		.9		.6
Nigeria		--		2.6
Pakistan		.5		.5
South Africa, Republic of		.3		1.6
Switzerland		.7		.5
United Kingdom		.2		.6
Zambia		.9		.4
Other		r2.0		2.3
Total	NA	26.7	NA	35.8
Cut, set and unset:				
Australia	NA	2.1	NA	2.8
Brazil		12.5		32.7
Canada		.1		1.3
China		2.5		5.0
Germany, Federal Republic of		11.8		12.0
Hong Kong		22.6		20.4
India		4.5		6.1
Japan		152.8		240.7
Switzerland		4.5		.7
Taiwan		4.8		5.4
Thailand		2.6		2.8
United Kingdom		.8		1.5
Other		r5.9		5.6
Total	NA	227.5	NA	337.0

rRevised. NA Not available.
[1]Less than 1/10 unit.

Table 6.—Value of U.S. imports of synthetic and imitation gem stones, including pearls, by country

(Million dollars)

Country	1983	1984
Synthetic, cut but unset:		
Austria	1.3	0.8
France	1.0	1.4
Germany, Federal Republic of	6.1	5.5
Japan	1.0	1.4
Korea, Republic of	6.7	9.4
Switzerland	3.2	3.6
Other	1.2	1.7
Total	20.5	23.8
Imitation:		
Austria	10.9	17.4
Czechoslovakia	1.2	1.8
Germany, Federal Republic of	4.4	6.0
Japan	2.4	4.5
Other	1.4	2.7
Total	20.3	32.4

Table 7.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1983		1984	
	Quantity	Value	Quantity	Value
Diamonds:				
Rough or uncut[1]	1,026	292,687	1,085	325,851
Cut but unset	5,239	1,982,686	7,143	2,579,466
Emeralds: Cut but unset	2,117	134,130	4,410	154,644
Coral: Cut but unset, and cameos suitable for use in jewelry	NA	2,584	NA	3,120
Rubies and sapphires: Cut but unset	6,257	151,931	8,532	162,677
Marcasites	NA	121	NA	152
Pearls:				
Natural	NA	3,019	NA	2,823
Cultured	NA	162,833	NA	240,439
Imitation	NA	3,015	NA	6,171
Other precious and semiprecious stones:				
Rough, uncut	NA	26,700	NA	35,792
Cut, set and unset	NA	58,983	NA	90,421
Synthetic:				
Cut but unset[2]	36,787	18,948	52,484	21,368
Other	NA	1,536	NA	2,410
Imitation gem stones	NA	17,281	NA	26,182
Total	XX	2,856,454	XX	3,651,516

NA Not available. XX Not applicable.

[1]Includes 16,799 carats of other natural diamond, advanced, valued at $759,200 in 1983, and 2,084 carats valued at $700,100 in 1984.

[2]Quantity in thousands of stones.

WORLD REVIEW

De Beers Consolidated Mines Ltd.'s sales of rough diamond through the Central Selling Organization was $1.6 billion, virtually the same as that of 1983. The value of De Beers' stocks of rough diamond has increased from $936 million in 1980 to $2.0 billion in 1984, even though world retail jewelry sales had set new records every year. The 1983 retail value of world diamond jewelry sales increased 9% to $21.6 billion, representing 45 million pieces containing 9.2 million carats of gem diamond. The largest consuming markets were the United States, 36%, and Japan, 19%, with 50% of their diamond needs imported from India, the world's largest processor of small diamonds.

Angola.—Angola, whose diamonds are considered by the market to be "nice goods," is ranked among the top three countries in the world in terms of quality.

Although diamonds have been found over much of Angola in alluvial and eluvial deposits, Companhia de Diamantes de Angola (DIAMANG), 77% owned by the Angolan Government, has concentrated its prospecting and exploitation in a 50,000-square-kilometer concession in Lunda Norte Province in northeast Angola near the Zairian border. A labor force of 17,000 workers and dozens of mining and treatment sites, complicated by smuggling and illicit operations, continued to present major problems at the mining headquarters at Dundo. Diamond production was estimated at over 1 million carats in 1984, 97% of which was gem or near-gem quality. In 1983, the three mining divisions' production was Lucapa, 443,000 carats; Andrada, 295,000 carats; and Cuango, 296,000 carats. In late 1984, the Angolan Press Agency said that 124 people were on trial for smuggling, which caused the loss of about $140 million to DIAMANG. Of these, 1 person was sentenced to death, and 122 others were jailed. The trials were a major attempt by the Angolan Government to curb the smuggling.[2]

Australia.—Argyle Diamond Mines Joint Venture produced 5.7 million carats of diamond in its second year of alluvial mining operations, an 8% decline compared with 1983 production, reflecting the expected depletion of the higher grade alluvial material. The 1985 production was projected by Argyle to decline as the remaining alluvial material is mined out. Although much of the Argyle infrastructure was already in, construction was initiated at the beginning of 1984 for the $400 million mine and treatment plant on the AK-1 kimberlite project. The primary crushing plant was delivered in September with planned test operations of the mine and concentrator in mid-1986. Design capacity called for the treatment of 3 million metric tons of ore annually to produce over 20 million carats of diamond, 45% of which will be gem and near-gem quality, with the balance industrial quality. The AK-1 pipe is estimated to contain 150 million tons of kimberlite with a grade of 6.5 carats per ton.[3]

CRA Ltd. and Ashton Mining Ltd. established a diamond marketing organization in Antwerp, Belgium. It was to be run by Argyle Diamond Sales Ltd. (ADS), and was owned 60% by CRA and 40% by Ashton. The organization will eventually handle some 6 million carats of diamond per year. From June 1984, ADS was responsible for marketing 25% of the cheap-gem and industrial diamonds, which will increase to a level of 6 million carats per year when the AK-1 project comes on-stream in 1986. Northern Mining Corp. NL, the other partner in Argyle, had been previously purchased by the Western Australian government and in 1984 was selling its 5% share of production through a Belgian agent. A $65 million public offering of the Western Australian government share was made through the Western Australian Development Corp.[4]

The Bow River joint venture, 20 kilometers from the Argyle project, composed of Freeport of Australia Pty. Inc. and Gem Exploration and Minerals Ltd., recovered 0.35 carat per ton and 0.56 carat per ton from two of the four terraces sampled during 1983-84.[5]

Three equal joint venture members, Ashton, AOG Minerals Ltd., and Aberfoyle Ltd. have delineated a potentially major new diamond province in the Coanjula area of the Northern Territory of Australia near the border of Queensland. Diamonds were discovered in 15 of the 22 first priority geophysical targets.[6]

Stockdale Prospecting Ltd. and United Nickel Ltd. were drilling the Jubilee diamond prospect near Kalgoorlie, Western Australia.[7]

Australia produced over 80% of the world's opal, and over 70% of the world's uncut sapphire. In the last 15 years, production has increased to a total value in 1984 of over $50 million. Small syndicates and individuals operated opal mines at Coober Pedy and Andamooka in South Australia, at Lightning Ridge and White Cliffs in New South Wales, and in Queensland. Sapphire production in 1984 was from the alluvial gravels of the Glen Innes-Inverell district in New South Wales and from the Anakie district in Queensland. The heat treatment of the steel-blue stones, as a method of enhancement, has greatly improved the quality in the international market.[8]

Belgium.—The World Diamond Congress held in Antwerp reported through the Diamond High Council that diamond prices were stronger, and that exports to the principal consuming countries, the United States, Switzerland, and Japan, were up substantially compared with those of 1983. Sales of Belgian, Israeli, and Soviet diamonds have benefitted from the movement in demand toward higher priced stones at the expense of the cheaper Indian goods.[9]

Botswana.—Botswana was the world's second largest producer of diamonds with a total of 12.9 million carats, a 20% increase compared with that of 1983. This included 5.8 million carats of gem diamond. The richness of the Jwaneng Mine, with over 149 carats recovered from 100 metric tons of ore, far surpassed any of De Beers' operations or joint ventures. In Botswana, 15.2 million tons of diamondiferous kimberlite was processed to produce 12.9 million carats of diamonds. The Jwaneng Mine produced 7.5 million carats, Orapa produced 4.7 million carats, and the Letlhakane, 0.7 million carats.[10]

Brazil.—Extratifera de Diamantes Brasil S.A. Exportacao de Comercio was investing $6.9 million in an alluvial diamond deposit in Romaria, Minas Gerais. Capacity was to be 240 cubic meters per hour of gravel with a recoverable content of 200 carats of diamond per day. When fully operational in 1985, the mine will produce 72,000 carats of diamond per year, 76% gem quality and 24% industrial.[11]

According to the Brazilian Department of Trade and Industry, Brazilian production of diamond almost doubled in 1983 to more than 1 million carats. About 60% of the diamond came from mines in the States of Minas Gerais, Matto Grosso, Para, Bahia, and the territory of Roraima.[12]

Minerção Tejucana S.A. was expanding its operations in Minas Gerais in 1984, with a fifth dredge on an alluvial diamond deposit with a capacity of 84,000 carats of diamond per year. Morro Vermelho Ltda. was developing its reserves and had a pilot plant in operation on its alluvial diamond deposit in Cuiaba, Matta Grosso. Design production was 60,000 carats per year.[13]

Brazil is a major world producer of gem stones, other than diamond. Exports in 1982 included over 1.1 million kilograms of crude and worked agate, 197,000 kilograms of crude and worked amethyst, 42,000 kilograms of crude and worked emerald, 32,000 kilograms of citrine, 26,000 kilograms of crude and worked aquamarine, and 400,000 kilograms of other crude and worked gem stones.[14]

Canada.—Two companies, Monopros Ltd. and BP Resources (Canada) Ltd., were actively prospecting for diamond in northeastern Ontario. Kimberlite has been found, not only as boulders in gravel, but as outcrops in the Kirkland Lake area of Ontario. In British Columbia, kimberlite has been found on two properties, and one gem-quality diamond measuring 0.43 millimeter was identified.[15]

Central African Republic.—Diamond production, the principal mining industry of the Central African Republic, improved in 1984. Although smuggling and illicit mining continued to be a problem, the High Commissioner of Mines and Geology announced a plan of stricter controls of the 40,000 workers, 200 collectors, and 12 purchasing offices. Production increased 19% to 350,000 carats, and it was planned to reach 530,000 carats in 1985.[16]

China.—The China Nonmetallic Minerals Industry Corp. estimated that China's annual production of diamond was less than 1 million carats, of which 17% was of gem quality. Mines were located in three Provinces: Liaoning, Hunan, and Shandong. Liaoning's Binhai Mines in Fu County was the best source of larger high-quality gem stones. Shandong has one principal placer mine, Chengjiafu near Tancheng, where stones of 96, 124, and 159 carats have been found since 1979. A number of smaller placer mines also were operated. The Changde Mine in Changde County, Hunan, began production in the early 1970's of principally industrial stones, with a recovery of 0.25 carat per metric ton. Kimberlite deposits were also identified in Guangxi and Guizhou.[17]

Colombia.—Empresa Colombiana de Minas and the United Nations Development Fund announced in 1983 a $2.5 million, 30-month exploration program for emeralds and improvement of mining techniques. Improved reserves at the Muzo Mine, 90 miles northwest of Bogota, and at the Coscuez and Peeas Blancas Mines, was to be attempted.[18]

Ghana.—Ghana Consolidated Diamonds Ltd. produced 340,000 carats of diamond in 1983, of which 10% was gem quality and the balance industrial quality. Reserves at Akwatia are nearing exhaustion, and production has declined progressively. The company will initiate production at its $12 million Birim River placer project in early 1985, in which diamond reserves were estimated at 20 million carats. Design capacity was based on an annual extraction rate of 800,000 cubic meters of gravel, with a recovery of 1 million carats of diamond.[19]

Guinea.—The $86.6 million Société Mixte Aredor-Guinea alluvial diamond mine initiated operations in April 1984. The mine is at Banankoro near Kissidougou in southeast Guinea near the Sierra Leone border.

Proven diamond reserves are 2.5 million carats, 90% of which is of gem quality having an average size of 0.53 carat. The average net selling price for the first production consignment was higher than expected, $248 per carat compared with an estimated price of $225 per carat. Diamond production was less than expected in the first 8 months of operation through December 1984, with 70,000 carats produced. Dragline operation encountered large boulders, clay beds, and undulating bedrock, which impeded operations. The latter problem required an increase in washing plant capacity from 400,000 cubic meters per year to 750,000 cubic meters per year. The target production level of 200,000 carats per year was to be achieved by July 1985.[20]

In 1984, diamond prospecting rights were awarded to several other companies in Guinea as follows: Brady Nixon, 10,000 square kilometers in Kindia-Telemele; ADG, 39,000 square kilometers in Faranah-Kouroussa; and Gulf African Enterprises, 9,000 square kilometers in Nzerekore-Yomou.[21]

India.—India has the world's leading diamond cutting and polishing industry. Centered in Surat, Navsari, and Bombay, approximately 300,000 workers operate in the cottage industry. Low wages enabled India to compete very favorably on the world market. In 1984, 28 million carats of rough cheap-gem material, commonly called "Indian goods," was processed as cuttables. India apparently is consuming more than the estimated 26 million carats in the world supply, and is using a substantial portion of the natural industrial stones; 38 million carats in 1984. The Indian Ministry of Commerce and the Hindustan Diamond Co., Ltd. have agreed to develop a sawn-goods industry to provide more cutting material for the cottage industry. Sawn goods are being processed mainly by Belgium and Israel, and their excess supply could be made available to India, especially for the cheaper and small sizes. India's exports of cut and polished diamonds were 5 million carats with a value of $584 million.[22]

Israel.—Imports of rough diamond were $881 million, a 13% increase compared with that of 1983. Exports of cut and polished diamonds were $1,035 million, a 3.5% decrease compared with that of 1983. Israel produced more small stones and larger stones than in the recent past, and its traditional medium range was less in demand. It also had firmly established itself as the main source of fancy cuts, especially marquises. The trend toward movement of manufacturing activities to smaller plants continued. Sales to the United States represented about one-half of Tel Aviv's diamond exports.[23]

Ivory Coast.—The Ivory Coast Syndicate (ICS) recently completed a second field program on its 1,800-square-kilometer concession in the Sanwi region in the southwest. ICS consisted of three Canadian companies, Eden Roc Mineral Corp., Golden Rule Resources Inc., and Dibi Resources Inc., which together held a 49% interest, with the state-owned Société pour le Développement Minière de La Cote d'Ivoire holding the balance. Eden Roc recommended diamond drilling in the Afema sector, pilot plant processing of Asupiri River alluvials, and bulk sampling of alluvials where a diamond occurrence was located. Further ground work over the anomalies also was recommended.[24]

Liberia.—Liberia's diamond production declined 27% to 240,000 carats, 45% of which was gem quality, and the balance industrial quality. Total value was $11 million, a 36% decrease compared with the $17.2 million in 1983.[25]

More than one-half of the diamonds exported from Liberia were believed to have originated in Sierra Leone and Guinea, because of the availability of hard currency in Liberia. Exporters must have a Government license.[26]

Namibia.—DeBeers' CDM (Pty.) Ltd. continued mining operations at a reduced rate and produced 930,200 carats of diamond from the beach placers, a 3% decrease compared with that of 1983. However, overburden stripped increased to 19.3 million tons, a 12% increase compared with that of 1983. A bedrock vacuum cleaning unit was commissioned with encouraging results. Seawall construction had advanced the high-water mark to 260 meters seaward, and mining was taking place 200 meters beyond the original high-water mark. The Namibian Government increased the tax on diamond mining to 55%, and CDM pointed out that its tax burden in 1984 will climb to 75% of profits.[27]

Sierra Leone.—British Petroleum Co. Ltd. sold its 49% interest in Sierra Leone's National Diamond Mining Co. (DIMINCO) for $8.5 million. DIMINCO is now virtually state-owned. Negotiations for the financing of the $100 million Kono kimberlite project collapsed at yearend. An estimated 70% of Sierra Leone's diamond production is gem quality, and smuggling and illicit mining has intensified.[28]

South Africa, Republic of.—De Beers' Consolidated Mines represented 94% of South African diamond production, and mined 22.1 million tons of ore with a recovery of 9.5 million carats of diamond. The Finsch diamond mine, the Republic of South Africa's largest and richest source of diamond, treated 5.1 million metric tons of ore and produced 4.9 million carats, 65% gem quality, and the balance industrial quality. The Finsch ore grade of 95 carats of diamond per 100 metric tons of ore was the highest of all other South African diamond mines. Finsch underground mine development has progressed to the 680-meter level. As the mine shifted from open pit to underground mining, the last phases of open pit mining produced a lower grade material, and resulted in an ore grade of 95 carats per 100 metric tons in 1984, compared with 100 carats per 100 metric tons in 1983.[29]

De Beers' Namaqualand Div. recovered high-quality gem diamonds from marine alluvial deposits along the Namaqualand coast similar to those produced by CDM north of the Orange River in Namibia. Production was from farm concessions Tweepad, Karreedoornvlei, Koingnass, and Langhoogte. The Annex Kleinzee plant has been temporarily suspended since 1982. De Beers was awarded several prospecting leases off the Namaqualand coast, totaling over 9,000 square kilometers in 1984.

Ocean Diamond Mining Ltd. initiated a beach mining project off the coast of Namibia near CDM operations. An air-lift suction dredge will excavate diamondiferous gravels to a washing plant. The company expected to produce about 3,000 carats per month of over 95% gem-quality stones.[30]

Tanzania.—The famous Mwadui diamondiferous kimberlite mine in Tanzania is one of the largest kimberlites ever found in the world. Production of diamond, 70% gem quality, decreased to 262,000 carats in 1984. Results from a completed $30 million mineralogical survey performed by Geosurvey Ltd. of Nairobi, Kenya, indicated the presence of new diamond-bearing deposits. The Dar Madine al-Umma Ltd., a private Egyptian-Arab mineral resource development company, was considering the development of the newly found diamond resources.[31]

U.S.S.R.—Soviet annual diamond production in recent years has been constant at a level of 10.7 million carats, 40% of which was gem quality and cheap Indian goods, with the balance industrial stones. A major diamond mining complex on the Lena River had been temporarily closed for modernization for some time and was reopened in 1984. The new Anabar diamond placer mine on the Ebelyakh River, long delayed because of the severe weather conditions and permafrost, was commissioned in 1983.[32]

A large diamond weighing 291.6 carats was found at the Udachnaya Mine in the Yakutsk A.S.S.R. This was the second largest stone ever found in the U.S.S.R., and it was likely to remain in the country.[33]

The U.S.S.R. heavily sold cut diamonds, especially good-quality rounds in medium sizes, mainly in the Antwerp market, during two periods in May and October 1984. This caused considerable disruption in the cutting industries of Belgium and Israel, which produced comparable goods, because Soviet prices were 10% to 15% below market levels. A conservatively estimated $300 million in cut stones entered Europe, $200 million of which came through Antwerp, and generated badly needed foreign exchange for the U.S.S.R.[34]

Zaire.—Zaire became the world's largest producer of diamonds with a total of 18.5 million carats, a 54% increase compared with that of 1983. This included 5.2 million carats of gem and cheap gem quality. Artisanal mining almost doubled its production from 5.9 to 10.7 million carats. Production from the Bakwanga deposits has enabled Zaire to be the world's largest producer of industrial diamond (Congo boart) since the alluvial deposits were discovered in 1918. Société Minière de Bakwanga's (MIBA) new 100,000-cubic-meter-per-month bucket dredge was in production, and had the capacity to produce 1 million carats of diamond per year. MIBA's 1983 production was 5.5 million carats and was sold to Britmond-Zaire, a De Beers' affiliate, for $48 million. Only 3.5% of this production was classified as gem quality, but it sold for $21 million, 44% of MIBA's revenue.

Table 8.—Diamond (natural): World production, by country[1]

(Thousand carats)

Country	1980 Gem	1980 Industrial	1980 Total	1981 Gem	1981 Industrial	1981 Total	1982 Gem	1982 Industrial	1982 Total	1983[p] Gem[2]	1983[p] Industrial	1983[p] Total	1984[e] Gem[2]	1984[e] Industrial	1984[e] Total
Angola	1,110	370	1,480	1,050	350	1,400	915	310	1,225	1,003	31	1,034	970	30	1,000
Australia	--	48	48	21	184	205	251	306	557	2,770	3,385	6,155	2,560	3,130	[3]5,690
Botswana	765	4,336	5,101	744	4,217	4,961	1,165	6,604	7,769	4,829	5,902	10,731	5,810	7,104	[3]12,914
Brazil[4]	253	414	667	163	926	1,089	80	450	530	200	800	1,000	220	880	1,100
Central African Republic	227	115	342	209	103	312	186	91	277	230	65	295	[3]270	[3]80	[3]350
China[e]	[r]180	[r]720	[r]900	[r]190	[r]760	[r]950	[r]200	[r]800	[r]1,000	[r]200	[r]800	[r]1,000	200	800	1,000
Ghana	126	1,132	1,258	85	751	836	68	616	684	34	306	340	35	315	350
Guinea[e]	12	26	38	12	26	38	13	27	40	[r]23	[r]17	[r]40	[3]34	[3]14	[3]48
Guyana	4	6	10	4	6	10	[e]5	[e]6	[e]11	5	7	12	5	5	10
India	12	2	14	14	2	16	11	2	13	12	2	14	12	2	14
Indonesia[e]	3	12	15	3	12	15	3	12	15	5	22	27	5	22	27
Lesotho	50	4	54	49	4	53	39	3	42	--	--	--	--	--	--
Liberia	123	175	298	132	204	336	170	263	433	132	198	330	[3]108	[3]132	[3]240
Namibia	1,482	78	1,560	1,186	62	1,248	963	51	1,014	915	48	963	884	46	[3]930
Sierra Leone	317	275	592	208	97	305	203	87	290	242	103	345	240	105	345
South Africa, Republic of:															
Finsch Mine	465	2,442	2,907	1,002	3,463	4,465	847	3,003	3,850	1,765	3,278	5,043	1,714	3,184	[3]4,898
Premier Mine	407	1,632	2,039	510	1,530	2,040	615	1,845	2,460	800	1,844	2,644	765	1,785	[3]2,550
Other De Beers' properties[5]	1,550	1,489	3,039	1,603	1,069	2,672	1,359	906	2,265	1,400	569	1,969	1,452	593	[3]2,045
Other	390	145	535	314	35	349	521	58	579	589	66	655	585	65	650
Total	2,812	5,708	8,520	3,429	6,097	9,526	3,342	5,812	9,154	4,554	5,757	10,311	4,516	5,627	10,143
Tanzania	137	137	274	110	107	217	[e]100	[e]120	[e]220	183	78	261	182	78	260
U.S.S.R.[e]	2,250	8,600	10,850	2,100	8,500	10,600	2,100	8,500	10,600	3,700	7,000	10,700	4,300	6,400	10,700
Venezuela	238	483	721	102	388	490	[e]99	[e]394	[e]493	45	234	279	75	175	250
Zaire	345	9,890	10,235	450	8,550	9,000	[e]450	[e]8,550	[e]9,000	3,355	8,627	11,982	5,169	13,290	[3]18,459
World total	[r]10,446	[r]32,531	[r]42,977	[r]10,261	[r]31,346	[r]41,607	10,363	33,004	43,367	22,437	33,382	55,819	25,595	38,235	63,830

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

[1]Table includes data available through July 8, 1985. 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 (1980-84), Central African Republic (1980-84), Guinea (1984), Liberia (1980, 1981, 1984), Sierra Leone (1980-81), and Venezuela (1980-81), 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]Series changed from estimated data to reported data to conform with official Brazilian Government published data.

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

The Zairian Government's 1982 decree liberalizing diamond production and marketing by private Zairians, resulted in some abatement of illegal mining and smuggling. Total diamond exports increased from $72 million in 1982 to $139 million in 1983. The Société Zairoise de Commercialisation de Minerais was abolished by Presidential decree in 1984, and as a result, both MIBA and La Générale des Carrières et des Mines du Zaire were to be responsible for their own marketing. Britmond is the sole buyer of MIBA diamonds with a floor price of $8.55 per carat. Britmond stated that in the first half of 1984 the market value of the diamonds was below the floor price, attributing the decline to the theft of the more valuable stones, a continuing problem.[35]

TECHNOLOGY

Geological research of the West Kimberley Province in Western Australia indicated that diamonds are found in lamproites as well as kimberlites. Seventy new discoveries of lamproite on the southwest border of the Kimberley craton have been made. This was the first recognition of a primary terrestrial source of diamond other than kimberlite. Different properties and tectonic settings for these two diamond-bearing rocks has given a new and expanding geologic horizon, with different major elements, trace elements, indicator minerals, and geophysical responses.[36]

A research team at Cornell University has used a Q-switched YAG laser beam to melt a diamond surface at high pressure. This experiment was the first phase in investigations to determine whether molten carbon can exist in the earth's interior.[37]

Microscopic diamonds, the largest of which was about 30 micrometers, have been formed during the gas-phase decomposition of a mixture of methane and hydrogen in a microwave plasma, by the Hitachi Research Laboratory, Ibaraki, Japan. Diamond, a very good electrical insulator and heat conductor, could be a very important substrate for integrated circuits.[38]

The General Electric Research and Development Center in Schenectady, New York, produced gem-quality synthetic jadeite with a diamond-making press in samples large enough to be cut into gems.[39]

Soviet scientists at Kharkov University, developed a geobotannical prospecting method for location of diamondiferous kimberlites. Some well-known deposits in the Yakut A.S.S.R. were tested and showed excellent geological delineation.[40]

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[1]Physical scientist, Divison of Industrial Minerals.

[2]Helmore, R. Diamond Mining in Angola. Min. Mag. (London), v. 150, No. 6, June 1984, pp. 530-537.

Industrial Minerals (London). Company News & Mineral Notes. No. 208, Jan. 1985, p. 70.

[3]Mining Journal (London). Mining Annual Review—1984. June 1984, p. 327.

CRA Ltd. First Quarter 1985 Press Release. Melbourne, Victoria, Australia, Apr. 30, 1985, 2 pp.

[4]Industrial Minerals (London). Marketing Australian Diamonds. No. 199, Apr. 1984, pp. 9-10.

———. World of Minerals. Public Offered 5% Stake in Argyle. No. 204, Sept. 1984, p. 15.

[5]———. Company News & Mineral Notes. No. 207, Dec. 1984, pp. 66-67.

[6]Mining Journal (London). Industry in Action. V. 303, No. 7792, Dec. 21, 1984, p. 433.

[7]Diamond Intelligence Briefs (Geneva). V. 1, No. 1, Nov. 26, 1984, p. 5.

[8]Page 327 of first work cited in footnote 3.

[9]Pages 28 and 29 of second work cited in footnote 4.

[10]De Beers' Consolidated Mines Annual Report 1984. Pp. 24-25.

[11]U.S. Embassy, Rio De Janeiro, Brazil. State Dep. Airgram A-6, May 22, 1984, p. 30.

[12]Industrial Minerals (London). World of Minerals. Brazilian Diamond Output Surges. No. 201, June 1984, p. 9.

[13]Mining Magazine (London). V. 152, No. 1, Jan. 1985, p. 72.

[14]U.S. Embassy, Rio De Janeiro, Brazil. State Dep. Airgram A-7, May 23, 1984, p. 10.

[15]Mining Journal (London). Industry in Action. V. 304, No. 7797, Jan. 25, 1985, p. 59.

Northern Miner. V. 70, No. 49, Feb. 14, 1985, p. 20.

[16]Pages 395 and 396 of first work cited in footnote 3.

Mines Information (Bangui, Central African Republic). Bulletin Mensuel Du Haut Commissariat Aux Mines & a La Geologie. No. 6, Feb. 1985, p. 14. Available from the Central African Republic Government.

[17]Green, K. China's Gem Diamonds—Mystery Shrouds the Industry, But It May Have a Sparkling Future. China Bus. Rev., v. 12, No. 3, May-June 1985, pp. 11-13.

[18]Page 313 of first work cited in footnote 3.

[19]Mining Journal (London). Ghana To Produce More Diamonds. V. 303, No. 7778, Sept. 14, 1984, p. 186.

[20]Diamond Intelligence Briefs (Geneva). Behind the Scenes of Guinea's Aredor Project. V. 1, No. 3, Jan. 5, 1985, p. 17.

[21]Work cited in second part of footnote 2.

[22]U.S. Embassy, New Delhi, India. State Dep. Airgram A-11, Mar. 5, 1984, p. 23.

Jewellery News Asia. Sawn Diamonds A "Priority." Mar. 1985, p. 31.

[23]Page 15 of work cited in footnote 20.

[24]Mining Journal (London). Industry in Action. V. 303, No. 7779, Sept. 21, 1984, p. 200.

[25]Liberian Ministry of Lands, Mines and Energy. 1984 Annual Report. 3 pp.

[26]U.S. Embassy, Monrovia, Liberia. 1984 Economic Trend Report. State Dep. Airgram A-18, Sept. 28, 1984, p. 8.

[27]Page 24 of work cited in footnote 10.

Mining Journal (London). Mining Week. CDM Baulks at Diamond Tax Increase. V. 303, No. 7769, July 13, 1984, p. 3.

[28]Industrial Minerals (London). BP Cuts Diamond Ties. No. 206, Nov. 1984, pp. 13-14.

———. Company News & Mineral Notes. No. 208, Jan. 1985, p. 70.

[29]Page 21 of work cited in footnote 10.

[30]Industrial Minerals (London). Company News & Mineral Notes. No. 204, Sept. 1984, p. 119.

[31]Diamond Intelligence Briefs (Geneva). Arab Money To Boost Tanzania Mining. No. 3, Jan. 5, 1985, p. 17.

[32]Industrial Minerals (London). Company News & Mineral Notes. No. 200, May 1984, p. 187.

Page 477 of first work cited in footnote 3.

[33]I. Hennig & Co. Ltd. Newsletter No. 6. May 1985, p. 5.

[34]Mining Journal (London). Industry in Action. U.S.S.R. Gem Exports Hit World Prices. V. 303, No. 7790, Dec. 7, 1984, p. 401.

[35]———. Zaire Makes Some Progress. V.303, No. 7768, July 6, 1984, pp. 2-3.

U.S. Embassy, Kinshasa, Zaire. State Dep. Telegram 12356, Oct. 18, 1984, sec. 1 and 7.

[36]Atkinson, W. J., C. Smith, and J. Boxer. The Discovery and Evaluation of the Ellendale and Argyle Lamproite Diamond Deposits, Kimberley Region, Western Australia. Pres. at SME-AIME Fall Meeting, Denver, CO, Oct. 24-26, 1984. Soc. Min. Eng. AIME preprint 84-384, 13 pp.

[37]Chemical & Engineering News. Cornell Team Uses Laser To Melt Diamond Surface. V. 62, No. 36, Sept. 3, 1984, p. 25.

[38]———. V. 63, No. 1, Jan. 7, 1985, p. 48.

[39]Science News. Pressing the Jadeite Look of Gems. V. 126, No. 24, Dec. 15, 1984, p. 376.

[40]Engineering and Mining Journal. V. 185, No. 4, Apr. 1984, p. 13.

Gold

By J. M. Lucas[1]

Despite the effects of lower 1984 gold prices compared with that of 1983, domestic gold mine production increased for the fifth consecutive year as new gold mines began production and established mines maintained or improved existing capacity.

In both the United States and overseas, the search for new gold deposits and the development of recent discoveries continued at about the same level of intensity as in 1983. The strong momentum of gold exploration activity was especially evident when compared with that of most other mineral commodities.

The demand for gold and gold products in the international marketplace forged ahead. Among the principal end-use sectors, the jewelry and arts category registered the greatest increase in consumption.

Table 1.—Salient gold statistics

	1980	1981	1982	1983	1984
United States:					
Mine production thousand troy ounces	970	1,379	1,466	r1,956	2,059
Value thousands	$594,050	$633,918	$550,968	r$829,514	$742,517
Percentage derived from:					
Precious metals ores	66	71	80	83	87
Base-metal ores	32	27	17	14	11
Placers	2	2	3	3	2
Refinery production:					
Domestic and foreign ores thousand troy ounces	787	805	719	892	751
Secondary (old scrap) do	2,184	1,610	1,444	1,380	1,310
Exports:					
Refined do	4,702	5,238	1,637	1,881	3,482
Other do	1,417	1,199	1,333	1,258	1,499
Imports for consumption:					
Refined do	4,090	4,164	4,238	3,599	6,032
Other do	452	488	682	994	1,837
Gold contained in imported coins do	3,081	2,612	2,908	1,948	2,769
Net deliveries from foreign stocks in Federal Reserve Bank do	1,785	1,181	1,330	-220	381
Stocks, Dec. 31:					
Industry[1] do	872	635	776	630	773
Futures exchange do	4,998	2,449	2,303	2,530	2,359
Department of the Treasury:					
Gold medallion sales[2] do	338	189	63	634	419
Olympic gold coin sales do	--	--	--	--	[3]156
Consumption in industry and the arts do	3,215	3,276	3,423	r3,061	3,082
Price:[4] Average per troy ounce	$612.56	$459.64	$375.91	$424.00	$360.66
Employment[5]	5,500	7,500	6,800	5,200	5,000
World:					
Mine production thousand troy ounces	r39,179	r41,257	43,083	p44,882	e46,035
Official reserves[6] million troy ounces	r1,149.6	r1,150.0	r1,145.1	r1,143.0	1,141.5

eEstimated. pPreliminary. rRevised.
[1]Unfabricated refined gold held by refiners, fabricators, and dealers.
[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	1980	1981	1982	1983	1984
Chicago Board of Trade	Chicago	7.15	1.47	1.96	10.15	9.73
Commodity Exchange Inc	New York	788.72	1,041.67	1,212.40	1,038.28	911.55
International Monetary Market[1]	Chicago	254.35	251.82	153.35	99.40	.88
Mid-America Commodity Exchange	do	14.86	15.59	12.73	11.59	2.02
Total		1,065.08	1,310.55	1,380.44	1,159.42	924.18

[1]A division of the Chicago Merchantile Exchange.

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 112 lode gold producers in operation to which a survey request was sent, 53% responded, representing 97% of the total mine production shown in tables 1, 3, 4, 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.—The Office of Federal Supply and Services of the General Services Administration (GSA) issued a final ruling clarifying agency responsibilities and reporting requirements in the Governmentwide precious metals recovery program. The ruling, effective January 19, 1984, expanded the options for agency participation in the U.S. Department of Defense Metals Recovery Program. GSA is responsible for the initiation and development of the Governmentwide precious metals recovery programs, exclusive of those programs issued and administered by the Department of Defense. Each agency generating precious metal scrap is required to submit a consolidated report on its recovery activities annually, on a fiscal-year basis.[2]

Beginning January 1, 1984, the Internal Revenue Service (IRS) required reporting by coin dealers and brokers on certain sales of South African krugerrand, Canadian maple leaf, and Mexican 1-ounce[3] gold coins. Broker reporting under section 6045 of the IRS code required information reporting on sales of property that could be delivered to satisfy a contract approved for trading by the Commodity Futures Trading Commission.[4]

Legislative actions and programs affecting gold mining were enacted by several States during the year. For the first time in Nevada, State-authorized industrial development bonds, the interest on which is free of State taxes, were issued to help finance development of a gold- and silver-mining operation.

In South Dakota, a bill was passed reducing the State's precious metals severance tax, thereby reducing the previous 6% severance tax on gross receipts to 2% and imposing an 8% tax on net profits. The change, which became effective July 1, 1984, was expected to encourage mine development.

In midyear, amendments to Idaho's Dredging Mining Act were enacted to accomplish the following goals: mandate the restoration of lands explored or mined by placer or dredging methods; provide changes in bonding requirements; give the State Board authority to reject permit-bond applications; and establish a dredge and placer mining account with monies raised.

A law was passed in Alaska allowing Alaskan placer gold miners to receive grants of State funds up to $100,000 to study and test new mining techniques aimed at reducing water pollution resulting from mining operations. If the new technology is effective, the miner repays the State by passing the new process on to other miners. However, grant monies expended on failed technology convert to loans that must be repaid to the State. Similar grants were also offered to miners to encourage the development of new water recycling techniques.

DOMESTIC PRODUCTION

Domestic gold exploration, stimulated in the early 1970's by the removal of restraints on the private ownership of gold, continued at a steady pace during 1984. Many mining and exploration companies, impacted by the continuing slump in demand for copper and other metals, directed their attention toward precious metals exploration with gold as the principal target. Nevada continued to attract the greatest share of the attention of those companies and individuals, both domestic and foreign, whose interests were tied to the search for new gold deposits. Reflecting the successes of earlier exploration efforts as well as the occurrence of geological environments favorable to the formation of commercial quantities of gold, Nevada, with production of about 1 million troy ounces, enjoyed its fifth consecutive year as the Nation's premier source of newly mined gold.

Of the Nation's total gold production, 92% 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 0.007 ounce per cubic yard washed.

Refinery production of gold from imported and domestic ores declined substantially, reflecting in part a decline in the processing of gold-bearing copper ores. The production of refined gold from old scrap continued to decline from the high level of production recorded during 1980 when historically high gold prices attracted a large volume of scrap to the market.

Table 3.—Mine production of gold in the United States, by State

(Troy ounces)

State	1980	1981	1982	1983	1984
Alaska	12,881	26,531	30,513	r39,523	23,232
Arizona	79,631	100,339	61,050	61,991	51,548
California	4,078	6,271	10,547	38,443	85,858
Colorado	39,447	51,069	64,584	63,063	60,010
Idaho	W	W	W	W	W
Montana	48,366	54,267	75,171	161,436	181,190
Nevada	278,495	524,802	757,099	r914,531	997,508
New Mexico	15,847	65,749	W	W	W
Oregon	W	2,830	W	322	W
South Carolina	--	W	--	--	--
South Dakota	267,642	278,162	185,038	309,784	310,527
Tennessee	--	W	--	--	--
Utah	179,538	227,706	174,940	238,459	W
Washington	W	W	W	W	W
Total	969,782	1,379,161	1,465,686	r1,956,400	2,058,784

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Alaska.—Gold production in Alaska reported to the Bureau of Mines was 23,232 ounces, compared with 39,523 ounces reported for 1983. However, an informal annual survey of Alaskan gold producers begun several years ago by the Alaska State Division of Geological and Geophysical Surveys again suggested that a much larger total may have actually been produced. The State's survey indicated that about 175,000 ounces was recovered; this figure compares with similarly derived figures for 1983 and 1982 of 169,000 ounces and 174,900 ounces, respectively. The value of 1984 production was estimated by the State at $63 million, compared with about $70 million for 1983 and nearly $68 million for 1982. The lower 1984 value reflects gold's lower price rather than reduced production. Annual expenditures for all metallic mineral exploration, mostly for gold, reported by the State for the years 1981 through 1984 were $64 million, $43 million, $31 million, and $20 million, respectively. Placer mining activity, the mainstay of Alaskan gold production, continued at a high level during 1984. About 300 placer operations were active during the height of the summer operating season. One interesting sidelight of Alaskan placer mining in recent years has been the occasional documented recovery of diamonds in placer operations along Crooked Creek in central Alaska; a stone found in 1984 weighed 1.4 carats. Environmental problems associated with placer mining, such as perceived threats to water quality and marine life, were featured prominently in news media releases from Alaska during the year.

An increasing interest in the potential for commercial gold in Alaska's offshore placer deposits resulted in the filing of numerous applications with various governing agencies for offshore exploration permits. For example, Power Resources Corp. of Lakewood, CO, sought permits to dredge 8,600 cubic yards per day in Norton Sound, near Nome, beginning in the summer of 1985. In

1984, another Colorado firm, Aspen Exploration Corp., requested permits necessary to explore in selected areas of Cook Inlet. Noranda Exploration Inc. conducted investigations in the area offshore from the Yakataga Beach deposits. South of Juneau in the Gastineau Channel, Juneau Mining Co. continued preparations to recover gold and silver from mill tailings in or near the channel.

According to the Alaska Department of Natural Resources, the operators for Camindex Mines, WGM Inc. and SUM Resources, recovered 20,000 ounces of gold from the Valdez Creek joint-venture property, in south-central Alaska. This production reportedly represents the largest gold production from any one Alaskan producer in over 25 years.[5]

At Livengood, about 80 miles north of Anchorage, Livengood Placers Inc. (80% owned by Callahan Mining Corp.) entered into an arrangement with the bankruptcy trustee for Galaxy Minerals Inc., the former lessee of Livengood's property, under which a contract operator, Alaska Placer Development, will clean up gold-bearing gravel remaining in the pit area previously worked by Galaxy. By order of the trustee, on-site plant and equipment belonging to Galaxy was sold at auction in October.

The joint owners of the Grant Mine, in the Ester Dome area near Fairbanks, continued work aimed at returning the old underground mine to productive status.

On Admiralty Island, southwest of Juneau, Noranda Mining Inc. discovered a new ore body at its developing Greens Creek silver, gold, lead, zinc, and copper deposit. Underground development and engineering studies were proceeding toward a targeted startup date of 1987. Several other lode gold mines, including old workings centered around the Chichagof Mines on Chichagof Island, underwent further rehabilitation during 1984.

Arizona.—The recent economic difficulties of Arizona's copper producers, which also recover gold as an important byproduct, were reflected in the State's lower gold production. Gold developments in the State were essentially a repeat of the 1983 activities, with exploration for precious metals by corporations and individuals being focused on the mining districts of Cochise, La Paz, Maricopa, Mohave, Pima, Santa Cruz, Yavapai, and Yuma Counties.

The Small Mines Div. of Phelps Dodge Corp., which has directed its interests in recent years toward developing ore bodies that may be quickly and inexpensively brought on-stream, recovered 2,600 ounces of gold and 104,000 ounces of silver during the year from various properties, principally in Cochise and Greenlee Counties.

In midyear, Consolidated Mining and Milling Ltd. of Tucson constructed heap-leaching facilities to recover gold from the dump at the old Yuma Mine adjacent to the Saguaro National Monument, west of Tucson. However, problems associated with gaining suitable access to the minesite and objections on environmental grounds led to a court-ordered closure near yearend.

Declining gold and silver prices plus environmental problems reportedly led Tombstone Exploration Inc. to close its open pit gold and silver mine at Tombstone.

In Maricopa County, Goldsil Mining and Milling Co. continued exploration, metallurgical testing, and plans for both open pit and underground development at the Mystic Mine property. The property was recently held and explored by the former Ranchers Exploration and Development Corp. of Albuquerque, NM, and its joint-venture partner, American Copper & Nickel Co. Inc., a subsidiary of Inco Ltd. of Toronto, Ontario, Canada.

Echo Bay Mines Ltd. of Edmonton, Alberta, Canada, entered into an agreement with a subsidiary of Magic Circle Energy Corp. of Oklahoma City, OK, to explore the old Congress Mine, about 65 miles north of Phoenix, in Yavapai County. A drilling program yielded a number of good gold values.

California.—The thousands of abandoned past producers in the Mother Lode and elsewhere continued to be the focus of attention. Exploration and development drilling was in progress at numerous sites, and metallurgical testing and heap-leaching trials were being conducted at others. Several mines began production in the State during the year, and several others delayed opening for a variety of reasons.

A zoning change was approved in Yolo County, north of San Francisco, to allow Homestake Mining Co. to construct a reservoir and proceed with its planned open pit mining. The company should bring the new 3,000-ton-per-day McLaughlin gold mine on-stream in early 1985. Homestake's successful approach to solving the complex developmental problems associated not only with opening a new mine in a populated area but one that fell within the jurisdiction of three separate county governments (Yolo, Lake, and Napa Counties) was commended in remarks before the U.S. House of Representatives.[6] When fully in production in late 1985, the mine was expected to produce more than 200,000 ounces of gold per year. To process McLaughlin's complex ores, a patented pressure oxidation process employing autoclaves was developed.

In Imperial County, Gold Fields Mining Corp., a wholly owned subsidiary of Consolidated Gold Fields PLC of the United Kingdom, moved forward with its plans to construct a relatively large open pit heap leach gold mining operation at Mesquite, 35 miles east of Brawley. Mining operations there were scheduled to commence in early 1986. Exploration of the Mesquite property delineated a large, flat-lying, disseminated-type gold deposit and, based on this result, a preliminary decision to proceed was made in June 1984. Gold production at Mesquite during the first 3 years was expected to average 100,000 ounces per year. Ore was scheduled to be mined at the rate of 2 to 3 million tons per year.

In 1984, Chemgold Inc., the U.S. subsidiary of Glamis Gold Ltd. of Vancouver, British Columbia, Canada, completed its second full year of production at its open pit Picacho Mine. This open pit, heap leach operation was reported by the company to be producing at a rate of about 2,000 ounces per month toward yearend. Production for the 1983-84 fiscal year ending July 31, 1984, was just over 13,000 ounces. Near yearend, Chemgold acquired the old Yellow Aster Mine in Kern County. Exploration there was proceeding.

The ABM Mining Group of Vancouver, British Columbia, Canada, continued exploration of three prospects in the Mother Lode. Through its subsidiary, Inca Resources Inc., the group reached the permitting stage with its Rich Gulch Prospect in Plumas County while another subsidiary, Sonora Gold Corp., proceeded with the drilling required to further delineate reserves at the old Crystalline, Harvard, Dutch-App, and Jumper Mines, which together were to comprise the new Jamestown Mine. The mine, originally scheduled for production in late 1984, was expected to start up in 1986 at a rate of about 120,000 ounces of gold and 140,000 ounces of silver per year. Sonora acquired the Jamestown properties in 1983 from New Jersey Zinc Exploration Co. In 1984, ABM, through another subsidiary, Goldenbell Resources Inc., was also exploring an ore body, the Pine Tree-Josephine property, located in Mariposa County between Mariposa and Coulterville.

Placer Services Corp. postponed indefinitely its plans to open the San Juan Ridge gold property. Community opposition, a use permit considered too restrictive by the company, and low gold prices toward yearend reportedly contributed to the decision. The new mine had been expected to produce 38,000 ounces of gold per year. A request by Gold Fields Mining for a special-use permit to do exploration drilling on its remote gold prospect near Shingle Springs reportedly sparked a controversy with El Dorado County residents opposed to mining and culminated in the passage of a November ballot initiative requiring a 10,000-foot buffer zone around any future open pit mining operations. The Surface Mining Initiative, called Measure A was to go into effect in 1985. However, continuing opposition to the initiative reportedly may lead to legal challenges.

A cease-and-desist court order issued in September 1983 against Noranda Grey Eagle Mines Inc., as a result of a cyanide leak from the holding pond at the Grey Eagle Mine in Siskiyou County, was dropped in October 1984 in exchange for an agreement between the company and the North Coast Regional Water Quality Control Board, whereby the company would undertake a 30-year cleanup and reclamation program at the minesite following closure in about 2 years.

Colorado.—In 1984, the old London Mine, near Fairplay, east of Climax, continued to be explored and developed by joint owners, Cobb Resources Corp. of Albuquerque, NM, and HNG Resources Inc. A feasibility study to confirm ore reserves and plan future mill construction was commissioned in November; plans called for construction of a 500-ton-per-day mill capable of later expansion to 1,500 tons per day as mining developments warranted.

In July, Hecla Mining Co. of Wallace, ID, suspended underground gold exploration in the Cripple Creek-Victor mining district of Teller County. Sampling had indicated that further exploration work was unwarranted. Hecla performed the work under an August 1983 agreement with Texasgulf Inc., whereby Hecla assumed active management of properties held by Texasgulf and the Golden Cycle Gold Corp., which together operated as the Cripple Creek and Victor Gold Mining Co. Elsewhere in the Cripple Creek District, Silver State Mining Corp. of Victor and Nerco Minerals Co. of Portland, OR, formed a joint venture to continue development of Silver State's Iron Clad Mine. Nerco, as operator of the property, planned to increase production at the mine from 20,000 ounces per year to over 60,000 ounces.

In Boulder County, northwest of Denver, Gold Hill Mining Co., a joint venture between the mine's owners and Cosmos Resources Ltd. of Vancouver, British Columbia, Canada, moved toward an early 1985 startup at the Cash Mine. The company was to mine telluride gold ore from the former producer, which had been closed since 1964.

In March 1984, Standard Metals Corp. of New York, operator of Colorado's largest gold mine, the Sunnyside Mine at Silverton, filed for protection from its creditors under chapter 11 of the Federal bankruptcy code. Losses attributed to subsidiary companies reportedly prompted the filing, which was not expected to immediately affect the mining operations.

Idaho.—With the completion of a feasibility study and construction of minesite facilities ongoing, Coeur d'Alene Mines Corp. moved another step closer to the planned spring 1986 startup of the proposed open pit, heap leach operation at Thunder Mountain, 40 miles east of McCall in Valley County. The new mine will be centered around the ore body of the old Sunnyside Mine, formerly a prominent producer. Also in Valley County, near Stibnite, seasonal operations progressed during 1984 at the West End Gold Mine. The operators of the mine, Superior Oil Co. of Houston, TX, a subsidiary of Mobil Oil Corp., reportedly processed 500,000 tons of ore during the operating season between May and November. Superior Oil, together with its joint-venture partner, TRV Minerals Corp. of Vancouver, British Columbia, Canada, reportedly recovered about 28,000 ounces of gold and nearly 12,000 ounces of silver from the heap leach operation. Toward yearend, TRV was negotiating the possible purchase of Mobil's 75% interest in the property.

A number of large and small placer mining operations were active throughout Idaho during the summer season. In the Leesburg Basin about 10 miles west of Salmon, the largest operation, that of Leesburg Land and Mining Inc. of Denver, CO, managed some intermittent mining late in the season following construction of a new plastic-lined settling pond to prevent leakage of sediment-laden water into nearby Napias Creek. Near Murray, ID, north of the Coeur d'Alene mining district, operators of the Golden Chest claims, Trans-Atlantic Pacific Inc. and Golden Chest Inc., reportedly produced some placer gold.

Many companies actively exploring for precious metals in Idaho during 1983 maintained their interests during 1984. Queenstake Resources Inc. and its joint-venture partner, Western Resources Inc., began exploration and evaluation of their 5,700 claims in the Neal District of Elmore County, southeast of Boise.

Montana.—Both exploration for metallic minerals and metal production from small mining operations were reduced somewhat from the levels of 1983. Similarly, fewer small placer mines operated during 1984 than in 1983. On the other hand, overall gold production in the State surpassed production of 1983, largely as a result of increased performance and recovery efficiencies at the new Golden Sunlight Mine, which began production in February 1983. According to the mine owner, Placer U.S. Inc., production at the new mine, near Whitehall, increased from nearly 80,000 ounces in 1983 to about 97,000 ounces in 1984. Placer U.S. also reported that mill throughput increased from 1.6 millon tons in 1983 to almost 1.9 million tons in 1984. Development of the open pit continued during the year as did studies aimed at developing the mine's deep West Mineral Hill Zone.

In Phillips County in north-central Montana, Pegasus Gold Inc. continued to produce gold and silver from its heap leach operation, which processes extremely low-grade ore extracted from two separate open pit mines, the Zortman and the Landusky. The combined production of the two mines, located about 2 miles apart, was about 70,000 ounces. In August, Pegasus merged with Montoro Gold Inc. Montoro continued to develop its 3,000- to 4,000-ton-per-day open pit, heap leach property to be known as the Beal Mine at German Gulch, south of Butte.

Near Lewiston, in central Montana, Golden Maple Mining and Leaching Co. of Kellogg, ID, poured its first bar of gold in September, at its new open pit Gilt Edge Mine.

Near Helena, in Jefferson County, Centennial Minerals Ltd. of Vancouver, British Columbia, Canada, and U.S. Minerals Exploration Co. of Arvada, CO, continued studies directed toward opening their joint-venture Montana Tunnels project. A detailed feasibility study and metallurgical tests were concluded near yearend, and a decision was made to begin production at a rate of about 167,000 ounces of gold per year by late 1986. Silver, lead, and zinc were also to be produced as byproducts.

In 1984, north of Gardiner in Park County, Homestake and American Copper & Nickel filed joint-venture plans with State and Federal agencies to pursue development of their property at the old mining camp of Jardine in the Absaroka Range.

According to a State report on mining activities in Montana, several old mines in the State were reopened for exploration during the year; among these were the old B and H Pete and Joe Mine, in Madison County, by Winchester Gold Corp. of Spokane, WA, and the old Spotted Horse Mine, in Fergus County.[7]

Nevada.—In 1984, 11 of the 25 leading gold-producing mines in the Nation were located in Nevada. Exploration activity continued at a relatively brisk pace, and a number of new discoveries and mine openings were announced during the year.

Near the town of Carlin, in Eureka County, north-central Nevada, Carlin Gold Mining Co., a wholly owned subsidiary of Newmont Mining Corp., began development of its new Gold Quarry Mine during the first quarter. The ore body, 10 miles south of the company's Carlin Mine, was discovered in 1980 and has since been under extensive metallurgical and engineering study. During 1984, about 8 million tons of overburden at Gold Quarry was removed to expose the new ore body. Facilities to process the ore were to be completed in the third quarter of 1985 with production scheduled to begin at that time. With more than 8 million ounces of gold, the deposit is the second largest in the State. In 1984, production from the Carlin Mine of nearly 158,000 ounces, according to Newmont Mining, was down a small amount from that of 1983, reflecting a decline in ore grades from the Carlin, Blue Star, and Maggie Creek pits as well as declines in both tonnage and grades of ores processed by heap leaching.

Freeport Gold Co., a wholly owned subsidiary of Freeport-McMoRan Inc., reported that gold production at its 70%-owned Enfield Bell Mine, at Jerritt Canyon, north of Elko, amounted to 243,000 ounces, down from the 262,000 ounces produced during 1983, but still well above the design capacity of 200,000 ounces. Conversion of the original dual-circuit mill in late 1983 to a single ore-treating system treating lower grade (0.220 ounce per ton) ore was the principal reason for the lower production total. Under the new system, gold recoveries were increased from 86% in 1983 to about 91% in 1984. Total ore mined reached a record-high level during the year, and mill throughput rose 11% over that of 1983, exceeding the daily design capacity of 2,750 tons by nearly 600 tons. The remaining 30% interest in the Jerritt Canyon property is held by FMC Gold Corp., a subsidiary of FMC Corp. In 1984, Freeport Gold's search for additional gold reserves was focused on the Jerritt Canyon area and also on Big Springs in northern Nevada, where the company was conducting engineering and metallurgical studies to better define the potential reserves of this deposit.

On October 19, following a 4-month construction period within an overall span of 23 months from acquisition to gold production, Lacana Gold Inc. of Reno, a 70%-owned subsidiary of Lacana Mining Corp. of Toronto, Ontario, Canada, officially opened its new Relief Canyon gold mine. The new mine, east of Lovelock, in Pershing County, will employ open pit mining methods followed by heap leaching to recover approximately 24,500 ounces of gold per year. The same week that Relief Canyon opened, Lacana Gold, together with its joint-venture partners, opened a second new gold mine, the Dee Mine, 57 miles northwest of Elko and 12 miles northwest of the Carlin Mine. The new open pit property, expected to produce 40,000 ounces of gold per year, was developed by Lacana Gold and its partners, Dome Mines Exploration (U.S.) Ltd., Rayrock Mines Inc. (a subsidiary of Rayrock Resources Ltd. of Toronto, Ontario, Canada), and J. S. Livermore; together, the partners formed the Cordex Syndicate from which the operator, Dee Gold Mining Co., was established. Unlike at the Relief Canyon property, gold recovery at the Dee Mine entailed both heap leaching and conventional cyanide milling processes. Shortly after the opening of the Relief Canyon and Dee properties, production began at the Preble deposit, under development also by Lacana Gold with partners Rayrock Mines and United Siscoe Mines Inc. The partners together constitute the Pinson Mining Co., operator of the Pinson gold mine, northeast of Winnemucca. The Preble deposit, 15 miles south of the Pinson open pit, was to be mined by open pit methods with higher grade ores to be processed at the Pinson mill; lower grade ores were to be heap leached. Production was expected to be about 17,000 ounces per year. Early in the year, Pinson began testing its new CX Zone, an ore body discovered immediately northeast of the Pinson pit. Near Hawthorne, Lacana Gold and Westley Mines Ltd. investigated the feasibility of opening their Santa Fe gold and silver prospects; bulk heap-leaching tests were in progress at yearend.

In November, the Duval Corp., the mining subsidiary of Pennzoil Corp., began production at its new Fortitude gold and silver mine adjacent to its Battle Mountain Mine in Lander County. The new mine was expected to yield, when fully operational, 200,000 ounces of gold and more than 250,000 ounces of silver per year. In terms of gold reserves, Fortitude, discovered in 1981, is the fifth largest deposit in Nevada.

Cominco American Incorporated's open pit Buckhorn Mine in Eureka County started up in June but was shut down in November for modification of the ore-handling and crushing equipment. The modification was to be completed in early 1985, and a decision about reopening the mine was to be made then. The small heap-leaching operation, which utilizes a cement agglomeration step to enhance the effectiveness of the leaching process, had been under development since 1983. The mine was designed to yield and process gold ore at a rate of 750,000 tons per year. East of Reno, in Storey County, the Gooseberry Mine of ASARCO Incorporated and Ican Resources reached full production capacity in 1984 of 350 tons of gold and silver ore per day; improvements in the leaching circuit of the mill reportedly paved the way for greater productivity. At Manhattan, 50 miles northeast of Tonopah, Tenneco Minerals Co. started production at its Manhattan open pit gold and silver mine; the mine had been closed since early 1982. In 1984, in Lander County, Minex Resources Inc. of Riverton, WY, poured its first bar of gold recovered from heap-leaching operations at its new open pit Fire Creek Mine.

In Humboldt County, Standard Slag Co. of Reno and Youngstown, OH, began production at its new 3,500-ton-per-day open pit, heap-leaching gold and silver operation. The new mine, known as the Lewis Mine, began production in August and was the first mining project to be developed in the State with the aid of industrial development bonds.

At the beginning of the year, the Minerals Div. of FMC Corp. announced the discovery of a major gold and silver deposit at Paradise Peak near Gabbs, in Nye County. Preliminary tests at the Paradise Peak project indicated reserves in excess of 1 million ounces of gold and 43 million ounces of silver. Further testing and environmental assessment were proceeding toward yearend with a startup date targeted for mid-1986. In late 1984, Atlas Corp. announced that a substantial quantity of gold-bearing ore had been discovered by surface drilling on its Gold Bar properties in Eureka County; commercial open pit production was expected to begin before the end of 1985.

The ownership status of several operations was changed or modified during 1984 with foreign corporations, chiefly Canadian, as prominent new partners in several transactions; the most notable change was the purchase by Echo Bay Mines of The Louisiana Land and Exploration Co.'s wholly owned subsidiary, the Copper Range Co. Copper Range held a 50% interest in, and was the operator of, the Round Mountain gold mine in Nye County. The change in ownership was scheduled to become effective January 1, 1985. Additionally, during 1984, Homestake acquired Felmont Oil Corp., owner of a 25% interest in the Round Mountain property. The remaining 25% interest was held by Case, Pomeroy and Co. of New York.

Oregon.—Most producers listing gold as a principal product produced on an intermittent or seasonal basis. According to an annual review of activities prepared by the State,[8] production of lode gold was mainly from Silver King Mines Inc.'s Iron Dyke Mine in Baker County; the Thomason Mine, also in Baker County, which has been operated on a seasonal basis for the past 6 or 7 years; and the Pyx Mine in Grant County, operated seasonally since 1980. During 1984, a number of small placer mines operated in Baker and Grant Counties and in the southwestern Oregon counties of Josephine and Douglas.

According to the State report, production at the old Iron Dyke Mine was about 6,000 tons, averaging 0.26 ounce of gold, 1.4 ounces of silver, and 2.3% copper per ton.

American Copper & Nickel continued exploration in the Susanville and Sunrise Butte Districts of Grant County and at the Bald Mountain-Ibex Mines area of Baker and Grant Counties, where nearly 13,000 feet of drilling was performed under a joint venture with Nerco of Portland. Rayrock Mines continued exploration for additional reserves at the Turner-Albright gold and base metal massive sulfide deposit in Josephine County. The search for epithermal-type gold deposits was continued in Malheur County in eastern Oregon and Lake County in south-central Oregon; companies that have been involved there included Homestake, Manville Corp., Freeport-McMoRan, The Anaconda Minerals Co., and Meridian Land and Minerals Co., the exploration arm of Burlington Northern Inc.

South Dakota.—According to Homestake, the Homestake Mine at Lead, the Nation's largest underground gold mine, produced 295,941 ounces of gold, 3.8% below the 307,494 ounces produced in 1983. Homestake's average cost of production in 1984 was $324 per ounce compared with $301 in 1983. During 1984, the average grade dropped by 9.8%, and this was a major contributor to the higher per ounce production cost. Production began at the mine's open pit test site at Terraville. Surface ore production totaled 202,000 tons at an average grade of 0.054 ounce per ton. Total gold production from the open pit was 10,958 ounces with a mill recovery of 88%. Test milling was to continue through 1985 while evaluation of test results were to determine the feasibility of beginning commercial production.

During 1984, Homestake announced plans to begin work on its Ragged Tops gold project adjacent to Spearfish Canyon, near Savoy in Lawrence County. Mining activities were expected to be conducted for 5 years, and a total of 870,000 tons of ore—15,000 tons per month during peak activity—was to be crushed on-site and transported to existing processing facilities at Lead.

Also in Lawrence County, at the Bald Mountain project, a 50-50 joint venture between Homestake and Wharf Resources (USA) Inc. of Helena, MT, a tentative agreement was reached on the course to be followed by the partners in developing the Foley Ridge portion of the project. Adjacent to Bald Mountain, Wharf Resources applied for and was granted permits necessary to allow the company to operate its new Annie Creek open pit, heap leach operation on a year-round basis, thereby increasing its annual ore production from 500,000 to 800,000 tons. A new pumping system was installed that will reportedly allow the leaching process to proceed uninterrupted throughout the year. Heavy summer rains forced a temporary shutdown of the leaching operations to avoid exceeding the holding capacity of leachate ponds.

Early in the year, Viable Resources Inc. and St. Joe American Corp., a subsidiary of the Fluor Corp., entered into a joint venture to further evaluate Viable's carbonate mining properties. An extensive geochemical and drilling program had been completed earlier, and metallurgical studies indicated that a large low-grade ore body amenable to heap leaching existed at the Lawrence County prospect. Near Lead, Lacana Mining of Toronto, Ontario, Canada, reported that preliminary work at the Gilt Edge property had indicated proven and probable open pit reserves of mixed oxide and oxide-sulfide material of 5.7 million tons grading 0.057 ounce of gold per ton. Large-scale metallurgical testing was in progress at yearend.

Utah.—As a consequence of the continuing slump in the world's copper markets, Kennecott reduced its mining operations at the Bingham Canyon Mine near Salt Lake several times during the year. The reduction in copper output also affected the output of gold, which is recovered as an important byproduct.

In July, Getty Mining Co., a wholly owned subsidiary of Texaco Oil Co., completed the first full year of production at its new Mercur gold mine about 25 miles south of Tooele. In March, Sunshine Mining Co. resumed shipments of gold and silver ore from the Trixie Mine near Eureka. Sunshine operated the mine under a lease purchased from Kennecott in April 1983. Production in 1984 was the first from the East Tintic mining district since 1982, when Kennecott closed the mine.

Washington.—In 1984, interest in gold was again directed toward developments around Wenatchee in Chelan County where Asamera Minerals (U.S.) Inc. and its partner, Breakwater Resources Ltd., both affiliates of Canadian companies, continued to develop the new $50 million Cannon Mine, scheduled to begin production in 1985. Full production, expected near yearend 1985, was scheduled at an estimated rate of 150,000 to 180,000 ounces per year plus subordinate quantities of silver. By yearend 1984, most of the major underground facilities were in place and construction of the new 2,000-ton-per-day flotation mill was well advanced. Further evaluation of the mine's B-Reef ore bodies reportedly increased the proven and probable ore reserves to more than 5 million tons averaging 0.214 ounce of gold per ton. New underground facilities completed include a production shaft, 5,000 feet of decline, 2,000 feet of level development, and an underground crusher. The results of metallurgical and pilot plant studies reportedly indicated that gold recoveries of 86% to 92% at the new mill should be obtainable. Construction of a tailings impoundment dam was underway at yearend. The joint venture expanded its exploration and land acquisition activities to selected associated properties in the area of the Cannon Mine, and by yearend, the partners controlled more than 4,000 acres.

Part of the B-Reef Zone is held by United Mining Corp., which in midyear merged with Silver Strike Resources Ltd. of Vancouver, British Columbia, Canada, and at the same time finalized an option agreement with Tenneco Inc. to explore Wenatchee area properties. Subsequent drilling by Tenneco in the B-Reef holdings reportedly cut mineralized ground assaying as high as 1.35 ounces per ton over 51 feet.

The excitement generated by the Wenatchee developments attracted numerous individual and corporate gold seekers to the lower Wenatchee Valley. Among the many companies with a land position and with active exploration programs underway were Teck Resources (U.S.) Inc., Weaco Resources Ltd., Templar Mining Co., Seagold Ltd., and Del Norte Chrome Corp.; many other areas of Chelan County with gold potential also received attention.

Following discovery of additional gold and silver reserves at the Knob Hill Mine near Republic in Ferry County, Hecla, reversing its earlier announced decision to close the mine, extended operations for at least 2 more years. Hecla also milled ores from the nearby Seattle Mine, operated by Crown Resources Corp. and its joint-venture partners. Crown conducted exploration at the Granny property near Curlew and conducted heap-leaching tests on ore from the South Penn Mine near Republic. Heap leaching of gold and silver ore was continued at the Gold Dike Mine, near Danville in Ferry County, by Vulcan Mountain Inc. Leaching was begun on 10,000 tons of gold and silver ore mined from the Minnie Mine near Twisp in Okanogan County.

Exploration was conducted around many of Washington's numerous former gold-producing mines and gold prospects; in addition to activity in Chelan County, most of the activity was concentrated in the Okanogan Highlands of Stevens, Ferry, and Okanogan Counties. Rexcon Inc. of Spokane continued exploration and drilling at its Junction Reef Prospect in Lincoln County. Mining and exploration activities in the State during the year were summarized by the Washington State Department of Natural Resources.[9]

The U.S. Bureau of Mines, in conjunction with the Washington State Department of Natural Resources, published a series of multicolor maps showing Federal lands within the State and their availability for mineral exploitation. Copies of Geological Map GM-30 and its accompanying report, entitled "Availability of Federal Land for Mineral Exploration and Development in the State of Washington," are available for a $1 postage charge from the Division of Geology and Earth Resources, Department of Natural Resources, State of Washington, Olympia, WA 98504.

Other States.—Near Ishpeming, MI, Callahan Mining moved into the final stages of development and construction at its new Ropes Gold Mine, targeted for production in mid-1985. The 7,216-foot decline to the ore zone was completed near yearend 1984, and the inactive Humboldt Mining Co.'s iron ore flotation mill, 16 miles from the mine, was purchased; renovation to convert the mill to process gold ore at a rate of 2,000 tons per day was underway at yearend. The total capital cost of the new mine was expected to be about $20 million, and production was expected to be 30,000 to 60,000 ounces per year.

In northern Minnesota, at least six major exploration and mining companies were actively exploring the greenstone belts in Beltrami, Itasca, Koochiching Lake, Lake of the Woods, Roseau, and St. Louis Counties. The greenstones are believed by some observers to be geologically similar to those hosting the recently discovered deposits in nearby Hemlo, Ontario, Canada. The Kerr-McGee Corp. of Oklahoma reportedly drilled up to 150 holes and did some sample trenching on 1 of its properties near Ely. The company reportedly also held leases on lands in Koochiching, Lake of the Woods, and St. Louis Counties. Several companies exploring for gold and base metals in the northern counties in 1983 withdrew during 1984.

In the South Pass area of the southern Wind River Range of Freemont County, WY, a flurry of exploration and claim-staking activity occurred during the summer when 2,000 acres of previously withdrawn land was released for mineral entry. Several small lode and placer operations were active during 1984 in the area.

In April, Freeport-McMoRan executed a lease-option agreement with Louisiana Land and Exploration and Superior Mining Co. to begin exploration at the Bald Mountain copper and precious metal deposit in Aroostook County, ME. In Penobscot County, Getty Mining was drilling and investigating its polymetallic-precious metal property, 10 miles north of Petten.

Some of the companies actively exploring for gold in North Carolina included AMAX Exploration Inc., Asarco, Amselco Minerals Inc., Cominco American, Gold Fields Mining, Newmont Exploration Ltd., Petromet Resources Ltd., Phelps Dodge, Tenneco, and Texasgulf. Cominco American, with its joint-venture partner, Yellowknife Bear Resources Inc., conducted an underground sampling program at the old Howie gold mine in Union County. Gold Fields Mining carried out sampling and drilling at the old Sawyer Mine in Randolph County and at the old base and precious metals mines around Gold Hill, southeast of Rockwell in Rowan County. In Montgomery County, Tenneco conducted geophysical surveys and did some drilling, while to the west, in Cleveland County, Texasgulf carried out a drilling program at the old Kings Mountain Mine. In November, Petromet Resources signed an option agreement on the old Portis gold property in Franklin County, 48 miles northeast of Raleigh. The company expanded an earlier trenching and drilling program to establish minable reserves in the main ore zone; a drill hole in the main zone reportedly intersected 12 feet of ore averaging 0.54 ounce per ton, and another hole cut 15 feet averaging 0.35 ounce per ton. The Portis Mine produced approximately 50,000 ounces between 1835 and its last year of operation, 1935.

In South Carolina, Piedmont Mining Co. of Charlotte, NC, was reported to be moving toward a targeted early 1985 startup at the old Haile Mine near Kershaw in Lancaster County. Amselco was reportedly investigating gold development possibilities around the old Brewer Mine in Chesterfield County.

Exploration activity in some other Southern States, though less evident than in prior years, nonetheless continued. The old gold-producing areas of Georgia, Alabama, and Virginia continued to attract the attention of both corporate and individual gold seekers, although by and large the year's lower gold prices tended to reduce the level of activity, compared with that of 1982-83.

Table 4.—Mine production of gold in the United States, by month

(Troy ounces)

Month	1980	1981	1982	1983[r]	1984
January	77,922	98,887	106,956	131,338	138,844
February	78,301	93,385	109,407	128,604	143,149
March	87,040	115,200	138,066	150,265	172,082
April	89,477	110,366	136,674	158,487	164,840
May	93,054	108,291	143,212	175,805	180,800
June	83,279	119,676	116,925	174,808	192,917
July	59,595	126,675	114,845	175,386	184,308
August	57,130	125,505	114,538	187,670	180,854
September	73,888	124,629	109,024	184,878	176,271
October	84,161	123,201	127,928	179,297	184,103
November	83,366	119,386	127,843	162,082	172,153
December	102,569	113,960	120,268	147,780	168,463
Total	969,782	1,379,161	1,465,686	1,956,400	2,058,784

[r]Revised.

Table 5.—Twenty-five leading gold-producing mines in the United States in 1984, 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	Carlin & Maggie Creek Pit	Eureka, NV	Carlin Gold Mining Co	Do.
4	Utah Copper (Bingham Canyon)	Salt Lake, UT	Kennecott	Copper ore.
5	Round Mountain	Nye, NV	Copper Range Co	Gold ore.
6	Golden Sunlight	Jefferson, MT	Golden Sunlight Mines Inc	Do.
7	Zortman-Landusky	Phillips, MT	Pegasus Gold Inc	Do.
8	Mecur	Tooele, UT	Getty Minerals Co	Do.
9	Pinson	Humboldt, NV	Pinson Mining Co	Do.
10	Battle Mountain	Lander, NV	Duval Corp	Do.
11	Alligator Ridge	White Pine, NV	Amselco Minerals Inc	Do.
12	Borealis Project	Mineral, NV	Tenneco Minerals Co	Do.
13	Cortez	Lander, NV	Cortez Gold Mines	Do.
14	Ortiz	Santa Fe, NM	Gold Fields Operating Co	Do.
15	Grey Eagle	Siskiyou, CA	Noranda Grey Eagle Mines Inc	Do.
16	Gold Strike	Eureka, NV	Western States Minerals Corp	Do.
17	Northumberland	Nye, NV	Cyprus-Northumberland Mining Co	Do.
18	Sunnyside	San Juan, CO	Standard Metals Corp	Do.
19	West End	Valley, ID	Superior Mining Co	Do.
20	Knob Hill	Ferry, WA	Hecla Mining Co	Do.
21	San Manuel	Pinal, AZ	Magma Copper Co	Copper ore.
22	Manhattan	Nye, NV	Tenneco Minerals Co	Gold ore.
23	Picacho	Imperial, CA	Chemgold Inc	Do.
24	Leadville Unit	Lake, CO	ASARCO Incorporated	Lead-zinc ore.
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	Gold ore, Troy ounces of gold	Gold-silver ore, Short tons	Gold-silver ore, Troy ounces of gold	Silver ore, Short tons	Silver ore, Troy ounces of gold	Copper ore, Short tons	Copper ore, Troy ounces of gold
1980	16,968	9,892,599	599,506	872,019	33,428	1,924,939	5,472	197,292,230	272,665
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	162,286,553	233,093
1983	r53,887	r23,221,617	r1,547,406	r1,124,556	r43,455	r7,472,289	34,931	154,950,481	258,222
1984:									
Alaska	23,232	--	--	--	--	--	--	--	--
Arizona	--	W	W	W	W	W	W	83,571,577	48,465
California	W	W	W	W	W	--	--	--	
Colorado	--	W	W	W	W	1,200	267	--	--
Idaho	W	W	W	W	W	W	W	--	--
Montana	W	W	W	1,255	374	W	W	--	--
Nevada	W	15,819,143	948,505	W	W	3,013,036	17,352	--	--
New Mexico	--	W	W	2,800	379	W	W	W	W
Oregon	W	W	W	--	--	--	--	--	--
South Dakota	--	2,481,984	310,527	--	--	--	--	--	--
Utah	--	W	W	W	W	W	W	W	W
Washington	--	W	W	--	--	--	W	--	--
Total[1]	41,396	30,055,762	1,728,898	1,468,870	37,201	4,380,945	25,785	119,803,180	195,380
Percent of total gold	2	XX	84	XX	2	XX	1	XX	9

Year and State	Lode: Lead and zinc ores, Short tons	Lead and zinc ores, Troy ounces of gold	Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores, Short tons	Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores, Troy ounces of gold	Old tailings, etc., Short tons	Old tailings, etc., Troy ounces of gold	Total[1], Short tons	Total[1], Troy ounces of gold
1980	3,410,956	1,887	1,145,259	37,092	67,623	[2]2,764	214,605,625	969,782
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	187,382,420	1,465,686
1983	--	--	(3)	(3)	r [4]858,749	r [6]18,509	r187,627,692	r1,956,400

See footnotes at end of table.

Table 6.—Gold produced in the United States, by State, type of mine, and class of ore —Continued

	Lode						Total[1]	
	Lead and zinc ores		Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Old tailings, etc.			
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
1984:								
Alaska	--	--	--	--	--	--	--	23,232
Arizona	W	W	--	--	W	W	83,651,912	51,548
California	--	--	--	--	W	W	1,223,651	85,858
Colorado	--	--	W	W	--	--	868,308	60,010
Idaho	W	W	--	--	W	W	W	W
Montana	--	--	--	--	W	W	8,027,944	181,190
Nevada	--	--	--	--	W	W	19,719,340	997,508
New Mexico	--	--	--	--	--	--	W	W
Oregon	--	--	--	--	--	--	W	W
South Dakota	--	--	--	--	--	--	2,481,984	310,527
Utah	W	W	--	--	--	--	W	W
Washington	--	--	--	--	--	--	W	W
Total[1]	(3)	(3)	(3)	(3)	[7]472,359	[8]30,124	156,117,357	2,058,784
Percent of total gold	XX	(3)	XX	(3)	XX	2	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." to avoid disclosing company proprietary data.
[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: Ore treated (short tons)	Amalgamation: Gold recovered (troy ounces)	Cyanidation: Ore treated (short tons)	Cyanidation: Gold recovered (troy ounces)	Smelting of concentrates: Ore concentrated (short tons)	Smelting of concentrates: Concentrates smelted (short tons)	Smelting of concentrates: Gold recovered (troy ounces)	Smelting of ore: Ore smelted (short tons)	Smelting of ore: Gold recovered (troy ounces)	Total ore processed[1] (short tons)	Total gold recovered (troy ounces)
1980	128,334	9,015	11,779,580	603,255	235,024,840	5,556,520	324,132	566,204	16,412	247,498,958	952,814
1981	186,790	14,945	15,899,228	912,742	294,297,268	6,213,345	404,750	486,916	17,859	310,870,202	1,350,296
1982	236,000	25,416	19,910,268	1,101,721	193,630,280	3,937,951	290,023	353,088	10,143	214,129,636	1,427,303
1983	137,200	24,689	[r]27,495,818	[r]1,585,608	[r]159,710,478	3,817,671	[r]282,375	284,196	10,494	[r]187,627,692	[r]1,903,166
1984:											
Arizona	--	--	18,000	700	83,571,579	1,911,946	48,478	62,333	2,370	83,651,912	51,548
California	W	W	W	W	W	W	W	W	W	W	W
Colorado	W	W	W	W	W	W	W	W	W	868,308	60,010
Idaho	--	--	W	W	W	W	W	W	W	W	W
Montana	--	--	7,767,869	179,810	W	W	W	W	W	8,027,944	[2]181,190
Nevada	--	--	16,869,366	917,107	2,849,947	19,955	69,753	27	[2]10,648	19,719,340	[2]997,508
New Mexico	--	--	W	W	W	W	W	W	W	W	W
Oregon	--	--	--	--	--	--	--	W	W	W	W
South Dakota	--	--	2,481,984	310,527	--	--	--	--	--	2,481,984	310,527
Utah	--	--	W	W	W	W	W	--	--	W	W
Washington	--	--	W	W	W	W	W	--	--	W	W
Total	125,288	23,274	31,921,484	1,661,057	123,994,627	3,395,245	319,043	75,958	[2]14,214	156,117,357	[2]2,017,588

[r]Revised. 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 1980-82. Excludes molybdenum and tungsten ores from which gold was recovered as a byproduct and ores leached for recovery of copper.

[2]Includes some placer production to avoid disclosing company proprietary data.

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)
1980	7,869,153	483,113	3,910,427	120,142
1981	7,023,836	648,334	8,875,392	264,408
1982	7,616,036	710,688	12,294,232	391,033
1983[r]	11,317,285	1,086,205	16,178,533	499,403
1984	12,063,871	1,136,504	19,857,613	524,553

[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: Thousand troy ounces	Gold recoverable: Value (thousands)	Gold recoverable: Average value per cubic yard
Bucketline dredging:						
1980	2	3	[2]170	3	$1,719	$10.111
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	3	4	5,461	33	11,757	2.153
Dragline dredging:						
1980	3	11	[3]55	[4]6	3,379	[5]5.780
1981	1	7	[3]30	[4]3	1,200	[5]13.023
1982	3	14	[3]29	[4]3	1,188	[5]18.960
1983	2	13	[3]110	[4]3	1,333	[5]3.481
1984	4	15	[3]126	[4]4	1,593	[5]12.617
Hydraulicking:						
1980	14	14	453	4	2,657	5.869
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
Nonfloating washing plants:						
1980	7	10	[3]314	[4]4	2,605	7.811
1981	9	13	[3]894	[4]9	4,438	4.869
1982	10	11	805	13	4,829	6.000
1983	[r]6	[r]6	[r]961	[r]18	[r]7,450	[r]7.750
1984	8	8	302	3	1,036	3.345
Underground placer, small-scale mechanical and hand methods, suction dredge:						
1980	2	2	3	([6])	33	12.473
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	225	1	454	2.017
Total placers:[7]						
1980	28	40	[2 3]994	[4]17	10,394	[5]7.220
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	[r]35	[r]48	[r 3]6,026	[r 4]54	[r]22,849	[r 5]3.792
1984	26	39	[3]6,142	[4]41	14,930	[5]2.426

[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	1980	1981	1982	1983	1984
Concentrates and ores:					
Domestic	773	801	718	885	747
Foreign	14	4	1	7	4
Old scrap[1]	2,184	1,610	1,444	1,380	1,310
New scrap	1,640	1,475	1,596	r1,598	1,721
Total[2]	4,612	3,890	3,760	r3,870	3,782

rRevised.
[1]Excludes upgrading of U.S. Government-owned gold (mostly coin gold) by the U.S. Assay Office, amounting to 2,921,587 ounces in 1980 and 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

U.S. demand for gold in its various forms at an estimated 3.1 million ounces was only fractionally greater than similar data recorded in 1983. As in previous years, gold's use in jewelry and the arts was dominant (about 53% of total demand). Gold's industrial uses, as in electronic products, specialty alloys, and aerospace applications, accounted for about 35%. Of the remaining 12%, virtually all was absorbed in dental applications.

Gold coins and medallions of U.S. Government mintage absorbed by the domestic market during the year included nearly 500,000 ounces of newly struck U.S. Department of the Treasury Medallions, part of the Celebrated American Artist Series, and 156,000 ounces contained in the new olympic gold coin, the first official gold coin minted in the United States in over 50 years.

The intensity of gold futures trading activity on the Nation's commodity exchanges was somewhat less than during the period from 1979 through 1983, when contracts totaling over 1 billion ounces per year were traded. The reduced contract volume traded during 1984 apparently reflected policy adjustments by several traders, expanded cooperation between domestic and foreign markets, and the increasing popularity of alternative investment vehicles.

Table 11.—U.S. consumption of gold,[1] by end use

(Thousand troy ounces)

End use	1980	1981	1982[2]	1983[2]	1984[2]
Jewelry and the arts:					
Karat gold	1,249	1,420	1,638	r1,410	1,384
Fine gold for electroplating	30	24	17	18	18
Gold-filled and other	226	286	301	237	225
Total[3]	1,505	1,730	1,954	r1,665	1,627
Dental	341	314	358	360	363
Industrial:					
Karat gold	38	50	64	44	42
Fine gold for electroplating	592	528	389	344	415
Gold-filled and other	657	633	649	r644	628
Total[3]	1,287	1,210	1,102	r1,032	1,084
Small items for investment[4]	82	22	9	r3	8
Grand total[3]	3,215	3,276	3,423	r3,061	3,082

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.—Domestic bullion stocks at yearend were down nearly 600,000 ounces from that at yearend 1983. This decline probably largely reflects diversion of bullion to satisfy the minting requirements of official coin and medallion programs.

Official gold reserves of the market economy countries, including stocks held by the International Monetary Fund (IMF) and the Bank for International Settlements, totaled 1.142 billion ounces at yearend compared with yearend 1983 stocks of 1.143 billion ounces. IMF stocks at yearend 1984 of 103 million ounces were unchanged for the fourth consecutive year.

Commercial.—Industrial stocks of refined gold at yearend registered an increase of 140,000 ounces over stocks on hand at yearend 1983, perhaps reflecting both an optimism for continued improvement in the business climate and gold's relatively favorable price levels toward yearend 1984. Stocks of gold on hand at the Nation's futures exchange at the close of the year were little changed from those reported at the end of 1983.

Table 12.—Yearend stocks of gold in the United States

(Thousand troy ounces)

	1980	1981	1982	1983	1984
Industry	872	635	776	630	773
Futures exchange	4,998	2,449	2,303	2,530	2,359
Department of the Treasury[1]	264,330	264,116	264,046	263,406	262,814
Earmarked gold[2]	354,453	350,640	348,555	341,402	337,873

[1]Includes gold in Exchange Stabilization Fund.
[2]Gold held for foreign and international official accounts at New York Federal Reserve Bank.

PRICES

The price of gold on international markets, although generally lower in 1981-84 than the record-high level of $850 per troy ounce reached in early 1980, remained well above levels established prior to 1980. The Engelhard Industries-London daily final price per ounce of refined gold began 1984 at $383, peaked at nearly $406 in early March, then declined steadily toward yearend, reaching the year's low of $307.90 on December 20. The average for the year was $360.66 compared with the 1983 average of $424. Improvements in the U.S. and world economic outlook plus increasing value of the U.S. dollar beginning in midyear apparently contributed to gold's price decline during the second half of the year.

Table 13.—U.S. gold prices[1]

(Dollars per troy ounce)

Period	Low	(date)	High	(date)	Average
1980	481.50	(Mar. 18)	850.00	(Jan. 21)	612.56
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:					
January	365.10	(Jan. 24)	383.00	(Jan. 3)	371.29
February	376.00	(Feb. 14)	399.25	(Feb. 28)	386.36
March	385.75	(Mar. 28)	405.85	(Mar. 5)	394.66
April	376.20	(Apr. 30)	387.20	(Apr. 1)	381.98
May	371.90	(May 8)	386.80	(May 30)	377.68
June	368.30	(June 18)	394.15	(June 1 and 5)	378.06
July	335.40	(July 23)	370.40	(July 2)	346.84
August	339.40	(Aug. 1)	354.40	(Aug. 14)	348.09
September	335.65	(Sept. 17)	348.15	(Sept. 24)	341.31
October	333.90	(Oct. 31)	348.90	(Oct. 3)	340.57
November	329.40	(Nov. 28 and 30)	350.85	(Nov. 13)	341.54
December	307.90	(Dec. 20)	332.40	(Dec. 4)	319.50
Average	XX		XX		360.66

XX Not applicable.
[1]Engelhard Industries daily quotation.

FOREIGN TRADE

The growing strength of the U.S. dollar in foreign exchange during the year was reflected by an increase in net imports of many commodities and products. Gold in one form or another was among those commodities that registered substantial gains in net inflow during the year; net imports of refined metal were nearly 70% greater than net imports of 1983. Conversely, the United States was, as in 1983, a net exporter of gold-bearing waste and scrap materials, which, in large part, went to overseas refiners and semirefiners. Some of these same materials probably returned later as imports of refined or partially refined gold in one form or another.

Gold imported in bullion coins such as the South African krugerrand and the Canadian maple leaf amounted to nearly 2.8 million ounces during 1984, up nearly 42% over comparable 1983 imports.

Table 14.—U.S. exports of gold, by country

Year and country	Ore and concentrates: Quantity (troy ounces)	Ore and concentrates: Value (thousands)	Waste and scrap: Quantity (troy ounces)	Waste and scrap: Value (thousands)	Doré and precipitates: Quantity (troy ounces)	Doré and precipitates: Value (thousands)	Refined bullion: Quantity (troy ounces)	Refined bullion: Value (thousands)	Total[1]: Quantity (troy ounces)	Total[1]: Value (thousands)
1980	23,121	$10,998	1,320,762	$806,707	72,751	$42,796	4,702,197	$2,787,431	6,118,831	$3,647,932
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:										
Belgium-Luxembourg	--	--	74,865	27,251	376	166	895	334	76,136	27,750
Brazil	--	--	160	64	--	--	3,117	1,056	3,277	1,120
Canada	1,217	223	718,522	254,372	28,045	9,747	2,032,599	750,663	2,780,383	1,015,005
Colombia	--	--	--	--	--	--	3,239	1,104	3,239	1,104
France	482	83	93,875	33,728	--	--	930	323	95,287	34,135
Germany, Federal Republic of	--	--	59,234	20,318	2,386	1,011	171,949	57,176	233,569	78,505
Hong Kong	--	--	432	156	--	--	61,229	20,717	61,661	20,872
Israel	--	--	4,005	1,343	--	--	9,818	3,810	13,823	5,153
Japan	25	3	--	--	7,556	2,620	16,956	5,474	24,537	8,097
Panama	--	--	--	--	--	--	36,752	13,203	36,752	13,203
Singapore	--	--	--	--	3	1	8,888	3,291	8,891	3,292
Sweden	--	--	14,326	4,902	3,274	1,086	11	4	17,611	5,992
Switzerland	1,473	207	4,256	1,151	23,074	6,396	264,970	95,634	293,773	103,387
United Kingdom	--	--	451,016	159,201	5,703	2,752	857,845	327,315	1,314,564	489,268
Uruguay	--	--	--	--	--	--	7,523	2,789	7,523	2,789
Other	101	29	2,158	752	2,053	724	5,752	1,828	10,064	3,333
Total[1]	3,298	545	1,422,849	503,237	72,470	24,502	3,482,473	1,284,718	4,981,090	1,813,002

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

Table 15.—U.S. imports for consumption of gold, by country

Year and country	Ore and concentrates: Quantity (troy ounces)	Ore and concentrates: Value (thousands)	Waste and scrap: Quantity (troy ounces)	Waste and scrap: Value (thousands)	Doré and precipitates: Quantity (troy ounces)	Doré and precipitates: Value (thousands)	Refined bullion: Quantity (troy ounces)	Refined bullion: Value (thousands)	Total[1]: Quantity (troy ounces)	Total[1]: Value (thousands)
1980	65,372	$37,257	199,102	$98,466	187,035	$107,507	4,090,488	$2,506,889	4,541,997	r$2,750,119
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	r4,592,956	1,977,118
1984:										
Argentina	--	--	--	--	1,016	312	10,411	4,077	11,427	4,389
Belgium-Luxembourg	1,015	549	--	--	7,648	2,840	34,808	13,345	43,471	16,734
Bolivia	349	101	66,865	23,205	17,545	5,166	40,141	13,884	124,900	42,357
Brazil	1,146	430	53,496	19,099	760	90	85,324	28,538	140,726	48,156
Canada	19,908	7,302	32,756	11,146	759,525	274,891	3,360,629	1,260,585	4,172,818	1,553,924
Chile	112,161	36,436	--	--	17,709	6,612	220,665	84,500	350,535	127,549
Colombia	8	1	8,555	3,017	4,583	1,696	11,249	4,502	24,395	9,216
Dominican Republic	--	--	16,202	4,252	383,180	141,829	174	50	399,556	146,131
Germany, Federal Republic of	--	--	228	94	11,532	4,478	9,986	4,044	21,746	8,617
Guyana	2,988	943	4,000	1,598	638	187	3,700	1,311	11,326	4,039
Italy	67	4	--	--	--	--	5,286	2,136	5,353	2,140
Malaysia	--	--	5,852	1,851	--	--	--	--	5,852	1,851
Mexico	21,010	8,590	24,346	9,473	2,909	1,293	15,924	5,824	64,189	25,180
Netherlands	402	151	3,728	1,467	--	--	13,960	4,608	18,090	6,226
Netherlands Antilles	--	--	30,091	10,044	3,405	980	8,496	3,208	41,992	14,232
Panama	--	--	12,854	5,257	324	109	31,253	12,102	44,431	17,468
Peru	16,966	6,286	4,954	1,814	903	360	69,491	25,817	92,314	34,277
Philippines	15,830	4,701	3,962	1,276	--	--	--	--	19,792	5,976
South Africa, Republic of	13	4	585	222	3,866	1,231	18,118	6,932	22,582	8,389
Spain	5,971	2,072	--	--	--	--	89,412	32,757	95,383	34,828
Switzerland	25	2	7	2	2,680	1,161	344,134	130,004	346,846	131,170
United Kingdom	1	1	687	259	31,571	11,232	602,791	221,345	635,050	232,837
Uruguay	--	--	845	292	482	125	944,940	397,071	946,267	397,488
Venezuela	924	165	72,720	23,618	23,495	6,085	77,353	25,331	174,492	55,199
Yugoslavia	--	--	--	--	--	--	11,667	4,092	11,667	4,092
Other	4,003	1,325	14,386	4,495	3,375	1,084	21,638	7,545	43,402	14,447
Total[1]	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

rRevised.

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

WORLD REVIEW

World gold mine production continued to grow in 1984, with the Republic of South Africa accounting for nearly 50% of the world mine output, and Brazil, Canada, China, the U.S.S.R., the United States, and 58 other countries accounting for the remainder.

In its annual summary of world gold supply and demand, Consolidated Gold Fields reported that the supply of gold (excluding most secondary gold) available to commercial purchasers in the market economy countries was about 46 million ounces, or nearly 3 million ounces greater than that available during 1983.[10] Of the 1984 total, about 37 million ounces was mined in the market economy countries, 6.6 million ounces originated as net trade with centrally planned economy countries such as China, North Korea, and the U.S.S.R., and net sales of gold to the market from official or governmental sources amounted to about 2.7 million ounces. Most of the gold entering the world market from the Republic of South Africa, the U.S.S.R., and several other producing countries continued to be traded through long-established outlets in Switzerland, the United Kingdom, and other Western European countries.

According to Consolidated Gold Fields' report, the consumption of gold in the commercial sector of the market economy countries during the year was about 39.6 million ounces, an increase of about 4.2 million ounces over the demand level estimated for 1983, and the highest figure since 1979. Gold consumed in 1984 in the market economy countries was divided, in millions of troy ounces, with 1983 demand in parentheses, between the following end-use categories: jewelry, 26.3 (19.1); electronics, 3.9 (3.3); dental, 1.6 (1.7); other industrial and decorative uses, 1.7 (1.7); medallions and unofficial coins, 1.4 (1.0); and official coins, 4.2 (5.3).

Australia.—Despite relatively lower gold prices, a number of companies with gold properties under study in Australia, and particularly in the State of Western Australia, began production or opted to commit the funds necessary to bring their properties to productive status. Some established producers also directed funds toward expanding the capacity of their existing operations.

In northeast Queensland at yearend, the new Kindston gold mine, 70% owned by Placer Development Ltd., was nearing completion, several months ahead of schedule. The new open pit mine, to be Australia's largest gold mine with a forecasted first year's production of over 250,000 ounces, was expected to come on-stream in January 1985. The average production of gold over the first 5 years was expected to be 196,000 ounces per year, at an estimated cost, using the February 1985 exchange rate of US$137 per ounce. The development included construction of a dam on the Copperfield River, 14 miles from the minesite and a 185-mile-long powerline to deliver electricity to the mine from the coastal city of Townsville.

Elsewhere in Queensland, Central Coast Exploration NL, began mining operations in 1984 at the Croyden gold deposit. The Mount Morgan Ltd. and Anglo American Gold Pty. Ltd. mill tailings retreatment operation was again the largest gold producer in the State. Freeport of Australia Pty. Inc., a subsidiary of Freeport-McMoRan, reported that its exploration efforts at the Gympie Prospect had been particularly encouraging. Several drill holes had yielded assay values of about 0.05 to 1 ounce of gold per ton, and further drilling was planned. Freeport-McMoRan's joint-venture partners are Southland Mining Ltd. and Gympie Eldorado Gold Mines Pty. Ltd. Other gold prospects that were under evaluation in the State included the placer deposits in the Palmer River region of north Queensland, old lode mines at Day Dawn and Last Chance, and prospects at Mount Rawdon, Mount Leyshon, Selwyn, and Starral.

In the State of New South Wales, Renison Goldfields Consolidated Ltd., the Australian subsidiary of Consolidated Gold Fields of the United Kingdom, continued drilling and evaluation of its Peak Hill gold prospect. The company also conducted similar exploration at its jointly held Beaconsfield project in Tasmania. Near Wagga Wagga, New South Wales, British Petroleum Ltd., together with its 75%-owned Seltrust Holdings Ltd., explored the Temora gold prospect.

Western Mining Corp. Holdings Ltd. (WMC) began a major percussion drilling program in conjunction with its ongoing exploration of the historic Bendigo Goldfield in the State of Victoria. The company reported that results obtained by midyear were encouraging and that drilling was continuing. WMC's Stawell joint venture, 50% with Central Norseman Gold Corp. N.L., began production near yearend and became Victoria's major producer. Construction at a 220,000-ton-per-year, carbon-in-leach gold treatment plant was completed, and treatment of ores mined from both the open pit and underground operations began in August. Production was expected to be about 26,000 ounces per year. In the State of South Australia, WMC continued feasibility studies on the jointly held Olympic Dam deposit, one of the largest deposits ever found in Australia.

In Australia's Northern Territory, Renison Goldfields and its partner, Enterprise Gold Mines NL, announced an agreement, subject to environmental approval and a final partnership agreement, to proceed with development of the Pine Creek gold mine. The mine was expected to start producing gold in 1985 at a rate of about 57,000 ounces per year. In 1984, in the Tanami (central-western region of the Northern Territory), North Flinders Mines Ltd. began underground exploration at the Granites gold project. A feasibility study to consider mining the Granites deposit was scheduled for completion in 1985. Peko-Wallsend Ltd.'s Warrengo Mine at Tennant Creek was again the Northern Territory's leading producer, yielding nearly 59,000 ounces of gold in the 1983-84 financial year. Copper and bismuth concentrates were byproducts. In January 1984, the company began shaft-sinking operations at its developing Argo Mine (formerly known as Explorer 46) just outside of Tennant Creek.

The State of Western Australia, which accounted for more than 80% of Australia's gold production, was again Australia's principal center for gold exploration, development, and expansion activity. Exploration was especially directed toward those small- to medium-size gold deposits amenable to open pit mining.

Several Western Australian properties began production or expanded their mining or treatment capacity during the year. The Nevoria Mine of Southern Goldfields Ltd. and Jingillic Minerals NL at Marvel Loch was commissioned in December. The mine was expected to yield about 27,000 ounces of gold per year. Near Leonora, the old Sons of Gwalia Mine was reopened as an open pit by Sons of Gwalia N.L. Nearby, Forrest Gold, a subsidiary of CRA Ltd., began open pit mining at the Tower Hill gold mine and produced nearly 17,000 ounces of gold. About 80 miles north of Meekathara, at its Horseshoe Lights property, Barrack Mines Ltd. completed conversion of its treatment plant from vat leaching to carbon-in-pulp. South of Meekathara, Metana Mineral N.L.'s Reedy Mine was commissioned in June and was scheduled, when fully operational, to produce about 26,000 ounces of gold per year. Further north, in the Pilbara region, near Marble Bar, Kitchener Mining NL and partners began mining at the Bamboo Creek Mine. Both open pit and underground methods were to be used. Retreatment of the old dumps at Wilnna by Western Alluvials Pty. Ltd. started in June, and by yearend, over 9,000 ounces of gold had been recovered. At Kalgoorlie, Central Kalgoorlie Gold Mines began production, mostly from small pits on its leases held within the town limits. The company poured its first gold in September. Other mines beginning production in Western Australia included the Great Victoria Mine of Great Victoria Mines Ltd. and the Porphyry Mine, belonging to Edjudina Gold Mines Pty. Ltd.

Mines nearing production status in Western Australia at yearend included the Harbour Lights Mine of Esso Exploration and Production Australia Inc. and its partners; the Paddington Mine at Broad Arrow, just north of Kalgoorlie, by Pancontinental Mining Ltd.; the Broad Arrow joint venture by Samantha Exploration NL and partners; and the Bluebird Prospect near Meekathara, under development as an open pit by Endeavor Resources Ltd.

Many other properties throughout Western Australia, though less developed than the aforementioned, were expected onstream by 1985 or 1986. Perhaps the most interesting of these developing properties was the recently discovered Boddington deposit 75 miles southwest of Perth. The discoverers, the Worsley Alumina Consortium, completed preliminary plans for mining and treatment of the large deposit, which is closely associated with the consortium's bauxite deposit. The plans call for developing a 3-million-ton-per-year open pit operation utilizing carbon-in-pulp recovery and incorporating special handling procedures to effectively deal with the high clay content of the ore. Preliminary estimates of the extent and quality of the deposit suggest that a yield of about 170,000 ounces per year may be anticipated. The consortium is a joint venture between Reynolds Alumina Australia Ltd. (40%), Shell Co. of Australia Ltd., BHP Co. Ltd., and Kobe Alumina Associates (Australia) Pty. Ltd.

Western Australia's largest gold producers, Kalgoorlie Mining Associates (KMA) and WMC, were responsible, through their various holdings, for much of the State's production during 1984. KMA operated two mines in Kalgoorlie; the largest, the Mount

Charlotte operation at the east end of the town's center, together with the company's nearby Fimiston Mine produced 194,302 ounces of gold, including metal recovered from cleanup and miscellaneous sources. At Mount Charlotte, the new concrete-lined Cassidy shaft was extended to 3,800 feet and numerous improvements were made at surface facilities. WMC's extensive gold operations at Kalgoorlie, Kambalda, Lancefield, Norseman, and Mount Magnet, and not including production at affiliated KMA mines in Kalgoorlie, amounted to 275,228 ounces.

Brazil.—The classic gold rush that began in earnest in 1980 following the discovery of the rich Serra Pelada deposit in Brazil's northern State of Pará continued throughout most of 1984, although with less intensity than the 1980-83 period. A number of reports covering the gold rush in Brazil were released during 1984. One report,[11] noted that during the summer over 1,000, mostly hand-built, floating suction dredges were working on the underwater placer gold deposits along the Rio Madeira, which flows northeastward out of the Andes Mountains. Gold-bearing rivers such as the Tapajós and others were similarly populated.

At the Serra Pelada Mine, a 6-month closure of the huge hand-dug open pit, followed by violent clashes between police and individual prospectors, known as garimpieros, demanding its reopening, and problems associated with pit slope instability and uncontrollable water incursions combined to lower the mine's estimated production to about 70,000 ounces from the 400,000 or so ounces estimated to have been recovered during 1983. In 1984, Mineração Morro Velho S.A. (MMV), an indirect subsidiary of the Anglo American Corp. of South Africa Ltd. (AAC), which operated two gold-mining complexes in the States of Bahia and Minas Gerais, continued work aimed at expanding its annual production capacity to nearly 300,000 ounces per year by 1986. Much of the expansion entailed reopening of the old Raposos Mine and construction of a new mine at Cuiba, both in Minas Gerais. Extractive metallurgical tests were conducted on the ores from both properties to determine the processes required to effect optimum gold recoveries. MMV's principal operation was the old Morro Velho Mine near Nova Lima. The company continued to concentrate its gold exploration efforts in Minas Gerais as well as in the States of Goiás and Bahia where further exploration took place and resulted in studies being extended to parts of the Amazon Basin. Also in Minas Gerais, the Republic of South Africa's General Mining Union Corp. Ltd. (Gencor) reached a decision to spend $90 million to bring its São Bento gold mine into production by early 1987. Gencor, with its Brazilian partners, expected to recover nearly 60,000 ounces per year from the new underground operation.

North of Serrinha, in the State of Bahia, Cia. Vale do Rio Doce, the Brazilian state mining company, through its exploration arm, Rio Doce Geologia e Mineração S.A. (Docegeo), continued exploration and development of its recently discovered Araci Mine, also known as the Fazenda Brasileiro. An open pit, heap-leaching operation producing about 16,000 ounces per year was planned. About 100 miles further north, Docegeo was investigating an alluvial deposit at Fazenda Mary while further inland at Salabo, near Serra Pelada, the company was negotiating with a private company to develop another alluvial deposit. Docegeo was also investigating lode gold deposits in Pará's Serra das Andorhinas area. In other gold-related developments, the Brazilian Government concluded a number of joint-venture agreements with domestic and foreign corporations searching for gold throughout the country, and the Brazilian press reported that the Casa da Moeda do Brazil (the mint) in the State of Rio de Janeiro would begin gold-refining operations capable of producing standard 400-ounce "Good delivery" gold bars with a purity of 0.9999 fine. The objective of internalizing the process was to eliminate the need to export gold for refining and thereby increase the value received from sales. Once converted to "Good delivery" status, Brazilian bullion reserves become a more liquid asset in international financial transactions than bullion of a less acceptable quality.

Canada.—The spotlight continued on gold developments in the Hemlo, Ontario, area on the Trans-Canada Highway, 23 miles east of the town of Marathon, on the north shore of Lake Superior. Noranda Mines Ltd. and its partners, Golden Sceptre Resources Ltd. and Goliath Gold Mines Ltd., were rapidly developing their new Golden Giant gold mine. Nearby, the Teck Corp. and its partner, International Corona Resources Ltd., were constructing their new Corona project. To the west, a third company, Lac Minerals Ltd. of Toronto, progressed toward an April 1986 startup of its Williams property, to be developed using a combination of open pit and underground mining methods. The Hemlo properties held by Teck-Corona, Noranda-Goliath-Golden Sceptre, and Lac Minerals all cover different portions of one large ore body. By yearend 1984, Noranda and its partners were nearing completion of the five-compartment shaft targeted for a first-stage depth of about 3,300 feet, and construction of the 1,100-ton-per-day concentrator and surface support facilities was nearly complete. The new mill was constructed to accommodate a later expansion to about 3,300 tons per day. Mining at the Golden Giant, originally scheduled to begin in December, was postponed until early 1985 owing to a change in shaft-sinking contractors. Feed for the new mill will initially come from a newly discovered ore zone, minable by open pit methods, 1.5 miles west of the main development area. Noranda expected to be recovering about 280,000 ounces of gold per year from the Golden Giant by 1987 with final production at a rate of about 330,000 ounces per year expected later. The company anticipated that its gold production costs would be among the lowest in the world.

Construction at the Teck-Corona property, which began in November 1983, essentially parallels that underway at the Golden Giant and includes a four-compartment shaft scheduled for a final depth of 3,800 feet by late 1985. In evaluating its Hemlo claims, Teck's exploration efforts during 1984 produced over 40 miles of diamond drill core. Exploration by numerous other companies for extensions to the Hemlo deposit continued throughout the southern part of the region. In December, Lytton Minerals Ltd., of Toronto, reportedly discovered what might turn out to be the long-sought Hemlo extension on its Peekongay property, located at Heron Bay, 10 miles west of Hemlo. However, further exploration will be required to determine if there is any positive geological relationship between Peekongay and Hemlo.

At Dobie, Ontario, in the Kirkland Lake area, Inco (65%) and Queenston Gold Mines Ltd. (35%) began mining at their new 500-ton-per-day McBean Mine. The mine was expected to produce about 20,000 ounces per year. The new Detour Lake gold mine, 120 miles northeast of Timmins, Ontario, of Campbell Red Lake Mines Ltd. and Amoco Canada Petroleum Co. Ltd., which began production in late 1983, experienced some metallurgical and milling problems, and as a consequence, production during 1984 was lower than earlier anticipated. Full production was expected to be 200,000 ounces per year.

In the Northwest Territories at Contwoyto Lake, 56 miles south of the Arctic Circle, Echo Bay Mines increased the capacity of its Lupin mill by 50%. The Lupin Mine had begun production in October 1982 and as a result of the expanded mill capacity and an increase in the efficiency of recovery operation, gold production in 1984 was nearly 182,000 ounces, compared with about 118,000 ounces in 1983. The 50% increase in production capacity during 1984 was accomplished with a total operating cost increase of only 13%. The company expected to improve its 1985 yield to about 200,000 ounces.

Gold mining and exploration activity in the Province of Quebec continued at a high level during 1984. The effect of weakening gold prices toward yearend continued to be offset by the positive effects of provincial tax incentives that encouraged investment in mining. In August, Société Minière Louvem Inc. opened its new Chimo gold mine at Val d'Or, east of Rouyn, and in July, the new 880-ton-per-day mill at the Dest-or Mine, 25 miles north of Rouyn, was started up by Aiquebelle Resources Inc. A number of mines and prospects were in various stages of preproduction development elsewhere in Quebec; for example, Corporation Falconbridge Copper moved toward an early 1985 startup at its new 827-ton-per-day Lac Shortt Mine in northwestern Quebec.

In the Province of Saskatchewan, Flin Flon Mines Ltd. began production at its new Rio Mine and mill complex, Saskatchewan's first producing gold mine in nearly 40 years. The new mine will produce about 9,000 ounces of gold per year.

China.—Since the ban on sales of gold jewelry in China was lifted in October 1982, sales of 14- to 18-karat gold jewelry have soared, with sales of higher karatage gold products reportedly gaining substantially during the second half of 1984 and accounting for 65% of overall sales. Increasing affluence in China as well as the restoration of some traditional Chinese customs were reportedly responsible for much of the increase. Young couples increasingly preferred to give gold rings and necklaces as tokens of engagement. Gold jewelry tended to be purchased by the Chinese more for its intrinsic value than for its ornamental qualities.

Estimated gold production continues to

increase each year as more and more Chinese are encouraged to prospect. An estimated 100,000 former peasants were reportedly involved in the search for gold during 1984, with more than 50% considered as individual gold panners and the remainder working in small mines run by local governments and collectives. Gold-mining specialists regularly visited many gold-mining areas to encourage further production by providing expertise and guidance to small miners and prospectors in matters such as prospecting, mine development, and equipment requirements. Rewards for new discoveries and for increased performance in mining and recovery were offered as incentives by some local and Provincial governments. Minting and sales of official gold coins was an increasingly popular method of earning foreign exchange.

Shandong Province was again the principal gold-producing Province, with new discoveries and mining activity reported there as well as in Guangdong, Heilingjiang, Jilin, Qinghai, Shanxi, and Sichuan Provinces.

Colombia.—In an attempt to stimulate greater domestic gold production and to discourage smuggling of gold outside of the country, Colombia's National Bank was reported to be paying a 30% premium on domestically produced gold. Smugglers attracted by the higher prices were reportedly bringing some in from neighboring countries. Bijou Mines and Oils Ltd., of Trenton, Ontario, Canada, reportedly began placer mining operations in May at its 3,750-acre deposit, 45 miles from Medellín. Bijou also maintained ownership of three other Colombian placer deposits totaling about 8,000 acres. In December 1983, a proposal by Phelps Dodge to reopen the old Marmato gold mines was accepted by the Government of Colombia. A feasibility study was begun in 1984 for the construction of a 300-ton-per-day mill. Reopening of the mines, in the western Caldas Department, would be through a joint venture between Phelps Dodge; Colombia's state-owned mining company, Empresa Colombiana de Minas; and various private investors.

Dominican Republic.—Rosario Dominicana S.A., operator of the Pueblo Viejo gold-silver mine, was reportedly continuing a study aimed at determining the economic feasibility of developing the large gold-silver-bearing sulfide reserves underlying the mine's diminishing oxide zone. Plans to develop a pilot plant to test the response of the sulfide ore to various precious metals recovery techniques were ongoing at yearend.

Ghana.—The Government of Ghana and Ashanti Goldfields Corp. (Ghana) Ltd. (AGC), owned 55% by the Government and 45% by Lonrho Ltd. of London, negotiated a 4-year, $158 million loan from a consortium of banks led by the International Finance Corp. to restore the productivity of AGC gold mines and rehabilitate the gold-mining operations in the country's Obuasi region. The objective of AGC was to increase production from the 260,000-ounce level achieved during fiscal year 1983-84 to 400,000 ounces during fiscal year 1989-90, a level last achieved by the mines in the mid-1970's. The two principal components of the project were (1) a 5-1/2-year program to sink three new shafts and (2) a 3-year program of rehabilitating and replacing existing plant and equipment as required as well as acquiring new machinery needed to expand capacity. Concurrent with the AGC improvements, efforts were to be undertaken to expand the country's gold ore reserves through an intensification of exploration.

Papua New Guinea.—Papua New Guinea's largest gold producer, Bougainville Copper Ltd., at its large open pit copper and gold mine at Panguna in the Crown Prince Range of north-central Bougainville Island, reportedly produced 503,898 ounces of gold during 1984, down nearly 75,000 ounces from production reported in 1983. Production at the mine, the country's largest private employer, declined because of lower grades of ore mined plus a labor strike that halted production for 16 days. Measured ore reserves at yearend reportedly were 744 million tons bearing 0.0134 ounce of gold per ton; this compares with the 1983 yearend millhead grade of 0.0160 ounce per ton.

On the mainland of the Island of New Guinea, Ok Tedi Mining Ltd. began mining the gold-rich cap at its gold-copper mine at an elevation of 7,000 feet in the rugged Star Mountains near the country's border with Indonesia. Despite numerous difficulties, such as a massive landslide, tailings pond leaks, and continuous problems associated with access to the remote site, construction of the new $1.5 billion facility was completed on time, with startup operations on schedule. Ore processing began in August, and the first gold was produced in September. Total production for the year was 79,000 ounces. The company proposed substantial changes in the timing and scope of future project development in light of anticipated metals prices. The Government of Papua New Guinea objected to the proposals, and at yearend, negotiations with the Government as to the future of the project were continuing. In the Wau Valley north of Port Moresby, New Guinea Goldfields Ltd. (NGG), purchased in 1982 by Renison Goldfields and Consolidated Gold Fields, both of Australia, treated over 250,000 tons of oxidized ore at its newly developed open pit mine to produce nearly 9,000 ounces of gold and 6,000 ounces of silver. An additional 2,058 ounces of gold and 1,736 ounces of silver were produced from associated alluvial workings, and tributors, independent contract miners, produced an additional 3,663 ounces of gold and 3,022 ounces of silver. NGG completed construction of a new 770-ton-per-day gravity-amalgamation mill in April 1983. A recovery of about 83% was realized from the ore, whose major gold content is in the 20- to 100-micrometer-size fraction. Pending favorable exploration results, the company was studying the feasibility of introducing carbon-in-pulp technology to increase the gold recovery.

In 1984, exploration was continued at the Porgera joint venture, near Mount Hagen in the Central Highlands, by Placer (PNG) Pty. Ltd. and its partners, Mount Isa Mines Ltd. and Renison Goldfields. Placer (PNG) reported the discovery of a new ore zone, identified by widespread visible gold and of considerably higher grade than other zones thus far discovered elsewhere in the deposit. Assays performed on the diamond drill cores reportedly encountered some gold values in excess of 1 ounce per ton. On Misima Island, southeast of the New Guinea mainland, Placer (PNG), together with its partner, CRA Exploration Pty. Ltd., completed an economic analysis of their gold-silver project; a decision to begin a feasibility study in 1985 was under consideration at yearend.

In 1984, on Lihir Island, just north of the island of New Ireland, Kennecott Explorations (Australia) Ltd. and its partner, Niugini Mining Ltd., continued drilling and exploration of their recently discovered gold prospect in the Linetz-Lamond area adjacent to the coast.

Peru.—The large increase in gold production, in part, reflected a 15% increase in gold-bearing copper production as well as increased production from placer gold deposits, which account for an estimated 50% of the country's production. Much of Peru's placer gold originated from placer mines located in the southeastern jungle region centered around the Madre de Dios and Inambari Rivers. Among the companies successfully pursuing placer gold there in 1984, South American Placers Inc., a Panamanian-registered company, reported that large increases in its placer gravel reserves, as a result of extensive exploration along the Rio Pukive and Rio Cachive in the Madre de Dios area, may support as many as three dredging operations; funding for a proposed dredging program was being sought. Exploration for new gold placer deposits as well as vein-type lode gold deposits was conducted by both state-owned mining firms and by private corporations, both foreign and domestic. The potential for the recovery of residual gold and silver from waste and tailings dumps at numerous abandoned mining properties using new, more efficient recovery techniques was not overlooked. One company, Cía. Minero Otuzco S.A., recovered gold and silver values from old tailings at a mill in northern Peru usng a carbon-in-pulp recovery system of U.S. design.

Philippines.—Despite problems in the copper sector that included increasing world supplies of copper, reported Philippine gold production, chiefly a byproduct of copper mining, declined by only about 5% from production reported in 1983.

The Benguet Corp., the country's oldest mining company and its largest gold producer, produced 102,000 ounces of gold from its four adjacent underground gold mines near Baguio City in the Province of Benguet and 144,000 ounces from its Dizon copper-gold mine in Zimbales Province. At the Baguio operations, the company began heap leaching low-grade ore from its newly opened Cal Horr open pit and from underground development rock that had previously been discarded as waste. Benguet expects this new facility to recover 500 ounces of gold per month. The company was engaged either singly or through joint ventures in a number of gold development and exploration projects throughout the islands during the year.

Atlas Consolidated Mining and Development Corp. began construction of its new Masbate heap leach plant project in June, and following test runs in September, began commercial operations in October, producing 1,470 ounces of gold and 1,224 ounces of silver by yearend. The ore being treated by the new leaching facility generally contained less than 0.044 ounce per ton. Full-scale annual production was expected to yield 5,800 ounces of gold and 4,100 ounces of silver. Atlas' Masbate open pit operation produced nearly 80,000 ounces of gold and over 70,000 ounces of silver during the year, exceeding production goals by 7% and 36%, respectively. The company's combined gold production from Masbate and its copper-gold operations on Cebu Island amounted to 189,532 ounces in 1984.

South Africa, Republic of.—Nearly 96% of all South African gold production during the year was produced by the 34 mines and 1 metallurgical recovery operation that were members of the Chamber of Mines of South Africa. The total ore milled, including ore milled by producers of byproduct and coproduct uranium, amounted to 111.5 million tons, averaging 0.19 ounce of gold per ton; in 1983, 101.1 million tons, averaging 0.22 ounce per ton, was milled. Working costs for South African gold mines in 1984 averaged[12] $203.14 per ounce and ranged from $103.36 per ounce at East Driefontein to $412.99 per ounce at East Rand Proprietary. Production by the six major mining groups was as follows, in million ounces: AAC, 7.8; Gold Fields of South Africa Ltd. (GFSA), 4.4; Gencor, 3.7; Rand Mines Ltd., 2.1; Johannesburg Consolidated Investment Co. Ltd. (JCI), 1.6; and Anglo-Transvaal Consolidated Investment Co. Ltd., 1.3. Mines that were not Chamber of Mines members produced about 602,000 ounces.

The largest producing mines, in millions of ounces of gold output, were Vaal Reefs with 2.7, Driefontein Consolidated with 2.4, Western Holdings and Western Deep Levels with 1.2 each, and Kloof with 1.0. Estimates of fully developed or block-out gold ore reserves reported by the Chamber of Mines at the close of 1984 totaled 487 million tons, containing, on average, about 0.31 ounce of gold per ton.

In a move reportedly aimed at optimizing the operating efficiency of several gold mines in the Orange Free State, AAC announced at yearend a proposal to merge four neighboring mines, thereby creating the world's largest single gold mine. The four mines involved in the proposal were Free State Geduld, President Brand, President Steyn, and Western Holdings. The combined production of these four properties amounted to over 3.6 million ounces. Objections to the proposal were reportedly voiced by the Government of the Republic of South Africa as well as by investors concerned about their interests in the individual properties.

As a consequence of the poor international market for uranium oxide as well as the year's generally poorer gold prices, several mines that produce both gold and uranium, either one as the principal product, experienced difficulty in maintaining the viability of their operations. Early in the year, citing poor market conditions as well as continuing problems associated with geological faults and water incursions, Gencor announced that St. Helena Gold Mines Ltd., a corporate member of the Gencor Group, would close its Beisa Section, a mine where gold is produced as a byproduct of uranium mining. Production at the mine ceased in October.

According to its 1984 annual report, AAC experienced favorable results with its recently introduced vibroseis geological surveying technique. The new technique reportedly led to an intensification of gold exploration activity in both the Orange Free State and in the Transvaal. Encouraging results were obtained especially in resolving problems of interpretation of geological structures. GFSA began drilling for possible gold occurrences on the perimeter of the Witwatersrand Basin and elsewhere, and JCI reported that an intensive drilling program on two areas in the Theunissen District of the Orange Free State had returned promising results.

Krugerrand sales on world markets during the year were reported by the International Gold Corp. to have amounted to over 2.6 million ounces. Cumulative sales of krugerrands since 1970 reached nearly 43 million ounces by yearend.

Many of the problems that beset the Republic of South Africa during 1983 continued to plague the country's gold producers throughout 1984, especially during the second half of the year. The effects of the persistent drought on the country's mining sector, though not as severe as in other sectors such as agriculture, nevertheless continued to worry the industry in general. The South African economy and the gold-mining sector in particular were under continued pressure, not only from declining international dollar prices for gold, but from rising domestic labor and working costs plus currency inflation, which at yearend was reportedly running at about 13%. Interest rates on new capital required by producers to expand productive capacity reached prohibitively high levels toward yearend, and some producers were forced to postpone or forego planned expenditures.

Production costs, operating profits, and prices received by producers for their product in terms of the South African rand were the highest seen in many years. However, the economic performance of gold producers in terms of U.S. dollars continued to depreciate as the year progressed. The value of 1 rand in terms of U.S. dollars declined by about 23% between yearends 1983 and 1984.

Beginning on April 1, the Government of the Republic of South Africa, to help in offsetting losses in revenue owing to reduced agriculture and exports earnings, increased the surcharge on taxes paid by the gold producers on their production from 15% to 20%. Concurrently, however, the Government announced a delay in implementing plans put forth in 1983 to terminate the Gold Mines Assistance Act whereby marginal producers receive state aid to continue mining operations.

On September 17, 1984, the recently formed National Union of Mineworkers (NUM) stayed off the job in the first legal strike by black workers in South African history. Seven of the eight mines affected by the walkout were owned by AAC. On September 18, the Chamber of Mines and NUM announced that union members had accepted a restructured wage offer, apparently somewhere between the 25% increase demanded by NUM and the 14.4% increase put into effect on July 1 by the Chamber. Gold production apparently was not affected by the walkout.

U.S.S.R.—Net deliveries of gold from the centrally planned economy countries to the market economy countries during the year were estimated at about 6.6 million ounces compared with 3.0 million ounces delivered during 1983.[13]

Toward yearend 1984, the U.S.S.R.'s principal gold and currency trading outlet, the Wozchod-Handelbank AG in Zurich, Switzerland, reportedly experienced considerable, but incompletely assessed, financial losses.

Table 16.—Gold: World mine production, by country[1]

(Troy ounces)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina	10,622	14,757	20,319	23,374	24,000
Australia	547,687	590,737	866,815	983,522	1,200,000
Bolivia	52,075	66,372	40,146	49,217	42,000
Brazil[e 3]	1,300,000	1,200,000	1,500,000	[r]1,750,000	1,750,000
Burundi	130	[e]100	[e]100	272	300
Cameroon	72	316	136	261	250
Canada	1,627,477	1,672,893	2,081,230	2,363,411	2,614,300
Central African Republic	2,000	1,386	1,000	2,492	2,500
Chile	219,773	400,479	543,569	570,971	560,000
China[e]	225,000	1,700,000	1,800,000	[r]1,850,000	1,900,000
Colombia	510,439	529,214	472,674	438,579	735,000
Congo	--	48	83	267	250
Costa Rica[e]	18,000	20,000	27,000	30,000	35,000
Dominican Republic	369,603	407,813	380,254	348,065	330,000
Ecuador	[r]225	2,347	[e]2,300	643	1,000
El Salvador	2,492	3,883	3,300	650	650
Ethiopia[e]	9,000	[4]11,930	12,000	14,000	15,000
Fiji	23,939	30,595	46,821	[r e]40,000	45,000
Finland	41,828	31,893	36,780	25,080	25,000
France	37,391	36,362	67,967	71,659	75,000
French Guiana[e]	4,000	4,000	4,000	4,000	4,000
Gabon[e]	[4]553	550	550	550	550
Germany, Federal Republic of	2,964	3,051	1,813	[e]1,900	1,500
Ghana	353,000	341,000	331,000	[r e]280,000	260,000
Guyana	11,003	19,263	7,347	4,607	6,000
Honduras	2,027	1,579	1,711	2,151	2,200
Hungary[e]	60,000	60,000	50,000	30,000	20,000
India[5]	78,834	79,875	71,935	70,158	68,000
Indonesia[6]	[r]54,970	[r]51,820	69,160	74,640	78,200
Japan	102,339	99,242	104,136	100,921	[4]103,519
Kenya	125	100	21	100	100
Korea, North[e]	160,000	160,000	160,000	160,000	160,000
Korea, Republic of[5]	[r]41,218	[r]43,147	55,750	72,083	70,000
Liberia[e]	7,243	[r 7]16,720	[7]12,656	[7]15,400	[7]10,500
Madagascar[e]	[4]114	110	110	110	110
Malaysia:					
Peninsular Malaysia	4,621	5,691	5,814	5,792	6,000
Sabah	[r]60,998	[r]69,503	80,945	82,662	82,000
Sarawak	[r]380	[r]67	26	162	100
Mali[e]	10,000	16,000	13,000	13,000	13,000
Mexico[8]	[r]176,089	[r]198,594	214,349	198,177	205,000
New Zealand	6,419	6,071	7,775	9,667	10,000
Nicaragua	[r]59,984	[r]61,913	54,384	46,428	34,000
Papua New Guinea	451,707	540,325	563,538	582,000	835,000

See footnotes at end of table.

Table 16.—Gold: World mine production, by country[1] —Continued

(Troy ounces)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Peru	142,041	[r]161,590	157,667	165,576	199,000
Philippines	643,806	753,451	834,439	812,333	[4]772,931
Portugal	8,855	10,931	6,783	9,603	[4]9,100
Romania[e]	65,000	65,000	65,000	65,000	65,000
Rwanda	944	1,204	286	623	600
Sierra Leone[9]	407	3,435	8,729	[e]9,000	9,000
Solomon Islands	1,093	1,050	1,318	[e]1,100	[4]2,572
South Africa, Republic of	21,669,468	21,121,157	21,355,111	21,847,310	[4]21,904,900
Spain	108,154	98,381	109,858	162,296	160,000
Sudan[e]	300	300	400	500	1,500
Suriname	350	[r]823	599	482	500
Sweden	[e]70,000	[e]70,000	77,160	102,880	100,000
Taiwan[5]	13,278	56,695	71,770	52,361	[4]37,794
Tanzania	246	[e]400	[e]600	[e]800	[4]1,900
U.S.S.R.[e]	8,300,000	8,425,000	8,550,000	8,600,000	8,650,000
United States	969,782	1,379,161	1,465,686	1,956,400	[4]2,058,784
Venezuela	13,565	[r]27,810	27,993	[r e]33,200	34,000
Yugoslavia[5]	106,226	[r]135,387	135,229	[r e]135,000	140,000
Zaire	40,864	64,430	62,233	147,885	[4]80,303
Zambia	10,576	10,545	13,439	10,160	[4]12,185
Zimbabwe	368,000	371,000	426,000	453,000	470,000
Total	[r]39,179,296	[r]41,257,496	43,082,814	44,882,480	46,035,098

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

[1]Table includes data available through June 4, 1985.

[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]Officially reported figures are as follows, in troy ounces: Major mines: 1980—131,432; 1981—140,691; 1982—148,408; 1983—199,206; and 1984—not available. Small mines (garimpos): 1980—310,704; 1981—414,744; 1982—671,982; 1983—1,526,775; and 1984—not available.

[4]Reported figure.

[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

Bureau of Mines research continued to be directed toward improving the technology of leaching low-grade gold ores. The Bureau reported a procedure for facilitating gold recovery from those low-grade ores frequently found to be contaminated with small quantities of mercury.[14] The procedure, one that employs the addition of calcium sulfide to the grinding circuit, is useful in limiting the amount of mercury that is extracted during leaching of gold ores and for eliminating mercury from the cyanide leach solution. A comprehensive State-by-State review of 118 domestic gold and silver heap- and dump-leaching operations was published by the Bureau.[15] The report also discusses current leaching technology and research and the various techniques employed to recover gold and silver from leaching solutions. Emerging in situ leaching technology is briefly discussed and various State and Federal permitting requirements are presented.

A report summarizing mineralogic observations of naturally occurring gold-silver nuggets from Western Australia illustrated that dissolution of the metals, usually in the presence of iron oxides, is a relatively frequent occurrence—especially during periods of lateritization.[16] The report went on to note that since the advent of the modern metal detector, numerous nuggets (many in excess of 30 ounces) have been recovered near the surface in chemically favorable zones within the lateritic weathering profile.

A geochemical study conducted over two gold ore bodies in Nevada indicated that geochemical anomalies for gold and associated trace elements, derived from samples of iron-rich rock fracture coatings, were typically more intense than those determined from rock samples for the same elements.[17] The large enhancement in geochemical response afforded by sampling fracture coatings may prove to be a valuable technique in the search for buried, disseminated gold deposits.

An ion-beam etching technique was developed to fabricate micrometer-sized gold strip lines employed in complex microelectronic circuitry as low-resistance paths.[18] The gold strip lines, 3 micrometers thick, 13 micrometers wide, and 1.5 centimeters long, are fabricated using argon ion-beam milling procedures.

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[1]Physical Scientist, Division of Nonferrous Metals.

[2]Federal Register. V. 49, No. 13, Jan. 19, 1984, pp. 2246-2248.

[3]Ounce refers to troy ounce.

[4]U.S. Department of the Treasury, Internal Revenue Service, Public Affairs Division. News release, June 8, 1984.

[5]Eakins, G. R., and T. K. Bundtzen. Alaska Minerals Activity Summary, 1984. Min. Eng., Soc. Min. Eng. AIME, v. 37, No. 5, May 1985, pp. 401-402.

[6]U.S. House of Representatives. Extension of remarks by Representative Vic Fazio on Tribute to Homestake Mining Co. Congr. Rec., v. 130, No. 92, pt. 2, June 29, 1984, p. E3193.

[7]McClernan, H. G. Mining and Mineral Developments in Montana—1984. Mont. Bur. Mines Geol., MBMG 150, 1984, 19 pp.

[8]Brooks, H. C., L. Ramp, M. L. Ferns, and J. J. Gray. Mineral Industry in Oregon, 1984. OR Dep. Geol. and Miner. Ind. OR Geol., v. 47, No. 4, Apr. 1985, pp. 39-46.

[9]Bunning, B. B. New Developments in Mining and Mineral Exploration in Washington, 1984. WA Div. Geol. and Earth Res. WA Geol. Newsletter, v. 13, No. 1, Jan. 1985, pp. 1-12.

[10]BuBoulay, L. Gold 1985. Consolidated Gold Fields PLC, London, May 1985, 59 pp.

[11]Gall, N. The Last Gold Rush. Harper's Mag., v. 269, No. 1615, Dec. 1984, pp. 59-65.

[12]Values have been converted from South African rands (R) to U.S. dollars at the rate of R1.00 = US$0.6954 for 1984, as shown in Int. Financial Stat., v. 38, No. 5, May 1985, p. 412.

[13]Work cited in footnote 9.

[14]Sandberg, R. G., W. W. Simpson, and W. L. Staker. Calcium Sulfide Precipitation of Mercury During Cyanide Leaching of Gold Ores. BuMines RI 8907, 1984, 13 pp.

[15]Camberlan, P. G., and M. G. Pojar. Gold and Silver Leaching Practices in the United States. BuMines IC 8969, 1984, 47 pp.

[16]Mann, A. W. Mobility of Gold and Silver in Lateritic Weathering Profiles: Some Observations From Western Australia. Econ. Geol., v. 79, No. 1, Jan.-Feb. 1984, pp. 38-49.

[17]Crone, W., L. T. Larson, R. H. Carpenter, T. T. Chao, and R. F. Sanzolone. Comparison of Iron Oxide-Rich Joint Coatings and Rock Chips as Geochemical Sampling Media in Exploration for Disseminated Gold Deposits. J. Geochem. Explor., v. 20, No. 2, Apr. 1984, pp. 161-178.

[18]Gee, C. M., and G. D. Thurmond. Optical Technology for Microwave Applications (1984). Wideband Traveling-Wave Electro-Optic Modulator. SPIE (Soc. Photo-Opt. Instrum. Eng.), v. 477, pp. 17-22.

Graphite

By Harold A. Taylor, Jr.[1]

Apparent consumption of natural graphite increased 50% in 1984 to 51,000 short tons. An amorphous graphite was mined domestically for the third consecutive year. All natural graphites, including crystalline flake, were in more than adequate supply even as demand by industrial users recovered along with the economy. Prices of imported graphites decreased from those of 1983, two of the prices to a significant degree.

Production of manufactured graphite increased 16% to 263,000 tons valued at $629 million. Production of graphite fibers increased 51% to 1,397 tons valued at $75 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, 95% responded, representing 100% of the total production data shown in table 4. Production for the two nonrespondents was believed to be small and was not included.

Table 1.—Salient natural graphite statistics

	1980	1981	1982	1983	1984
United States:					
Production short tons	--	--	W	W	W
Apparent consumption[1] do	52,438	[2]54,315	[2]42,815	[2]34,151	[2]51,147
Exports do	8,880	11,344	10,335	9,435	7,096
Value thousands	$3,695	$4,433	$4,099	$3,455	$2,807
Imports for consumption short tons	61,318	[2]65,659	[2]53,150	[2]43,586	[2]58,246
Value thousands	$15,765	[2]$19,093	[2]$15,676	[2]$11,921	[2]$14,579
World: Production short tons	[r]657,728	[r]650,193	621,187	[p]636,995	[e]631,842

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Excludes domestic production, which was relatively small.
[2]Data do not include artificial graphite.

Legislation and Government Programs.—There were no acquisitions or disposals of strategic graphite in 1984.

Table 2.—U.S. Government stockpile goals and yearend stocks of natural graphite in 1984, by type

(Short tons)

Type	Goal	National stockpile inventory
Madagascar crystalline flake	20,000	17,841
Sri Lanka amorphous lump	6,300	5,443
Crystalline, other than Madagascar and Sri Lanka	2,800	1,933
Nonstockpile-grade, all types	--	985

Source: General Services Administration. Inventory of Stockpile Materials as of Dec. 31, 1984.

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 in 1984 was significantly lower than in previous years. Graphite Sales Inc. marketed the material, which averaged 25% fixed carbon and was marketed to a variety of users. The material was not beneficiated before sale, but merely dried, crushed, and sized. At a lower production level, such as that of 1984, the reserves that the firm estimated at over 2 million tons would last even longer than previously thought. Other domestic deposits of graphite received little or no attention.

Output of manufactured graphite increased 16% to 263,000 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 51% to 1,397 tons.

The Wickes Co. emerged from bankruptcy during the year, and as part of the process sold its Graphitar product line, thereby leaving the graphite industry entirely. The successor firm with the Graphitar line is called U.S. Graphite Inc.

Dixon Ticonderoga Co., formerly the Joseph Dixon Crucible Co., closed its Jersey City, NJ, operations and its crucible plant in Philadelphia, PA.

Avco Corp., a conglomerate that produces high-modulus graphite fiber, was acquired by Textron Inc. in December. No immediate changes in the business were announced.

Superior Graphite Co. bought a plant at Russellville, AR, from The Dow Chemical Co., increasing its production capacity to 3,000 tons per year of graphite electrodes and 17,000 tons per year of extruded and baked carbon shapes. The 95,000-square-foot plant was acquired under a lease-purchase agreement and was brought back on-stream in February 1985. The plant had been closed since 1983 and was used by Dow to make graphite anodes for its electrolytic chlorine cells before it converted to permanent metal anodes.

Table 3.—Principal producers of manufactured graphite in 1984

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	
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.
Celanese Corp., Celanese 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	
BF Goodrich Co., Engineered Systems Div., Super Temp Operation.	Santa Fe Springs, CA	Other.
Great Lakes Carbon Corp	Elizabethton, TN	Anodes, electrodes, powder, crucibles, cathodes, high-modulus fibers, unmachined shapes, other powder.
Do	Morganton, NC	
Do	Niagara Falls, NY	
Do	Ozark, AR	
Do	Rosamond, CA	
Hercules Inc	Salt Lake City, UT	High-modulus fibers.
HITCO Materials Group, ARMCO Inc	Gardena, CA	Cloth and high-modulus fibers.
Hysol Grafil Co	Sacramento, CA	High-modulus fibers.
Ohio Carbon Co	Cleveland, OH	Motor brushes and unmachined shapes.
Pfizer Inc., 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, anodes, motor brushes, unmachined shapes.
Do	St. Marys, PA	
Superior Graphite Co	Russellville, AR	Powder and other.
Do	Hopkinsville, KY	
Ultra Carbon Corp	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	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Synthetic graphite products:				
Anodes	4,178	$11,311	4,680	$14,133
Cathodes	W	W	--	--
Cloth and fibers (low-modulus)	188	14,217	223	17,979
Crucibles, vessels, refractories	W	W	W	W
Electric motor brushes and machined shapes	W	W	W	W
Electrodes	153,742	370,450	177,116	398,180
Graphite articles	--	35,481	--	39,895
High-modulus fibers	739	33,854	1,174	56,636
Refractories	W	W	W	W
Unmachined graphite shapes	10,691	50,422	12,738	58,601
Other	28,636	29,712	37,263	36,635
Total	198,174	545,447	233,194	622,059
Synthetic graphite powder and scrap	29,487	7,372	29,911	6,668
Grand total	227,661	552,819	263,105	628,727

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

Table 5.—U.S. production of graphite fibers

Year	Cloth and low-modulus fibers		High-modulus fibers		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1974	153	$9,400	48	$4,675	201	$14,075
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	1,174	56,636	1,397	74,615

Union Carbide Corp. retrofitted its graphite electrode production facilities with computers. Of particular interest is the automated pin production line that uses robots in its Columbia, TN, plant and the computer-controlled rotary hearth furnaces in its Clarksville, TN, plant. The firm views the future graphite electrode market quite positively, particularly when the difficult markets of the last few years are considered.[2]

Ashland Petroleum Co. brought a 30-ton-per-year-capacity high-modulus graphite fiber plant on-stream in late 1984 at Catlettsburg, KY. Capacity was to be rapidly expanded to 100 tons per year and then to 300 tons per year in 1986. The product, "Carboflex," is a material with a somewhat lower modulus and lower price that is slated for the insulation and brake lining market. The fiber is made from a specialty petroleum pitch.

CONSUMPTION AND USES

Reported consumption of natural graphite decreased 3% to about 35,200 tons. The three major uses of natural graphite—refractories, foundries, and brake linings—accounted for 61% of reported consumption, compared with 54% in 1983.

A new market for graphite fiber is in the cathodic protection of reinforcing steel in concrete bridge decks. Salt damage to the bridge deck or other concrete structure can be prevented by installing conductive platinized wires and graphite fibers in slots cut in the deck and then surrounding them by a conductive polymer. A low-voltage direct current is run through the conducting material to make the steel cathodic and thus immune to attack by negative ions, such as chloride, that promote corrosion. Other systems exist that do not use graphite fiber. One using coke breeze has been tried and one using liquefied zinc is about to be tried.

Natural graphite is now being produced by a large number of countries compared with the situation 10 years ago, when China was a minor source of graphite, Brazil had only a small mine, and Canada did not produce at all. Several important new uses have become prominent, particularly the use of crystalline flake graphite in carbon-magnesite brick and graphite-alumina refractories. The use of graphite in lubricants and as expandable graphite has also been increasing.[3]

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)
1983						
Batteries	W	W	W	W	2,027	$3,699
Brake linings	986	$928	2,371	$2,006	3,358	2,934
Carbon products[3]	411	675	349	517	760	1,192
Crucibles, retorts, stoppers, sleeves, nozzles	1,984	1,307	--	--	1,984	1,307
Foundries[4]	432	630	6,791	2,518	7,223	3,148
Lubricants[5]	1,392	1,657	2,203	1,266	3,595	2,923
Pencils	1,448	2,014	298	164	1,745	2,178
Powdered metals	450	636	172	337	622	973
Refractories	W	W	W	W	8,902	3,650
Rubber	260	324	101	72	361	396
Steelmaking	270	127	2,571	727	2,841	854
Other[6]	1,111	1,080	1,549	1,159	2,660	2,239
Withheld uses	2,533	2,784	8,397	4,565	--	--
Total[2]	11,277	12,162	24,802	13,331	36,079	25,493
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	([7])	6	1,953	1,864
Foundries[4]	2,337	1,285	4,804	1,810	7,141	3,095
Lubricants[5]	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[6]	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

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]Includes foundry facings.
[5]Includes ammunition, packings, and seed coating.
[6]Includes paints and polishes, antiknock and other compounds, soldering and/or weld, electrical and electronic products, mechanical products, magnetic tape, and small packages.
[7]Less than 1/2 unit.

PRICES

Graphite prices are often negotiated between the buyer and seller, and are based on purity and other variable properties. 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 Sri Lankan lump graphite imports were little changed in 1984, while the prices of the other kinds dropped significantly. Prices for crystalline flake dropped by 8% to $509 per ton. Prices for Mexican amorphous graphite dropped by 29% to $40 per ton. Prices for all types of Sri Lankan lump graphite dropped by 8% to $1,065 per ton. Prices for other natural graphite (mostly fine crystalline flake and dust) dropped by 18% to $462 per ton.

Average prices for natural graphite at the point of consumption changed by only a small amount in 1984. The price for crystalline graphite (mostly crystalline flake, some crystalline dust, and a little lump graphite) was $1,127 per ton, up 5% from $1,078 in 1983. The price for amorphous graphite (including small amounts of amorphous-synthetic graphite mixtures) was $511 per ton, down 5% from $537 in 1983.

Table 7.—Representative yearend graphite prices[1]

(Per short ton)

	1983	1984
Flake and crystalline graphite, bags:		
China	$54-$1,542	$54-$1,542
Germany, Federal Republic of	318- 3,175	286- 3,084
Madagascar	227- 544	227- 726
Norway	181- 635	181- 816
Sri Lanka	499- 1,367	272- 1,361
Amorphous, nonflake, cryptocrystalline graphite (80% to 85% carbon):		
Korea, Republic of (bags)	82- 109	82- 109
Mexico (bulk)	64- 91	64- 109

[1]F.o.b. foreign port or border.

Source: Engineering and Mining Journal. V. 185, No. 12, Dec. 1984, p. 27.

FOREIGN TRADE

Exports of both natural and artificial graphite decreased. Exports of graphite electrodes totaled 58,027 tons worth $92.2 million, of which 9,064 tons ($14.0 million) went to Brazil, 7,581 tons ($13.2 million) to Canada, 7,218 tons ($6.9 million) to Norway, 6,125 tons ($9.6 million) went to Venezuela, and the balance to other destinations.

Imports of natural graphite increased 34% to 58,246 tons. Imports of natural graphite from China gained by 50% to 15,232 tons, while imports from Canada and Mexico rebounded toward levels last seen in 1981 and 1982, respectively.

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
1983:						
Canada	3,848	$1,203,364	1,103	$374,076	4,951	$1,577,440
Germany, Federal Republic of	2,339	651,463	142	52,298	2,481	703,761
Italy	83	27,873	59	38,934	142	66,807
Japan	239	225,916	577	425,096	816	651,012
Mexico	961	399,436	114	46,904	1,075	446,340
Netherlands	34	4,973	186	95,736	220	100,709
United Kingdom	453	166,110	123	133,003	576	299,113
Venezuela	348	235,845	35	37,912	383	273,757
Other	1,130	539,869	2,177	893,334	3,307	1,433,203
Total	9,435	3,454,849	4,516	2,097,293	13,951	5,552,142
1984:						
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
Netherlands	17	24,913	43	28,446	60	53,359
United Kingdom	252	136,464	155	111,990	407	248,454
Venezuela	301	177,294	36	37,102	337	214,396
Other	744	382,762	1,299	1,026,470	2,043	1,409,232
Total	7,096	2,807,441	4,226	2,786,215	11,322	5,593,656

[1]Amorphous, crystalline flake, lump or chip, and natural, not elsewhere classified.

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)
1982	10,771	$7,056	767	$1,140	11,263	$5,835	30,349	$1,645	[2]53,150	[2]$15,676
1983:										
Argentina	--	--	--	--	58	24	--	--	58	24
Austria	--	--	--	--	--	--	11	3	11	3
Belgium-Luxembourg	1	1	--	--	--	--	--	--	1	1
Brazil	1,642	1,196	--	--	1,447	830	--	--	3,089	2,026
Canada	7	7	--	--	953	623	--	--	960	630
China	3,684	1,740	--	--	3,311	1,393	3,152	200	10,147	3,333
France	--	--	--	--	617	358	--	--	617	358
Gambia	--	--	--	--	5	6	--	--	5	6
Germany, Federal Republic of	([3])	1	--	--	838	856	--	--	838	857
Hong Kong	--	--	--	--	--	--	230	12	230	12
India	116	58	--	--	100	71	--	--	216	129
Italy	--	--	--	--	([3])	3	--	--	([3])	3
Japan	--	--	--	--	79	38	--	--	79	38
Korea, Republic of	--	--	--	--	--	--	20	3	20	3
Madagascar	1,486	796	--	--	1,667	836	--	--	3,153	1,632
Malaysia	40	31	--	--	--	--	--	--	40	31
Mexico	--	--	--	--	380	265	21,744	1,211	22,124	1,476
Netherlands	--	--	--	--	7	4	--	--	7	4
Norway	--	--	--	--	56	16	--	--	56	16
South Africa, Republic of	--	--	--	--	419	242	--	--	419	242
Sri Lanka	--	--	751	870	--	--	--	--	751	870
Sweden	--	--	--	--	8	19	--	--	8	19
Switzerland	--	--	--	--	2	4	--	--	2	4
Taiwan	58	36	--	--	--	--	520	45	578	81
United Kingdom	--	--	--	--	40	64	--	--	40	64
Zimbabwe	--	--	--	--	137	59	--	--	137	59
Total	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

[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.

Table 10.—U.S. imports for consumption of artificial graphite and graphite electrodes, by country

Country	Artificial graphite		Graphite electrodes	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1983:				
Australia	(1)	$25	--	--
Austria	--	1	--	--
Belgium	--	36	--	--
Canada	1,214	292	746	$816
China	198	259	50	81
France	2	7	--	--
Germany, Federal Republic of	57	324	2,915	4,203
Italy	--	--	2,416	3,187
Japan	231	1,592	23,113	43,724
Netherlands	40	56	--	--
Singapore	76	86	--	--
Sweden	15	33	--	--
Switzerland	3,308	5,387	--	--
United Kingdom	1	31	--	--
Other	--	--	4,887	5,029
Total[2]	5,142	8,128	34,127	57,040
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

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

WORLD REVIEW

World demand for graphite dropped slightly, and world supply continued to be adequate. Japan, however, increased its demand for and therefore imports of natural graphite very substantially.

China.—Sales of coarser Chinese crystalline flake were reportedly being linked to sales of finer grades, particularly crystalline dust. Consumers are resisting this because they are often unable to use or market the finer material and hence have to consider it as part of their cost in buying crystalline flake.

For the first time in many years, comprehensive information on the Chinese graphite industry was published in an English-language journal. China has large deposits of both crystalline flake graphite and amorphous graphite and a large mining and processing industry. The graphite deposits being worked generally have gently dipping beds of thin to medium thickness; the graphite is extracted with natural stoping by horizontal slicing or overhead lean slicing. After mining, the crystalline flake graphite is beneficiated by flotation, but the amorphous graphite is simply crushed and screened to yield minus 200-mesh or minus 325-mesh products. The crystalline flake flowsheet can be summarized as follows: the ore is first crushed and ground, then subjected to scavenging flotation, with the tailings being processed for the recovery of rutile and pyrite. The rough graphite concentrate is reground four times and put through a cleaner circuit five times to obtain a final concentrate. The concentrate is then dewatered, dried, air classified to remove fines, and screened to separate the large flakes. Some of the equipment, such as the rougher flotation machine and the horizontal centrifugal mill for regrinding the graphite concentrate, is of local design. High-purity specialty graphite products are also produced.

China consumes about 70% of its own production. Of its total consumption, 30% is used in casting and foundry, 30% to protect slag in steelmaking, 15% in pencils, 10% to 12% in electricity conducting materials, 7% to 8% in refractories, and the balance in other uses.[4]

Czechoslovakia.—A new flotation plant was built at Male Urbno to process the ore from the Konstantin Microcrystalline Graphite Mine near Stare Mesto pod Snezniken. The plant produces six types of graphite products that contain 40% to 85% graphite and are used mainly for foundry purposes. The mine was opened in 1971 and has reserves of 550,000 tons of ore averaging 30% to 40% graphite, one-half of which can be mined by open pit methods. The ore occurs as a graphitic schist layer ranging from 15 to 65 feet in thickness that is part of a synclinally folded metamorphosed sedimentary sequence of Ordovician Age.

France.—Shortly after dropping out of another graphite fiber project, Pechiney bought a 32.5% share in the Société des Fibres de Carbon plant now being built by its former joint owners, Toray Industries Inc. of Japan and Société Nationale Elf Aquitaine, who will now own 35% and 32.5% of the project, respectively. The plant, having a capacity of 330 tons per year, was scheduled to be commissioned in 1985.

Vesuvius Crucible Co. concluded a purchase agreement for a fused silica refractory plant in northern France that will partly be converted to the production of graphite-alumina refractories.

Germany, Federal Republic of.—The Enka subsidiary of Akzo Zout Chemie Nederland BV of the Netherlands announced that it would build a 390-ton-per-year-capacity graphite fiber plant at Oberbruch, to come on-stream in 1986. The high-modulus fiber would be made from a polyacrylonitrile (PAN) precursor and will be marketed in Europe. The processing technology will be obtained from Toho Beslon Ltd. of Japan and its associate, Celanese Corp.

Israel.—Kibbutz Afikim came on-stream in 1984 with a medium-sized capacity graphite fiber plant that uses PAN as a raw material. The fiber is being distributed in the United States by Fiber Materials Inc. of Biddeford, ME.

Italy.—The sole Italian producer of graphite, Stá. Talco e Grafite Val Chisone S.p.A., closed its amorphous graphite mine near Pinerolo.

Japan.—In 1984, Japan outdistanced the United States in graphite importation by a wide margin for the first time. Imports of crystalline flake and Sri Lankan lump graphite rose from 28,384 tons in 1983 to 38,856 tons in 1984, of which 35,184 tons originated from China, 1,731 tons from Sri Lanka, 1,019 tons from Madagascar, 584 tons from Zimbabwe, and the balance from other sources. Amorphous graphite imports rose from 24,436 tons in 1983 to 46,408 tons in 1984, of which 33,983 tons came from the Republic of Korea, 12,153 tons from North Korea, and the balance from other sources. Imports of graphite, of which 75% or more, by weight, can pass through a 105-micrometer mesh sieve rose from 6,919 tons in 1983 to 8,441 tons in 1984, of which 7,825 tons came from China and the balance from other sources. Imports of graphite, particularly crystalline flake, have been increasing rapidly in the last 5 years because of the growing use of carbon-magnesite refractories.

Exports of graphite electrodes rose from 105,395 tons in 1983 to 122,217 tons in 1984, of which 33,688 tons went to the United States, 13,926 tons to the U.S.S.R., 10,849 tons to the Republic of Korea, 6,710 tons to Venezuela, and the balance to other destinations.

Major new capacity in graphite fiber was announced or came on-stream in 1984. Kureha Chemical Industry Inc. announced plans to double its present plant capacity to 550 tons by 1985. Its product is a lower modulus fiber made from petroleum pitch. Fuji Oil Co. began marketing its lower modulus fiber made in a 5-ton-per-year pilot plant in Yokohama that uses ultraheavy petroleum pitch as a starting material. Nippon Oil Co. is marketing the same kind of fiber from its pilot plant of the same size. Two more oil companies have built even smaller pilot plants.

U.S.S.R.—New information on the major Soviet graphite operation appeared in 1984, which also covered the development of the industry, and the mining and the recovery of graphite.[5] Accounting for 75% of national production, the Zaval'yevsky graphite complex is located near Gayvoron, Kirovograd Oblast, Ukrainian S.S.R., and produces crystalline flake, much of it fine. The operation, which consists of an open pit mine, a beneficiation plant, and a chemical purification plant, produces 90% of the nation's colloidal graphite preparations, or about 1,375 tons. It also produces 1,100 tons per year of graphite-based lubricants and 3,850 tons per year of high-purity graphite products containing from 99% to 99.9% fixed carbon. The new information shows that production of crystalline flake graphite at the operation first began in 1934 on a small scale, was interrupted by World War II, and continued at a rate of less than 5,000 tons per year into the 1950's. Major expansion followed and by 1967 the operation was producing 40,000 tons of graphite per year.

The Zaval'yevsky graphite deposit and mine are situated in the southwestern part of the Ukrainian Shield. The deposit is comprised of a number of bodies that range from 10 to 120 feet thick and dip steeply, ranging from 80° to 90°; the bodies are found from 100 to 1,100 feet below the surface. The reserves of "explored" graphite in this deposit total 110 million tons; the ore runs from 5% to 8% contained graphite and will reach 12% at times.

There are several other important mines besides the Zaval'yevsky. The Tayginskoye Mine at Kyshtym in the Urals produces crystalline flake; it was a major mine and produced about as much graphite as the Zaval'yevsky in the mid-1960's. However, its costs rose until they were about 70% higher than the Zaval'yevsky and hence output has declined to a much lower level. This shows that the Soviets will decrease graphite production at a mine when the costs increase significantly. An underground mine at Noginsk produces amorphous graphite. Another small graphite mine operates at Taskazgan, Uzbekistan S.S.R. A number of formerly important deposits have become depleted and the mines closed, such as the ones at Bogotol and Boyevka.

Table 11.—Graphite: World production, by country[1]

(Short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina	6	2	13	22	22
Austria	40,454	26,243	26,953	44,553	44,100
Brazil (marketable)[3]	23,473	19,289	16,990	[e]22,000	22,000
Burma[4]	482	1,568	308	220	250
China[e]	176,000	203,000	204,000	204,000	204,000
Czechoslovakia[e]	[r]56,100	[r]56,100	[r]56,100	[r]56,100	56,100
Germany, Federal Republic of	[5]6,270	[5]9,024	[5]12,845	11,023	9,900
India (mine)[6]	[r]60,580	[r]80,240	57,735	[e]38,600	44,100
Italy	4,362	3,897	3,538	2,534	--
Korea, North[e]	28,000	28,000	28,000	28,000	28,000
Korea, Republic of:					
Amorphous	65,209	37,533	29,033	35,903	33,000
Crystalline flake	1,575	928	691	766	660
Madagascar	13,506	14,698	16,925	14,934	14,300
Mexico:					
Amorphous	49,059	45,351	37,886	47,034	44,100
Crystalline flake	384	1,270	1,989	1,828	1,700
Norway	11,471	9,552	[r]8,213	8,885	8,800
Romania	[r] [7]13,779	13,800	13,800	13,900	13,700
Sri Lanka	8,591	8,348	9,704	6,094	6,600
Thailand	2,286	1,984	694	95	110
Turkey	NA	NA	3,704	3,704	3,600
U.S.S.R.[e]	[r]88,000	[r]77,000	[r]83,000	[r]88,000	88,000
United States	--	--	W	W	W
Zimbabwe	8,141	12,366	9,066	[r] [e]8,800	8,800
Total	[r]657,728	[r]650,193	621,187	636,995	631,842

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table includes data available through May 21, 1985.

[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: 1980—6,600; 1981—17,988; 1982—6,758; 1983—not available; and 1984—not available.

[4]Data are for fiscal year beginning Apr. 1 of that stated.

[5]Data 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] Reported figure.

The U.S.S.R. also has a sizable synthetic graphite electrode plant. However, the Soviets rely very heavily on natural graphite, and very minimally on synthetic graphites. The plant, located at Linevo, south of Novosibirsk, began operating in 1977 with a capacity of 110,000 tons of graphite electrodes plus 60,000 tons of carbon electrodes. The raw material for the plant is anthracite that is obtained from a nearby mine and also from the Donets Basin 2,000 miles away.

TECHNOLOGY

A Bureau of Mines study on natural graphite dealing mostly with crystalline flake graphite but also covering Sri Lankan lump graphite and Mexican amorphous graphite was published. The study develops engineering and cost data on major graphite deposits in the market economy countries as part of an effort to delineate world graphite reserves and resources. The report describes the mines and deposits briefly and presents the method of data acquisition and analysis.[6]

The Ontario Research Foundation developed a new flowsheet and plant design for production of crystalline flake graphite. Autogenous grinding was found to be the key step to liberating the graphite without flake deterioration. When combined with flotation and tabling, it can produce a coarse graphite with a purity of 91.5% carbon with 95% retained on a 48-mesh screen. A higher purity fine can be produced with further regrinding, elutriation, and flotation of the material. The proposed plant would handle 500 tons of ore per day.[7]

Researchers at Michigan Technological University made progress in developing high-strength cold-worked metal matrix composites. This is an important area of research because the difficulties encountered in making metal matrix composites with graphite fiber have prevented the commercialization of any graphite fiber metal matrix system. The structure of the liquid phase sintering materials was examined, and some theoretical explanations of the microstructure obtained were proposed. Some guidelines for development of high-strength metal matrix composites were drawn up, which could be applied to graphite fiber metal matrix composites.[8]

A new competitor and substitute for graphite fiber and similar high-technology materials was developed. It is a class of materials called "ordered polymers," because the molecules gain strength and stiffness by being physically ordered in a straight line. The polymer is spun into a fiber from solution. The resulting fiber has greater strength than graphite fiber but not quite the stiffness. Making a composite of the polymer is difficult because of low interpolymer compatibility, but a laboratory technique was developed in 1984. A number of universities and firms are doing further research.

A study of the possible substitution of polymeric materials for critical materials showed that graphite fiber composites can be used to lessen the domestic needs for chromium. Substitution of graphite fiber composites and other polymeric materials is possible for chromium-bearing stainless steels in equipment for handling corrosive chemical substances and in decorative items such as automotive trim. In the decorative items, the composites could substitute for both the stainless steels and the chromium-plated products. Substitutions for cobalt, manganese, and platinum-group metals were deemed to be not feasible.[9]

A new method for graphitizing electrodes was developed that reduced by one-half the amount of electricity required for production. This is important because the cost of electricity is the major portion of the cost of producing the electrodes. The technique used is the longitudinal method of graphitizing by direct resistance heating. The energy savings resulted from carefully controlling the electrical input and from keeping the heating time as short as possible. Large-scale use of the method allows switching from a one-line furnace to a multiline furnace for increased production.[10]

ASEA Metallurgical Industries Div. announced the operating data on a new single-electrode direct current arc furnace that will reportedly reduce graphite electrode consumption by one-half. While the new furnace costs 25% more, it was stated that the payback period was less than 1 year as a result of savings from lower electrode consumption. A furnace using this new technology is now in commercial operation in Sweden.

An efficient low-cost graphite electrode fuel cell was developed at Michigan State University. Until this breakthrough, users had to choose between an efficient but expensive platinum-electrode cell and a cheap but inefficient graphite-electrode cell. The high yield of the new fuel cell is derived from a porphyrin-coated graphite electrode that produces reactions similar to the energy-producing reactions of a living cell. The porphyrin is somewhat unstable, and research on constructing a more stable porphyrin analogue is proceeding.

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[1]Physical scientist, Division of Industrial Minerals.

[2]Metal Bulletin Monthly. Union Carbide Regroups To Serve Changing Markets. No. 163, July 1984, pp. 9-17.

[3]Robbins, J. Graphite—Drawing on Mixed Sources. Ind. Miner. (London), No. 202, July 1984, pp. 37-55.

[4]Zhaoyang, and Y. Yantang. Development and Utilization of Industrial Minerals in China. Paper in Proc. 6th Ind. Miner. Int. Cong., Ind. Miner. (London), 1984, pp. HZ1-HZ12.

[5]Soviet Geography. The Soviet Graphite Industry. V. 26, No. 1, Jan. 1985, pp. 66-67.

Gornyy Zhurnal. Sept. 1984, pp. 9-12.

[6]Oxford, T. P. Development of Engineering and Cost Data for Foreign Graphite Properties (contract J0225019, Zellar-Williams Inc.). BuMines OFR 169-84, Feb. 1984, 19 pp.; NTIS PB 85-103737.

[7]Lakshmanan, V. I., and J. Melnbardis. Pilot Plant Development Studies on Mt. Laurier, Canada Graphite Deposit. AIME Preprint 84-361, Littleton, CO, Oct. 24-26, 1984, 13 pp.

[8]Courtney, T. H., and J. K. Lee. Microstructural Development and Control in Liquid Phase Sintering; Processing, Structures and Properties of Cold Worked Metal Matrix Composites. MI Technol. Univ., Houghton, MI, June 3, 1984, 24 pp.; NTIS AD-A143 188/1.

[9]Verink, E. D., Jr. Substitution of Polymeric Materials for Critical Materials. Mater. and Soc., v. 8, No. 2, June 1984, pp. 305-311.

[10]Utzat, M. Method for the Production of Electro-Graphite Involving About 50% Reduction of Electrical Energy. Bundesminist. Forsch. und Technol., Bonn-Bad Godesberg, Federal Republic of Germany, Aug. 1983, 93 pp.; NTIS DE 83-751301.

Gypsum

By J. W. Pressler[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 1984, ended the year with record-high shipments of gypsum wallboard, 18.3 billion square feet, an increase of 9%. Output of crude gypsum and calcined gypsum also increased. Sales of gypsum products increased 10% to 24 million short tons valued at $2.3 billion. Imports for consumption of crude gypsum increased 11% to 9 million tons. Total value of gypsum product exports decreased 7% to $30 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 134 operations to which the annual survey request was sent, 99% responded, representing 99% of the total production shown in tables 1 and 2. Production for nonrespondents was estimated using prior year production data.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1980	1981	1982	1983	1984
United States:					
Active mines and plants[1]	114	113	109	111	113
Crude:					
Mined	12,376	11,497	10,538	12,884	14,319
Value	$103,059	$98,101	$89,131	$101,361	$113,671
Imports for consumption	7,365	7,593	6,718	8,031	8,904
Byproduct gypsum sales	663	696	697	760	780
Calcined:					
Produced	11,848	11,687	11,243	13,902	15,450
Value	$270,324	$243,140	$196,488	$270,136	$320,518
Products sold (value)	$1,241,949	$1,196,236	$1,121,775	$1,605,605	$2,274,261
Exports (value)	$27,222	$35,434	$29,550	$32,088	$29,852
Imports for consumption (value)	$51,880	$51,720	$53,646	$87,880	$169,667
World: Production	r86,380	r84,012	79,713	p86,374	e90,302

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 16% of the total world output.

Forty-two companies mined crude gypsum at 69 mines in 22 States. Production increased 11%. Leading producing States were Texas, Oklahoma, Michigan, Iowa, 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 2.7 million tons.

Leading companies were United States Gypsum Co., 12 mines; National Gypsum Co., 7 mines; Georgia-Pacific Corp., 6 mines; Celotex Corp., a subsidiary of Jim Walter Corp., and Genstar Building Materials Co., 3 mines each; and Weyerhaeuser Co., 1 mine. These 6 companies, operating 32 mines, produced 78% of the total crude gypsum.

Leading individual mines were United States Gypsum's Plaster City Mine, Imperial County, CA; United States Gypsum's Sweetwater Mine, Nolan County, TX; United States Gypsum's Alabaster Mine, Iosco County, MI; United States Gypsum's Shoals Mine, Martin County, IN; Weyerhaeuser's Briar Mine, Howard County, AR; National Gypsum's Sun City Mine, Barber County, KS; National Gypsum's Tawas Mine, Iosco County, MI; United States Gypsum's Southard Mine, Blaine County, OK; Pacific Coast Building Product's Las Vegas Mine, Clark County, NV; and Georgia-Pacific's Acme Mine, Hardeman County, TX. These 10 mines accounted for 43% of the national total. Average output per mine for the 69 U.S. mines increased 11% to 207,500 tons.

Fourteen companies calcined gypsum at 71 plants in 30 States, principally for the manufacture of gypsum wallboard and plaster. Calcined output increased 11% in tonnage and 19% in value. Leading States were Texas, California, Iowa, and Florida. These 4 States, with 20 plants, accounted for 35% of the national output.

Leading companies were United States Gypsum, 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 83% of the national output.

Leading individual plants were United States Gypsum's Jacksonville plant, Duval County, FL; United States Gypsum's Plaster City plant, Imperial County, CA; United States Gypsum's Sweetwater plant, Nolan County, TX; Weyerhaeuser's Briar plant, Howard County, AR; National Gypsum's Tampa plant, Hillsborough County, FL; United States Gypsum's Shoals plant, Martin County, IN; United States Gypsum's Stony Point plant, Rockland County, NY; U.S. Gypsum's Fort Dodge plant, Webster County, IA; Georgia-Pacific's Acme plant, Hardeman County, TX; and National Gypsum's Medicine Lodge plant, Barber County, KS. These 10 plants accounted for 28% of the national production. Average calcine production for the 71 U.S. plants was 217,600 tons, a 10% increase.

The following companies sold a total of 780,000 tons of byproduct gypsum, valued at $6.5 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; American Cyanamid Co. in Georgia; SCM Pigments Div. of SCM Corp. in Maryland; and Texasgulf Inc. in North Carolina. Approximately 19% was of nonphosphogypsum origin, compared with 15% in 1983. Some byproduct gypsum was mixed with natural gypsum and commercially used in the manufacture of wallboard at United States Gypsum's Baltimore, MD, plant using byproduct gypsum obtained from SCM Pigments Div.'s plant in Baltimore.

The capacities of two reopened gypsum wallboard plants combined with the expanded capacities of other plants resulted in a 4% increase in domestic capacity of operating wallboard plants to 20.87 billion square feet. Total wallboard shipments were 18.3 billion square feet, indicating an 88% utilization of operating capacity. Shipments were a new record, a 9% increase compared with that of 1983.

Republic Gypsum Co. of Duke, OK, doubled the capacity of its gypsum wallboard plant to 685 million square feet of board per year. The $15 million expansion, by the addition of a second production line, was completed by yearend.

Centex Corp., a major Dallas-based homebuilding, construction, and cement firm purchased the closely held Allied American Gypsum Co.'s wallboard plant in Albuquerque, NM. The White Mesa gypsum mine and crushing plant, 30 miles north of Albuquerque, were also included. The mine and plant were purchased at yearend and were to operate as the Centex American Gypsum Co.

One new gypsum mine was opened during the year. The W. R. Gypsum Co.'s California Valley Mine in San Luis Obispo County, CA, produced gypsum for agricultural use.

Western Plains Materials' McFaddin Mine in Woodward County, OK, produced mainly gypsum rock from its quarry for road construction use, but some was sold for use as a cement set retarder.

Winn Rock Inc.'s Winnfield Mine in Winn Parish, LA, the only anhydrite mine in the United States, produced mainly rock from its quarry for road construction use, 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 were closed, or remained closed during the year. Glen C. Archer Gypsum Co. in California remained closed. Ernest W. Munroe, Joe C. Lackey, Colorado Lien Co., and U.S. Soil Conditioning Co., all in Colorado, were dormant. E. J. Wilson & Son's Lidy Hot Springs Mine in Lemhi County, ID, was closed. 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, were dormant. The White Mountain Gypsum Co.'s Fillmore Mine in Millard County, VT, was permanently closed in May.

Table 2.—Crude gypsum mined in the United States, by State

State	1983			1984		
	Active mines	Quantity (thousand short tons)	Value (thousands)	Active mines	Quantity (thousand short tons)	Value (thousands)
Arizona	4	265	$1,929	4	261	$2,332
Arkansas, Kansas, Louisiana	5	1,328	8,038	5	1,465	9,577
California	10	1,213	10,668	10	1,382	12,443
Colorado, Idaho, Montana, South Dakota, Washington	7	349	2,865	7	428	3,576
Indiana, New York, Ohio, Virginia	5	1,766	13,699	5	1,844	14,330
Iowa	6	1,612	13,518	6	1,527	12,421
Michigan	4	1,097	8,104	5	1,534	10,304
Nevada	4	998	7,896	4	1,192	8,860
New Mexico	3	169	1,016	3	318	1,622
Oklahoma	6	1,351	11,571	6	1,549	13,485
Texas	7	2,049	16,357	7	2,166	19,431
Utah	5	305	2,736	4	277	2,671
Wyoming	3	382	2,963	3	376	2,618
Total[1]	69	12,884	101,361	69	14,319	113,671

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

Table 3.—Calcined gypsum produced in the United States, by State

State	1983			1984		
	Active plants	Quantity (thousand short tons)	Value (thousands)	Active plants	Quantity (thousand short tons)	Value (thousands)
Arizona and New Mexico	3	275	$5,779	3	382	$8,770
Arkansas, Louisiana, Oklahoma	6	1,399	27,411	6	1,600	30,318
California	6	1,487	31,561	6	1,519	35,364
Colorado and Utah	3	313	5,792	3	352	7,010
Delaware and Maryland	3	727	14,811	3	783	16,695
Florida	3	1,004	21,351	3	1,160	25,774
Georgia	3	666	14,574	3	702	15,940
Illinois, Indiana, Kansas	6	1,378	22,153	6	1,405	25,765
Iowa	5	1,090	19,752	5	1,173	22,931
Massachusetts, New Hampshire, New Jersey, Pennsylvania	5	630	13,312	5	789	17,387
Michigan	3	335	6,000	4	500	9,446
Montana, Washington, Wyoming	5	579	14,077	5	701	17,195
Nevada	3	671	11,398	3	779	13,877
New York	4	949	17,556	4	986	19,627
North Carolina and Virginia	3	600	11,274	3	628	12,835
Ohio	3	291	6,480	3	404	9,425
Texas	6	1,509	26,852	6	1,587	32,157
Total[1]	70	13,902	270,136	71	15,450	320,518

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

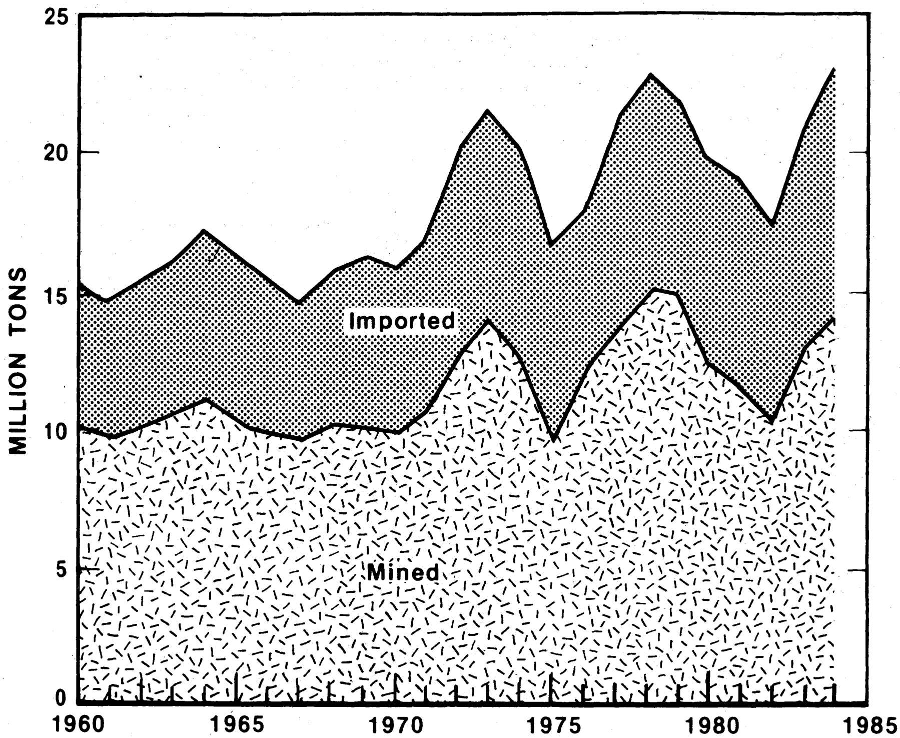

Figure 1.—Supply of crude gypsum in the United States

CONSUMPTION AND USES

Apparent consumption, production plus net imports plus industry stock changes, of crude gypsum, including byproduct gypsum, increased 7% to 24.1 million tons. Net imports provided 37% of the crude gypsum consumed. Apparent consumption of calcined gypsum increased 11% to 15.3 million tons.

Yearend stocks of crude gypsum at mines and calcining plants were 2.7 million tons. Of this, 58% was at calcining plants in coastal States.

Of the total gypsum products sold or used, 5.7 million tons, 24%, was uncalcined. Of the total uncalcined gypsum, 75% was used for portland cement and 23% was used in agriculture. Leading sales regions for gypsum used in cement were the West South-Central, South Atlantic, and Pacific; these three regions accounted for 62% of the total. For agricultural gypsum, the Pacific and East South-Central regions accounted for 84% of total sales.

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, 68% was regular wallboard, 22% was fire-resistant Type X wallboard, 5% was 5/16-inch mobile home board, and 5% was lath, veneer base, sheathing, and predecorated wallboard. Of the regular wallboard, 84% was 1/2-inch and 10% was 5/8-inch. The leading sales regions for prefabricated products were the South Atlantic, West South-Central, and Pacific, and accounted for 55% 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	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Uncalcined:				
Portland cement	3,955	39,770	4,286	41,046
Agriculture[1]	1,309	18,284	1,326	18,671
Fillers and miscellaneous	197	5,967	125	6,597
Total	5,461	64,021	5,737	66,314
Calcined:				
Industrial plaster	388	37,558	453	45,866
Building plaster:				
Regular base coat	158	14,906	155	15,356
Poured gypsum cement and concrete	46	4,391	4	365
Veneer plaster	83	11,219	89	12,680
Gaging plaster and Keene's cement	25	3,150	23	3,030
Other	9	1,186	9	1,201
Total	321	34,852	280	[2]32,633
Prefabricated products[3]	15,673	1,469,174	17,572	2,129,448
Total calcined	[2]16,381	1,541,584	18,305	2,207,947
Grand total	[2]21,843	1,605,605	24,042	2,274,261

[1]Includes most of 760,116 tons of byproduct gypsum in 1983 and most of 779,603 tons in 1984.
[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	1983 Thousand square feet	1983 Thousand short tons[1]	1983 Value (thousands)	1984 Thousand square feet	1984 Thousand short tons[1]	1984 Value (thousands)
Lath:						
3/8 inch	47,530	36	$4,981	30,600	23	$4,282
1/2 inch	99,180	91	9,930	1,500	1	202
Total[2]	146,710	126	14,912	32,100	24	4,484
Veneer base	369,019	386	33,784	408,270	470	50,882
Sheathing	338,839	316	38,315	337,720	325	49,773
Regular gypsumboard:						
3/8 inch	480,106	392	40,850	475,283	361	54,047
1/2 inch	9,695,968	8,679	774,993	10,490,118	9,262	1,135,688
5/8 inch	1,313,854	1,205	127,593	1,298,586	1,430	162,942
1 inch	53,570	91	9,794	61,600	126	13,513
Other[3]	130,269	114	11,744	162,370	125	18,880
Total[2]	11,673,767	10,481	964,974	12,487,957	11,304	1,385,069
Type X gypsumboard	3,266,579	3,546	306,175	4,040,744	4,677	507,100
Predecorated wallboard	112,480	109	33,920	127,110	134	41,013
5/16-inch mobile home board	853,314	706	76,593	853,850	615	87,704
Other	2,380	3	502	25,930	23	3,423
Grand total[2]	16,763,088	15,673	1,469,174	18,313,681	17,572	2,129,448

[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.

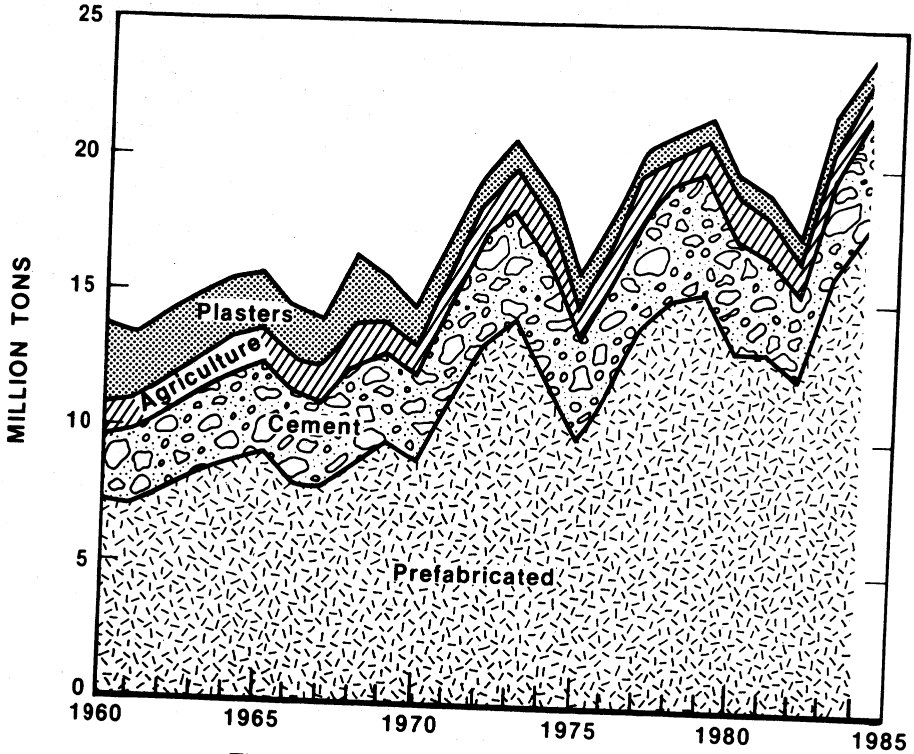

Figure 2.—Sales of gypsum products, by use.

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 7% to 2.43 million British thermal units.

As reported by the Gypsum Association, fuel sources for the gypsum industry were natural gas, 84.8%; electricity, 6%; propane, 1%; No. 2 fuel oil, 2.7%; No. 4 and No. 6 fuel oil, 2.3%; and coal, 3.2%.

PRICES

On an average value per ton basis, crude gypsum increased 1% to $7.94, calcined gypsum increased 7% to $20.75, and byproduct gypsum decreased 12% to $8.30.

The average value of gypsum products sold or used increased 29% to $94.60 per ton. Prefabricated products were valued at $121.18 per ton, industrial plasters at $101.25 per ton, building plaster at $116.55 per ton, and uncalcined products at $11.56 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 $114 per thousand square feet at Los Angeles to $232 at New York. Average price in December for 20 cities was $169 per thousand square feet, with some minor discounts for prompt payment. This represented a 19% increase compared with that of December 1983.

FOREIGN TRADE

The gypsum industry continued to rely on imports of crude gypsum rock for a significant fraction, 37%, of apparent consumption. Imports for consumption of crude gypsum, principally from Canada, 67%; Mexico, 21%; and Spain, 10%; increased 11% to 8.9 million tons. Spanish imports into the South Atlantic Coast and Gulf Coast States were more than 922,000 tons. Most of the imported crude gypsum was mined by subsidiaries of U.S. companies in Canada and Mexico.

Total value of gypsum products exported to all countries was about $30 million, a 7% decrease. Total value of gypsum and gypsum products imported was about $170 million, an increase of 93%. Gypsum wallboard imports principally from Canada, 91%, were 865 million square feet, a 175% increase.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed, or calcined: Quantity	Crude, crushed, or calcined: Value	Other manufactures, n.e.c. (value)[1]	Total value
1982	123	13,319	16,231	29,550
1983	117	13,621	18,467	32,088
1984	131	12,711	17,141	29,852

[1]Includes gypsum or plaster building boards and lath (TSUSA 245.7000) and articles, n.s.p.f., of plaster of paris (TSUSA 512.4500).

Table 7.—U.S. imports for consumption of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude: Quantity	Crude: Value	Ground or calcined: Quantity	Ground or calcined: Value	Alabaster manufactures[1] (value)	Plasterboard[2] (value)	Other manufactures, n.s.p.f.[3] (value)	Total value
1982	6,718	35,981	2	304	1,120	13,556	2,685	53,646
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

[1]Includes imports of jet manufactures, which are believed to be negligible.
[2]Includes gypsum or plaster building boards and lath (TSUSA 245.7000).
[3]Comprised of statues and articles, n.s.p.f., of plaster of paris (TSUSA 512.4100 and 512.4400) and gypsum cement (TSUSA 512.3100 and 512.3500).
[4]Data do not add to total shown because of independent rounding.

Table 8.—U.S. imports for consumption of crude gypsum, by country

(Thousand short tons and thousand dollars)

Country	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Australia	--	--	15	160
Canada[1]	5,476	43,231	6,006	58,980
Jamaica	27	154	112	977
Mexico	1,563	6,463	1,837	7,392
Spain	955	6,895	922	6,312
Other	[r]10	[r]218	12	143
Total[2]	8,031	56,960	8,904	73,965

[r]Revised.
[1]Includes anhydrite.
[2]Data may not add to totals shown because of independent rounding.

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.

Australia.—It was estimated that gypsum production in Australia increased 11% to 2.2 million tons. Approximately 35% was exported, principally as a cement set retardant, to Indonesia, 28%; New Zealand, 17%; and Taiwan and Singapore, 11% each. Domestic end uses were principally for gypsum plasterboard, 56%; plaster of paris, 44%; and some acoustical tile. Gypsum production in Australia was largely controlled by the country's two major plaster manufacturers, CSR Ltd. and Boral Ltd.'s subsidiary, Australian Gypsum Industries Ltd. Both companies mined gypsum in South Australia and Victoria; CSR also mined gypsum in New South Wales and Western Australia.[2]

Canada.—Canada was the second leading producer of crude gypsum, accounting for 11% of the world total with shipments of 9.6 million tons, a 16% increase.

Canada exported 6 million tons of crude gypsum, over 60% of its production, from Nova Scotia and Newfoundland, to the U.S. Atlantic and Gulf Coast States, principally to gypsum wallboard plants. Principal U.S. customs districts entered were Tampa, FL, 22%; New York, NY, and Philadelphia, PA, 17% each; Savannah, GA, 14%; Baltimore, MD, 11%; and the balance of 33% through 10 other customs districts. Canada also exported over 795 million square feet of wallboard into the Northern States, a 165% increase, and a new annual record. Three plants in Alberta, Ontario, and Quebec, two plants in Manitoba, and one in Saskatchewan exported gypsum wallboard to the United States through U.S. customs districts of Buffalo, NY, 49%; St. Albans, VT, 15%; Duluth, MN, 11%; Ogdensburg, NY, 9%; and the balance of 16% through 12 other customs districts. All Canadian gypsum wallboard manufacturers were members of the Gypsum Association in the United States, which announced that year-end Canadian wallboard capacity was 3.67 billion square feet, a 5% increase.

Anhydrite was produced by two mines in Nova Scotia, Fundy Gypsum Co. Ltd. at Wentworth and Little Narrows Gypsum Co. Ltd. at Little Narrows. Production from the two mines in 1983 was about 120,000 tons, most of which was shipped to the United States for use as a cement set retarder and as a peanut crop fertilizer.[3]

China.—An anhydrite mine with a capacity of 330,000 tons per year went into production near Nanjing in Jiangsu Province of China. With reserves of more than 770 million tons, it represented the largest anhydrite deposit found in the country. The anhydrite was to be used in the construction industry and for the manufacture of sulfur-rich chemical fertilizer for eastern China.[4]

Cyprus.—Production of gypsum in Cyprus declined for the fourth year to about 37,000 tons. Exports of crude and calcined gypsum remained small. About one-third of the production was used in manufacturing industrial and building plasters. Peletico Plasters Ltd. mined high-purity gypsum in an area about 5 miles northwest of Larnaca and produced lightweight and premixed building plasters.

Gypsotechnics Ltd. mined gypsum in the Aradippou area and crushed and calcined it at a plant about 1 mile from the Port of Larnaca. The plant had a capacity of about 100,000 tons per year of plaster of paris and gypsum-based building plasters. Gypsotechnics planned in 1985 to produce gypsum blocks by extrusion for internal partitioning of housing. United Gypsum Ltd. operated a quarry at Psematismenos and produced about 25,000 tons per year as a cement set retarder.[5]

Greece.—Both of the major cement producers, Titan Cement Co. and Heracles General Cement Co. have their own source of gypsum on the island of Crete. Titan has a quarry near Sitia with a capacity of 200,000 tons per year. Heracles has an affiliated company, Lava Mining & Quarrying Co. Ltd., which produced about 330,000 tons per year from its quarry near Altsi. The commercial mine-run material was about 60% gypsum, 30% anhydrite, and 10% calcium carbonate.[6]

Ireland.—Production of gypsum by Irish Gypsum Ltd. was almost 390,000 tons, but markets were constrained by less cement production and reduced building activity. Exports of crude and calcined gypsum to the

United Kingdom averaged about 50,000 tons per year.[7]

Jamaica.—Jamaica increased gypsum production 68%. Jamaica Gypsum and Quarries Ltd. made three 22,000-ton shipments to Lone Star Industries Inc. in New Orleans, LA, valued at about $7 per ton. Other U.S. gypsum imports from Jamaica entered customs districts of Charleston, SC, San Juan, PR, and Miami, FL.[8]

Japan.—Production of gypsum increased 4%. Virtually all gypsum supply was synthetic gypsum as phosphogypsum, 41%, flue gas desulfurization gypsum, 35%; fluorogypsum, 8%; titanogypsum, 7%; and other, 9%. End-use patterns were gypsum wallboard, 44%; cement set retarder, 43%; plaster, 4%; exports, 3%; and other, 6%.[9]

Morocco.—Gypsum is potentially Morocco's second most important mineral resource after phosphates. Major reserves of 5 billion tons are located near Safi. From 390,000 tons in 1979, production increased to 500,000 tons in 1984. Morocco is the leading exporter of gypsum to the Ivory Coast, Senegal, Gabon, and other West African countries, and exported small amounts to Europe, Asia, and Latin America.[10]

Pakistan.—A $6.3 million gypsum grinding and calcining plant was constructed and on-stream at yearend by the Gypsum Corp. of Pakistan at Taunsa, 50 miles north of Dera Ghazi Khan in Punjab. The plant had a capacity of 265,000 tons per year and was to manufacture agricultural gypsum, plaster of paris, and a variety of gypsum wall and ceiling plasters.[11]

South Africa, Republic of.—The Kimberley district contained the Republic of South Africa's most productive gypsum deposits, principally because of their location next to rail links. The belt extends 120 miles from Kimberley southwest to Prieska. Limestone overburden stripping must be accomplished in most cases, and some clay contamination required washing prior to shipment. Gypsum also occurs extensively in Cape Province and in central Transvaal. The Republic of South Africa's largest gypsum producer, Gypsum Industries Ltd., initiated a $30 million project for the construction of a rhinoboard and plaster plant, the largest expansion in the gypsum sector since the 1950's. The new plant was to use phosphogypsum from Triomf Fertilizer (Pty.) Ltd.'s phosphoric acid plant and was to be operational by 1987.[12]

United Kingdom.—Gypsum and anhydrite production remained virtually the same. British Gypsum Ltd. mined about 3.5 million tons of gypsum and 40,000 tons of anhydrite during 1983. The anhydrite came from the Newbiggen Mine at Kirby Thore in Cumbria, the only anhydrite producer in the United Kingdom. British Gypsum had nine underground gypsum mines and three quarries, and a fourth was about to come on-stream. Two-thirds of the production came from three deep mines and three quarries in the Midlands. Gypsum was also produced by Blue Circle Industries PLC from its 100,000-ton-per-year quarry at Kilvington, Nottinghamshire, principally for its own cement plants.[13]

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

(Thousand short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Afghanistan	--	--	3	[e]6	6
Algeria[e]	220	220	220	275	275
Angola[e]	28	22	22	[r]22	20
Argentina	1,028	739	679	563	550
Australia	1,443	[r]1,932	2,054	1,984	2,200
Austria[2]	919	882	802	828	816
Belgium[2]	192	170	([3])	([3])	--
Bolivia	1	1	1	[e]1	1
Brazil[4]	601	659	750	613	[5]613
Bulgaria	343	386	414	425	400
Burma[4]	41	34	29	38	[5]43
Canada (shipments)[2]	8,087	7,744	6,600	8,275	9,600
Chile	[r]300	[r]376	144	132	[5]234
China[e]	[r]3,600	[r]3,700	3,900	[r]4,700	5,300
Colombia	289	298	309	309	[5]287
Cuba[e]	134	143	140	145	145
Cyprus	48	[r]69	61	46	[5]37
Czechoslovakia	834	845	875	935	880
Dominican Republic	259	225	[e]230	[e]230	230
Ecuador	7	2	[e]2	[e]2	2

See footnotes at end of table.

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

(Thousand short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Egypt	1,036	1,047	1,026	795	800
El Salvador	10	7	6	[e]5	5
Ethiopia	1	5	4	[e]5	5
France[2]	7,155	[r]6,839	6,657	6,111	6,000
German Democratic Republic[e]	397	[r]379	379	[r]379	379
Germany, Federal Republic of (marketable)[2]	2,480	2,122	1,897	2,739	2,400
Greece[e]	[5]535	[r]550	[r]550	550	550
Guatemala	37	32	31	43	40
Honduras[e]	25	22	22	[r]22	25
India	955	1,045	1,070	1,145	1,400
Iran	7,700	6,600	[e]5,500	[e]6,000	5,500
Iraq[e]	190	190	190	190	330
Ireland	421	397	409	388	400
Israel	[e]90	46	46	46	50
Italy	1,801	1,702	1,472	1,530	1,400
Jamaica	116	206	118	119	200
Japan[6]	6,730	6,765	7,014	6,443	6,700
Jordan	[e]50	58	44	45	[5]121
Kenya[2]	--	--	(7)	1	1
Korea, Republic of[e 6]	700	700	800	1,000	[5]558
Laos	22	45	[e]70	[e]80	[5]90
Lebanon	11	10	6	6	6
Libya	[r]198	[r]198	193	198	[5]198
Luxembourg	1	1	(7)	(7)	(7)
Mauritania	13	2	[e]6	[e]4	1
Mexico	2,393	2,635	2,251	3,261	3,300
Mongolia[e]	33	35	35	35	35
Morocco	417	439	463	486	500
Nicaragua	[e]44	[e]33	22	13	10
Niger[e]	3	3	3	3	3
Pakistan	626	433	341	314	[5]376
Paraguay	13	11	7	4	[5]7
Peru	309	386	[e]400	[e]400	400
Philippines[6]	121	122	121	122	120
Poland[e 2]	[5]1,568	[r]1,450	1,430	1,430	1,430
Portugal	[r]226	268	[e]300	[e]300	300
Romania[e]	[5]1,776	1,800	1,800	1,800	2,000
Saudi Arabia	331	386	400	[r e]550	[5]331
Sierra Leone	--	--	--	4	4
South Africa, Republic of	499	612	590	571	[5]590
Spain	[r]5,757	[r]5,829	5,564	5,620	6,200
Sudan[2]	11	17	17	9	9
Switzerland[e]	[r]60	95	[r]80	[r]85	85
Syria	87	88	[e]90	186	[5]220
Taiwan[5]	9	7	2	3	[5]2
Tanzania[e]	12	13	13	13	13
Thailand	454	596	831	838	[5]1,224
Tunisia[e]	[r]80	[r]80	[r]80	95	100
Turkey	80	100	100	83	[5]64
U.S.S.R.[e 6]	[r]5,400	[r]5,400	[r]5,400	[r]5,400	5,400
United Kingdom[2]	3,800	3,245	3,021	3,271	3,300
United States[8]	12,376	11,497	10,538	12,884	[5]14,319
Uruguay	19	NA	135	167	165
Venezuela	129	241	175	226	170
Vietnam[e]	17	17	30	30	30
Yemen Arab Republic	--	[e]22	24	26	[5]27
Yugoslavia	682	737	705	772	770
Total	[r]86,380	[r]84,012	79,713	86,374	90,302

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 2, 1985.
[2]Includes anhydrite.
[3]Revised to zero.
[4]Data are for years beginning Apr. 1 of that stated.
[5]Reported figure.
[6]Includes byproduct gypsum. (In the case of Japan, byproduct gypsum was virtually all gypsum consumed during 1980-84.)
[7]Less than 1/2 unit.
[8]Excludes byproduct gypsum.

TECHNOLOGY

United States Gypsum started commercial production of a gypsum fiber filler in an 8-million-pound-per-year plant in East Chicago, IN. The filler is composed of whiskers of hemihydrate calcium sulfate with an aspect ratio of 30:1, with average lengths of 60 micrometers and diameters of 2 micrometers. It was considered as an inexpensive reinforcing filler as a partial replacement for fiberglass, with a market price of 40 cents per pound, about one-half that of glass fiber. The major market was expected to be plastics with a wide range of both thermosetting and thermoplastic materials.[14]

State-of-the-art technology characterized the megaplant expansion projects of United States Gypsum's two gypsum wallboard plants in Sweetwater, TX, and Jacksonville, FL. Both plants have capacities of over 600 million square feet of board annually and have high-speed computerized production lines and normal operating speeds of 250 feet per minute. The new Sweetwater production line was more than 1,500 feet long. These two plants, the largest gypsum wallboard plants in the world, were designed to serve the Sun Belt population areas with their high demand for housing.[15]

A new process was developed to convert the byproduct gypsum from flue gas desulfurization systems into a product that can be used in cement and other industries. The process oxidized calcium sulfite into sulfate or synthetic anhydrite. A fluid-bed thermal treatment system was used, which produced a dry pellet suitable for use as a cement set retarder, for other anhydrite uses such as specialty cements, and for temporary constructions in coal mining.[16]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Department of Resources and Energy, Bureau of Minerals Resources, Geology and Geophysics. Annual Review 1981, Australian Mineral Industry. P. 142.

[3]Stonehouse, D. H. Gypsum and Anhydrite. Can. Miner. Yearbook, 1983-84, 8 pp. (preprint).

[4]Industrial Minerals (London). Company News & Mineral Notes. No. 210, Mar. 1985, p. 78.

[5]Griffiths, J. The Industrial Minerals of Cyprus. Ind. Miner. (London), No. 207, Dec. 1984, p. 29.

[6]———. Hellenic Industrial Minerals. Ind. Miner. (London), No. 208, Jan. 1985, p. 31.

[7]Dhonau, N. B. Republic of Ireland. Mining Annual Review—1984. Min. Mag. (London), June 1984, p. 449.

[8]Mining Journal (London). Jamaica. Mining Annual Review—1984. June 1984, p. 323.

[9]Idemitsu Kosan Co. Ltd. 1984 Annual Report. Attachment, 2 pp.

[10]U.S. Embassy, Rabat, Morocco. State Dep. Airgram A-9, June 11, 1984, p. 6.

[11]Page 79 of work cited in footnote 4.

[12]U.S. Embassy, Johannesburg, Republic of South Africa. State Dep. Airgram A-16, May 25, 1984, Enclosure 1, p. 47.

[13]Mining Journal (London). Western Europe. Mining Annual Review—1984. June 1984, p. 448.

[14]Industrial Minerals (London). Gypsum Fibre Filler. No. 203, Aug. 1984, p. 14.

[15]Pit & Quarry. Wallboard Megaplants Designed To Serve Sun Belt Area. V. 75, No. 10, Apr. 1983, pp. 56-61.

[16]Chemical Market Reporter. Flue Gas Converted to Useful Products. V. 227, No. 9, Mar. 4, 1985, p. 35.

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 1,245 million cubic feet (MMcf) in 1984.[2] Grade-A helium exports by private producers were 392 MMcf, for total sales of 1,637 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 indispensable in supplying helium for the private helium market. Private crude helium previously stored under contract with the Government was delivered back to the owners for purification and sale to private industry.

DOMESTIC PRODUCTION

In 1984, 11 privately owned domestic helium plants were operated by 8 companies. Seven privately owned plants and one Bureau 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 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; Union Carbide Corp., Linde Div., Elkhart, KS; Union Carbide, Linde Div., Bushton, KS; and Union Carbide, Linde Div., Ulysses, KS. Cities Service Cryogenics Inc.'s purification plant at Ulysses was sold to Union Carbide on October 1, 1984.

The volume of helium recovered from natural gas increased because two private crude helium plants that were temporarily shut down during the summer months, owing to the lack of natural gas liquids markets, resumed operation sooner than anticipated and because the possibility of a high value being placed on helium at the wellhead was eliminated when the court established reasonable values in lawsuits involving the lessors, lessee-producers, and the helex companies. Most of the natural gas processed for helium extraction came from the gasfields in Kansas, New Mexico, Oklahoma, and Texas.

The Bureau's 500-liter-per-hour helium liquefier was accepted in 1981 and has operated satisfactorily. A wet-expansion engine is presently being installed in the liquefier to increase its output. This new equipment is expected to increase liquefaction capacity about 20%. The demand for liquid helium continues to grow as national defense, space, and energy research development projects using liquid helium expand.

Table 1.—Ownership and location of helium extraction plants in the United States in 1984

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.
Private industry:		
Air Products and Chemicals Inc	Hansford County, TX	Grade-A helium.[1]
Cities Service Cryogenics Inc	Scott City, KS	Crude helium.[2]
Cities Service Helex Inc	Ulysses, KS	Do.[2]
Kansas Refined Helium Co	Otis, KS	Grade-A helium.[1]
Navajo Refined Helium Co	Shiprock, NM	Do.[1]
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.[1]
Do[3]	Ulysses, KS	Do.[1]

[1]Including liquefaction (liquefier installed at Navajo Refined Helium in 1984).
[2]Output is piped to Ulysses, KS, for purification.
[3]Cities Service Cryogenics Inc.'s Grade-A facility at Ulysses, KS, sold to Union Carbide Corp., Linde Div., Oct. 1, 1984.

Table 2.—Helium recovery in the United States[1]

(Thousand cubic feet)

	1980	1981	1982	1983	1984
Crude helium:					
Bureau of Mines:					
Total storage	22,887	-257,799	-350,235	-275,714	-314,969
Private industry:					
Stored by Bureau of Mines	633,956	452,880	113,261	282,018	506,092
Withdrawn	-266,898	-304,987	-724,113	-729,134	-605,935
Total private industry storage	367,058	147,893	-610,852	-447,116	-99,843
Total crude helium	389,945	-109,906	-961,087	-722,830	-414,812
Stored private crude helium withdrawn from storage and purified by the Bureau of Mines for redelivery to industry	-200,612	-80,208	-51,234	-65,015	-49,057
Grade-A helium:					
Bureau of Mines sold	187,735	240,880	305,071	241,733	294,460
Private industry sold	986,601	1,014,543	939,496	1,120,955	1,342,961
Total sold	1,174,336	1,255,423	1,244,567	1,362,688	1,637,421
Total stored	189,333	-190,114	-1,012,321	-787,845	-463,869
Grand total recovery	1,363,669	1,065,309	232,246	574,843	1,173,552

[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)

	1982	1983	1984
Supply:			
Inventory at beginning of period[1]	14,375	20,368	22,400
Helium recovered: Exell plant: Grade-A[2]	362,298	308,780	339,280
Total	376,673	329,148	361,680
Disposal:			
Sales of Grade-A helium	305,071	241,733	294,460
Redelivered to private producers	51,234	65,015	49,057
Inventory at end of period[1]	20,368	22,400	18,163
Total	376,673	329,148	361,680

[1]At Amarillo and Exell helium plants.
[2]Includes 51,234 Mcf purified for private industry in 1982, 65,015 Mcf in 1983, and 49,057 Mcf in 1984.

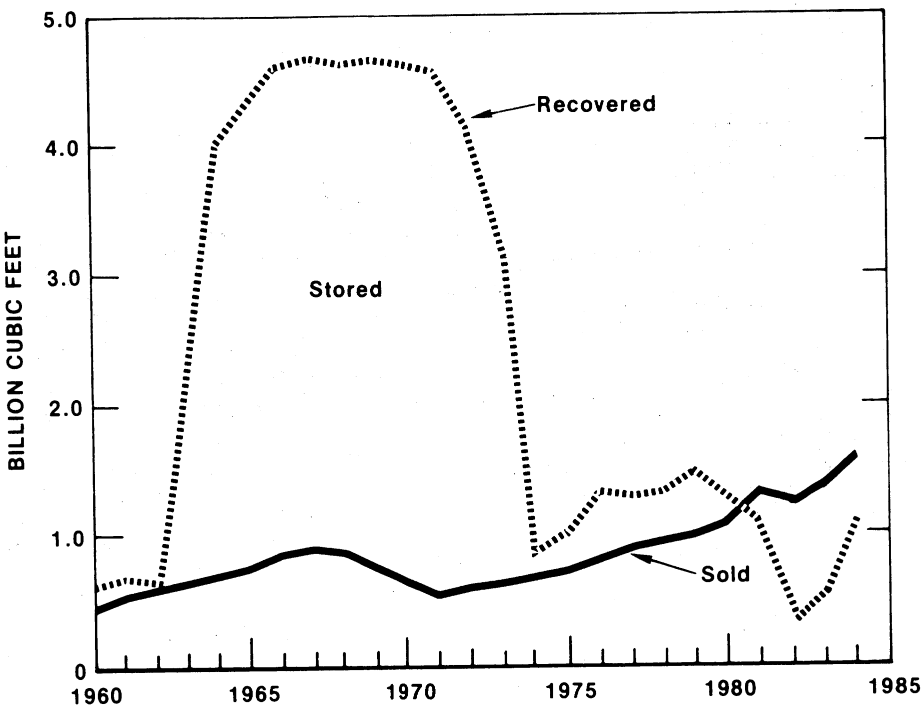

Figure 1.—Helium recovery in the United States, 1960-84.

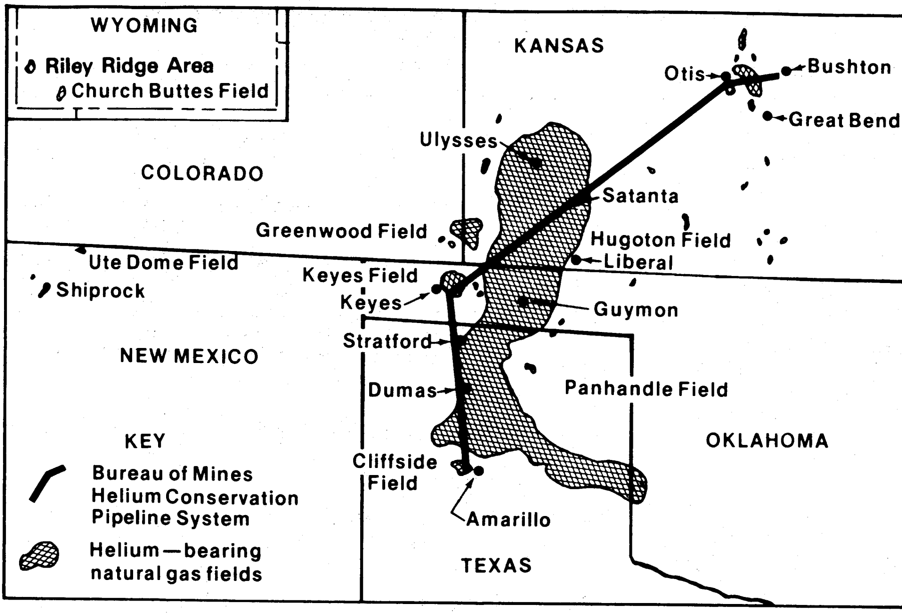

Figure 2.—Major U.S. helium-bearing natural gas fields.

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.

Five more successful space shuttle launches were made by the National Aeronautics and Space Administration using Bureau helium. The Challenger Space Shuttle was launched three times, and the Discovery Orbiter was launched twice. Each space shuttle launch requires about 7.5 million cubic feet of helium for purging and pressurizing. Helium demand for space activity is increasing and is expected to increase more when Vandenberg's space shuttle facilities are 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, the National Aeronautics and Space Administration, 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, which 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
1980	863
1981	866
1982	867
1983	995
1984	1,245

Table 5.—Bureau of Mines sales of Grade-A helium, by purchaser[1]

(Thousand cubic feet)

	1982	1983	1984
Federal agencies:			
Department of Defense	93,535	105,372	117,047
Department of Energy	29,939	32,821	34,599
National Aeronautics and Space Administration	37,447	37,674	49,323
National Weather Service	1,077	874	752
Other	2,812	2,957	4,052
Total	164,810	179,698	205,773
Federal agency sales supplied by private contract helium distributors[2]	136,359	59,059	86,434
Commercial sales	3,902	2,976	2,253
Grand total	305,071	241,733	294,460

[1]Table identifies Federal purchaser, which 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.

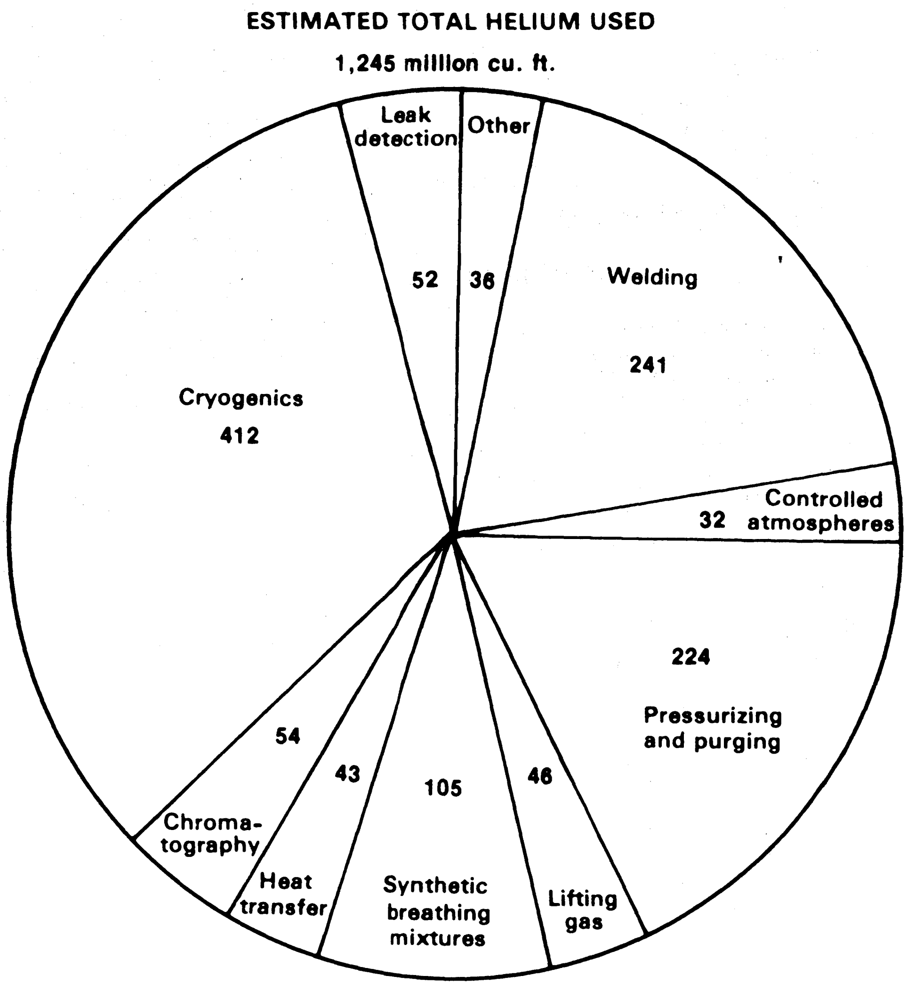

Figure 3.—Estimated helium consumption in the United States in 1984, by end use (million cubic feet).

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 38 billion cubic feet (Bcf) at yearend. The conservation storage system contains crude helium purchased by the Bureau of Mines under contract, Bureau helium extracted in excess of sales, and privately owned helium stored under contract. During 1984, 506 MMcf of private helium was delivered to the Bureau's helium conservation storage system and 655 MMcf was withdrawn, for a net decrease of 149 MMcf of private helium in storage.

Table 6.—Summary of Bureau of Mines helium conservation storage system[1] operations

(Thousand cubic feet)

	1982	1983	1984
Helium in conservation storage system at beginning of period:			
Stored under Bureau of Mines conservation program	36,137,610	35,787,375	35,511,661
Stored for private producers under contract	4,137,724	3,475,638	2,963,507
Total	40,275,334	39,263,013	38,475,168
Input to system:			
Net deliveries from Bureau of Mines plants[2]	-350,235	-275,714	-314,969
Stored for private producers under contract	113,261	282,018	506,091
Total[2]	-236,974	6,304	191,122
Redelivery of helium stored for private producers under contract[2]	-775,347	-794,149	-654,992
Net addition to system[2]	-1,012,321	-787,845	-463,870
Helium in conservation storage system at end 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

[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, 1984 (the latest figures available), are estimated to be 484 Bcf. The resources included measured reserves and indicated resources estimated to be 241 and 8 Bcf, respectively, in natural gas with a minimum helium content of 0.3%. The measured reserves included 38 Bcf stored in the Bureau's helium conservation storage system. Measured helium resources in natural gas with a helium content of less than 0.3% are estimated to be 58 Bcf. Indicated helium resources in natural gas with a helium content of less than 0.3% are estimated to be 177 Bcf. Approximately 89% of the domestic helium resources under Federal ownership are in the Riley Ridge area and Church Buttes Field, WY, and the Cliffside Field, TX.

Most of the domestic helium resources are located in the midcontinent and Rocky Mountain regions of the United States. The measured helium reserves are located in approximately 92 gasfields in 11 States. About 91% of these reserves are 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 analyzed a total of 389 natural gas samples from 27 States during the year 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 also 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 per Mcf to $37.50 per Mcf effective October 1, 1982, the first helium price increase in more than 20 years. The $37.50-per-Mcf price remained in effect throughout 1984. 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 surcharges.

FOREIGN TRADE

Exports of Grade-A helium, all by private industry, increased by 6.5% in 1984 to 392 MMcf (table 7). Over 57% of the exported helium was shipped to Europe. Belgium-Luxembourg, France, and the United Kingdom, collectively, received more than 95% of the European helium imports. About 28% of the U.S. helium exports went to Asia; 5% to South America; 3% to Australia and New Zealand; 2% each to North America, Central America, and the Middle East; and less than 1% 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 oil and gas, especially in the North Sea.

U.S. import tariffs on helium decreased 0.2% on January 1, 1984, to 4.2%. Future decreases are planned. Another reduction of 0.2% is scheduled on January 1, 1985, and a 0.1% reduction is scheduled for January 1, 1986. A final reduction of 0.2% is scheduled for January 1, 1987, with the import tariff reaching 3.7% at that time.

Table 7.—U.S. exports of Grade-A helium

(Million cubic feet)

Year	Volume
1980	298
1981	389
1982	378
1983	368
1984	392

Source: Bureau of the Census.

WORLD REVIEW

World production of helium, excluding the United States, was estimated to be 150 MMcf, most of which was extracted in Poland. The remainder was attributed to centrally planned economy countries.

TECHNOLOGY

Nuclear Magnetic Resonance (NMR) imaging is gaining acceptance in the medical field. NMR 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. NMR and computer-assisted tomography (CAT) scans are now utilized at U.S. clinics when a mother or fetus is known to be at risk. NMR offers several advantages over older methods (such as ultrasound) when little or no amniotic fluid is present, or obesity makes the fetus difficult to detect. Although presently limited to problem cases, medical personnel are virtually certain there are no harmful effects associated with NMR.

Fermi National Accelerator Laboratory's Tevatron/Tevatron 1 was recognized by the National Society of Professional Engineers as 1 of the 10 outstanding engineering achievements of 1984. Tevatron/Tevatron 1 is the world's first 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 sustained. 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 refrigerators. It roughly doubled the world's helium liquefying capacity.

Oak Ridge National Laboratory's International Fusion Superconducting Magnet Test Facility has completed preliminary tests. These tests established that the facility is suitable for simultaneously testing 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 Department of Energy to select the best design for future liquid helium superconducting magnets, which will be used in the final nuclear fusion reactor design.

Other technology, which is presently evolving and requires 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 simulate a thermonuclear airburst, and (6) in "Strategic Defense Initiative" equipment, such as laser and surveillance satellites.

Some research on helium-cooled reactors and the "Superconducting Super Collider" was conducted during the year. Either of these projects could have an impact on helium usage if successfully implemented.

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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 slightly during 1984. Three producers of crude iodine supplied less than one-half of domestic demand; the remainder was imported. The General Services Administration (GSA) discontinued sales of excess iodine from the National Defense Stockpile.

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 U.S. National Defense Stockpile contained 7.4 million pounds of crude iodine valued at $40 million in inventory at yearend. The stockpile goal remained at 5.8 million pounds. During 1984, 108,800 pounds of stockpile-grade excess iodine was sold for $511,360.

As part of the defense authorization legislature for fiscal year 1985, Congress considered several recommendations of the House Armed Services Committee concerning the disposal of surplus stockpiled commodities. Section 902 of Public Law 98-525 stopped the sales of iodine in 1984 and did not authorize any more disposals from stockpile excesses. Iodine was inadvertently omitted from the list of commodities proposed for disposal. GSA suspended the sale of surplus iodine in October.[2]

Iodine was 1 of 44 nonfuel materials in the National Defense Stockpile that were examined to determine the need for quality assessment. It was determined that iodine was one of six materials that needed quality assessment for such factors as likelihood of deterioration or contamination, technology changes in specifications, deficiency in analyses, quality data, end-use tests or specifications, inability to expeditiously use the materials in an emergency, and the costs involved to upgrade the form to meet end-use requirements.[3]

Public Citizen Health Research Group petitioned the U.S. Food and Drug Administration (FDA) to ban 10 widely used food, drug, and cosmetic dyes, including Red No. 3, or erythrosine. Red No. 3 dye has a grape-like color and contains 58% iodine, by weight. Erythrosine had been used in carbonated soft drinks, powdered drinks, gelatin desserts, icings, and pet foods. If the listing were to be revoked, Red No. 40, the only red dye remaining on the permanent list, could substitute, but it has a brick-red color. Red No. 3 is one of three dyes that account for over one-half of the total domestic annual food dye consumption. Amendments to the Food, Drug, and Cosmetic Act of 1960, the Delaney Clause, require that all permanently listed dyes be proven safe. The dyes have remained in the market because FDA has repeatedly extended their "provisionally listed" status. Bills introduced to revise the Delaney Clause of the 1960 act were defeated.[4]

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 1984. In October, Dow announced plans to discontinue brine production at Midland, MI, by 1986. Dow stated that it planned to remain in the iodine business, but no alternative production plans were available at yearend.

North American Brine Resources operated two miniplants at Dover and Hennessey in Kingfisher County, OK. The plants in operation were located at oilfield reinjection disposal sites. The brines, containing between 135 and 900 parts per million of iodine, were processed before reinjection into the ground. North American was a joint venture among Beard Oil Co., 40%; Godoe USA Inc., a wholly owned subsidiary of United Resources Industry Co., 50%; and Inorgchem Development Inc., a wholly owned subsidiary of Mitsui & Co. (United States), 10%.

Woodward Iodine Operations decreased sales and reduced inventories accumulated during 1982. Woodward was a joint venture between Amoco Production Co., 49%, and PPG Industries Inc., 51%. In July, PPG and Amoco sold Woodward to Woodward Iodine Corp., a subsidiary of Asahi Glass Co. of Japan. Iodine of greater than 99.9% purity was recovered by a conventional process with proprietary refinements from brine associated with natural gas. Production was less than the 2 million pounds per year of capacity.

CONSUMPTION AND USES

Establishing an accurate end-use pattern was inhibited because intermediate iodine 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.

GAF Corp. announced an expansion of rubber and pyrrolidone capacity at plants in Texas and Kentucky. Tennessee Eastman Co. brought on-stream a coal-to-methanol-to-acetic acid-to-acetic anhydride plant in Kingsport, TN. A methyl iodide catalyst was used to produce the acetic acid from methanol. Stauffer Chemical Co., a large consumer of crude iodine, was acquired by Chesebrough-Pond's Inc. Iodine continued to be produced for use in diagnostic contrast media containing between 47% and 67% iodine. In 1984, one of the large producers of these contrast media discontinued production and began buying the products from an overseas source. Mallinckrodt Inc. remained the only domestic producer of diagnostic contrast media.

Glowworms and luminescent fish were being used as sources for tagging agents for protein and hormone diagnostics in place of radioactive iodine. Uses of the substitutes included assays to pinpoint certain thyroid problems. The compounds have advantages of a longer shelf life and less equipment needed during tests.[5]

Table 1.—U.S. consumption of crude iodine, by product

Product	1983		1984	
	Number of plants	Consumption (thousand pounds)	Number of plants	Consumption (thousand pounds)
Reported consumption:				
Resublimed iodine	8	442	4	161
Potassium iodide	8	1,320	8	1,281
Sodium iodide	4	242	6	122
Other inorganic compounds	10	1,071	15	1,286
Ethylenediamine dihydriodide	4	736	8	1,137
Organic compounds	20	1,890	22	1,540
Total	[1]31	5,701	[1]29	5,527
Apparent consumption	XX	8,139	XX	W

W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Nonadditive total because some plants produce more than one product.

PRICES

Published U.S. iodine prices were between $4.99 and $5.87 per pound. Discounted market prices reported by industry were $5.00 per pound. Custom c.i.f. values of iodine imported from Japan averaged $5.23 per pound. Custom values for iodine imported from Chile averaged $4.51 per pound. Chilean Nitrate Sales Corp. reported that iodine imported from Chile averaged $5.03 per pound during 1984. GSA sold iodine during the year from stockpile excesses for $4.70 per pound. 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	$4.99- 5.87
Iodoform, N.F., 300-pound drums, f.o.b. works	21.50-21.75
Potassium iodide, U.S.P., granular, crystals, drums, 1,000-pound lots, delivered	9.32- 9.54
Resublimed iodine, U.S.P., granular, 100-pound drums, works	12.16-12.94
Sodium iodide, U.S.P., crystals, 300- to 500-pound lots, drums, freight equalized	9.10-11.85

[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. 226, No. 27, Dec. 31, 1984, pp. 20-28.

FOREIGN TRADE

The United States continued to be dependent on imports primarily from Chile and Japan to supplement domestic production.

Table 2.—U.S. imports for consumption of crude iodine, by country

(Thousand pounds and thousand dollars)

Country	1983		1984	
	Quantity	Value	Quantity	Value
Iodine, potassium:				
Belgium	--	--	([1])	3
Canada	2	11	([1])	([1])
Germany, Federal Republic of	([1])	1	3	22
India	10	50	24	116
Italy	2	4	7	7
Japan	101	554	25	135
Spain	5	4	--	--
United Kingdom	1	22	4	43
Total[2]	121	647	63	326
Iodine, crude:				
Canada	([1])	2	--	--
Chile	1,639	8,146	1,176	5,211
China	22	118	--	--
Japan	4,556	25,773	3,711	19,008
Mexico	--	--	179	93
United Kingdom	--	--	([1])	([1])
Total[2]	6,218	34,039	5,067	24,312
Iodine, resublimed:				
Canada	([1])	([1])	--	--
Japan	44	256	1	8
Sweden	1	10	([1])	([1])
Total[2]	45	266	1	9
Grand total[2]	6,384	34,952	5,131	24,649

[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

Chile.—Chile's natural deposits of nitrate and iodine are found in the Atacama Desert in an ore called caliche. The Chilean nitrate deposits were the only commercial-size nitrate deposits in the world and the only commercial source of iodine in an ore. The caliche ore contains small quantities of iodine in the form of iodates. Sociedad Química y Minera de Chile (SOQUIMICH) was the only producer of nitrates and their byproducts in Chile. Oficina Maria Elena and Oficina Pedro de Valdivia were active in the production of iodine. Maria Elena started production in 1927 and has ore reserves that could last 60 years. Pedro de Valdivia started production in 1930 and has 30 years of proven and probable reserves, but needed capital investment and improvement. The two oficinas had some 550 million short tons of tailings that could be reworked, possibly under a joint venture arrangement with a United States or Japanese firm.

About 50% of the original iodine content in caliche was produced by leaching the sodium iodate and adding sulfur dioxide. The iodine was separated and heated to 113° C to produce high-quality iodine. Packaging was in polyethylene bags inside round cardboard containers. The iodine was transported via railroad for shipping through the port at Tocopilla. Chilean Nitrate Sales Corp. was the sole agent for Chilean iodine in the United States.

In recent years, the Chilean economy had faced serious problems with declining gross national product, severe inflation, and exchange deficits. However, at yearend 1984, capacity for iodine production had increased 17% over the previous 4 years by the selective mining of high iodine sections of the nitrate deposits.[6]

Indonesia.—Iodine occurs with trace amounts of bromine in brines associated with oil. The most important iodine producing area is the Gujangon Anticline of sandstone and diatomaceous marls of the Upper Pliocene, Kalibeng Formation. The only crude iodine producer in Indonesia in 1984 was the state-owned pharmaceutical firm, P.T. Kimia Farma at Watudakon near Mojokerto, East Java.

Japan.—Ise Chemical Industry Co., Ltd. began an expansion program to develop iodine derivatives. Iodine accounted for 70% of the total sales of the company. Iodine of 99.5% purity was produced at Ise's seven plants in Chiba, Niigata, and Miyazaki Prefectures. The iodine was used in oil and rubber catalysts, disinfectants, pharmaceuticals, food products, and other uses. Calabrian International Corp. was the U.S. sales agent. Ise continued to produce a prilled iodine under the brand name Iseflo. The prilled iodine was chemically equivalent to the flaked form, but was cooled into spheres rather than grinding or flaking.

Iodine in Japan was produced from the dry type of gas or methane-rich gas. The southern Kanto Gasfield produced most of the natural gas associated with methane gas in Japan or about 6,600 short tons of iodine per year. The major iodine and gas reservoirs were found in the Kiwada, Otadai, and Umegase Formations of the Middle Kazusa Group of Late Pliocene to Middle Pleistocene Age.[7]

Okiniawa Natural Gas Development Co. continued exploration to locate high concentrations of iodine.[8]

Table 3.—Crude iodine: World production, by country[1]

(Thousand pounds)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Chile	5,734	5,926	5,723	6,158	5,700
China[e]	1,000	1,000	1,000	1,000	1,000
Indonesia	65	56	64	57	57
Japan	14,385	15,128	15,829	16,034	[3]16,098
U.S.S.R.[e]	4,400	4,400	4,400	4,400	4,400
United States	W	W	W	W	W
Total[4]	25,584	26,510	27,016	27,649	27,255

[e]Estimated. [p]Preliminary. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through June 11, 1985.
[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.

Panama.—The distribution of iodine, bromine, and organic carbon was examined in sedimentary cores from the Panama Basin. The concentrations vary with depth. Iodide was the dominant iodine species in interstitial water. Iodine and bromine concentrations have been shown to generally decrease with depth of burial in sediments undergoing early diagenesis. Iodine concentrations increased in interstitial water and ranged from 76 to 861 parts per million.[9]

Taiwan.—Natural gas and iodine were widely distributed in the Cholan Formation.[10]

TECHNOLOGY

Thin polymer films served as optical guides in electro-optical devices. The common Polaroid material was based upon employing an oriented iodine-polyvinyl alcohol complex or an oriented polyene structure. An important consideration was the development of "optical computers" employing electro-optical circuit elements. These have the advantage of speed and freedom from interference by electromagnetic radiation, thus protection from disruptions by electromagnetic pulses.[11]

Researchers at the University of Utah have used a hypervalent iodine compound to synthesize nonorganometallic compounds by ligand-ligand complexing. These compounds have potential to act as specific enzyme inhibitors. The research was supported by the National Cancer Institute.[12]

Iodine, formerly of the group VIIA in the American Chemical Society nomenclature, was being considered to be renamed to group 17. The nomenclature was also under consideration by the International Union of Pure & Applied Chemistry.[13]

Iodine was separated from well waters by electrolysis that oxidized the iodide ions to iodate. Diaphragms and anode insulation were not required, electrodes were not contaminated, chemical agents were not needed, and there was no air pollution.[14]

Since the introduction of Monsanto's acetic acid process in the 1960's, 90% of all new acetic acid plants have used a methyl iodide catalyst. A new process being explored by Texaco Inc. produced acetic acid by an iodide-free method. A ruthenium-lead-bromine precursor provided a stable and recyclable system that produced a 76% to 84% conversion rate.[15]

Iodine is one of the elements that is closely watched during any release of radioactivity from a nuclear powerplant. In a nuclear accident, iodine could account for 25% of total health effects and contribute 40% more than any other single isotope toward health effects. Because of iodine-131's short half-life of about 8 days, it is a relatively short-term health concern. The fact that iodine would be retained in the reactor containment was an important consideration in all nuclear accident planning.[16]

In Georgia and neighboring States, various types of nuclear installations have released radioiodine compounds. Iodine-129 was detected in Georgia and South Carolina at several orders of magnitude above background levels. Organic radioiodine compounds formed in nuclear reactor systems, nuclear fuel processing plants, or medical radioisotope distribution centers are more difficult to contain than inorganic radioiodine compounds. Organic radioiodine compounds can pollute aquifers by two primary means: Liquid releases enter the aquatic environment directly, and airborne releases enter through precipitation scavenging and drainage. Increases in nuclear installations intensified the need to understand the water chemistry of radioiodine compounds.[17]

Studies of the chemical behavior of radioiodine in soil water and in surface fresh water involved the oxidation of iodine by microbial action into organic compounds. In surface fresh water, the organic radioiodine compounds are mainly in solution. In soils, the radioiodine becomes bound to insoluble organic substances. Possible consequences of these reactions on the migration behavior of radioiodine was investigated.[18]

A practical field method was developed to collect radioiodine from milk using inexpensive industrial-grade resin and required minimal training of personnel. The technique is simple, rapid, and inexpensive and yields a good iodine collection efficiency.[19]

A new extraction process led to about 97% recovery of silver from a silver zeolite without release of radioisotopes. The zeolite was used in air filtration systems at many nuclear facilities to filter radioactive iodine. The process was similar to smelting and used sodium hydroxide as a flux.[20]

A reaction of an iodine compound yielded a new stable type of oxonium salt. The compounds were highly conductive, easily replaced the iodide ion, and underwent partial decomposition on prolonged storage in air and during recrystallization.[21]

Mercury iodide crystal growth was one of three material science investigations to be studied on Space Lab 3. The Space Lab offers unique advantages compared with experiments on Earth because of the absence of gravity that results in convection or circulation currents that affect crystal growth. Some crystals produced by diffusion processes were so weak at their growth temperatures that on Earth they deform under the strain of their own weight. These gravity-induced stress deformations should be minimal in space.[22]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Mining Journal (London). United States. V. 302, No. 776, May 11, 1984, p. 314.

[3]National Academy of Sciences—National Research Council. Priorities for Detailed Quality Assessments of the National Defense Stockpile Nonfuel Materials (contract EMW-C-1022). Mar. 30, 1984, 66 pp.

[4]Chemical Marketing Reporter. Dye Ban Urged by Health Research Group; Lawsuit Is Threatened If FDA Fails To Act. V. 226, No. 26, Dec. 24, 1984, pp. 5, 7.

[5]Chemical Business. Chemical Sidebars. V. 7, No. 4, Apr. 1985, p. 19.

[6]Industrial Minerals (London). Nitrogen-Fixed for a Fertile Market. V. 209, Feb. 1985, pp. 20-21.

[7]Fukuta, O. Japanese Iodine—Geology and Geochemistry. Salts & Brines '85, ed. by W. J. Schlitt. New York, 1985, pp. 149-171.

[8]Work cited in footnote 7.

[9]Pederson, T. F., and N. B. Price. The Geochemistry of Iodine in Sediments of the Panama Basin. J. Marine Res., v. 38, Nov. 3, 1980, pp. 397-411.

[10]Work cited in footnote 7.

[11]Stein, R. S. The Impact of Polymeric Substitutes on Critical and Strategic Applications of Imported Materials. Mater. and Soc., v. 8, No. 2, 1984, pp. 297-410.

[12]Chemical & Engineering News. First Acetylenic Esters Made by Utah Chemist. V. 63, No. 20, Apr. 15, 1985, p. 26.

[13]———. Science. V. 63, No. 5, Feb. 4, 1985, pp. 26-27.

[14]Shabanov, A. L., R. A. Rasulbekova, O. S. Mukhin, and A. D. Faradzhev. Electrochemical Method for Separating Iodine From Well Waters Through Iodates. Vaku Azerb. Khim. Zh. (Russian), No. 3, May-June 1983, pp. 143-146.

[15]Chemical & Engineering News. V. 63, No. 1, Jan. 7, 1985, pp. 46-47.

[16]Science Application Inc. Iodine-131 Behavior During the TMI-2 Accident. NSAC/30, Sept. 1981, 77 pp.

[17]Liotta, C. L., R. C. McFarland, and M. B. Bruce. Detection of Iodine Species in Dilute Aqueous Solutions and the Modification of the Physical and Chemical Properties of Iodide Salts With Macrocyclic Multidentate Ligands (USDI Project A-074-6A). Nov. 25, 1982, 23 pp.

[18]Behrens, H. New Insights Into the Chemical Behavior of Radioiodine in Aquatic Environments. Inst. Radiohydrometie (German), Apr. 19, 1982, 14 pp.

[19]Solbrig, R. M., R. L. Huchton, and B. O. Motes. Rapid Field Method for the Concentration of Radioiodine From Milk. Exxon Nuclear Idaho Co. Inc., Idaho Falls, ID, Oct. 1983, 26 pp.

[20]Chemical & Engineering News. Science/Technology Concentrates. V. 62, No. 12, Mar. 19, 1984, p. 20.

[21]Gomelya, N. D., N. G. Feshchenko, and A. G. Matyushu. Dialkylphosphinotetramethyleneoxonium Iodide. Leningr. Zh. Obshchey Khim. (Russian), v. 53, No. 4, Apr. 1983, pp. 937-938.

[22]Marshal Space Flight Center. Space Lab 3. Natl. Aeronautics and Space Admin., Washington, DC, EP203, 16M484, 1984, p. 13.

Iron Ore

By F. L. Klinger[1]

U.S. production of iron ore increased sharply in 1984, owing to a surge in demand from the iron and steel industry in the first 5 months, but fell below 1983 levels by yearend as demand again weakened. Although the ore industry's situation improved in 1984, with increased employment and productivity, the patterns of production, demand, and plant closings resembled those of 1983 and continued to emphasize the excess of production capacity compared with the level of domestic demand. Production of usable ore in 1984 was about 56% of productive capacity.

In the rest of the world, iron ore production and trade were considerably greater than in 1983 as output of iron and steel increased not only in Western Europe and Japan but in developing countries in South America, the Middle East, and Asia. Iron ore prices continued to decline, while ocean freight rates remained low. Investments in new facilities also remained relatively low, as overcapacity continued to be a problem in most of the major producing countries.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Iron ore (usable,[1] less than 5% manganese):					
Production	69,613	73,174	35,433	37,562	51,269
Shipments	69,594	72,181	35,756	44,596	50,883
Value	$2,544,121	$2,915,239	$1,491,809	$1,944,988	$2,247,686
Average value at mines dollars per ton	$36.56	$40.39	$41.72	$43.61	$44.17
Exports	5,689	5,546	3,178	3,781	4,993
Value	$230,568	$244,685	$150,522	$182,744	$239,257
Imports for consumption	25,058	28,328	14,501	13,246	17,187
Value	$772,844	$947,977	$470,847	$445,731	$529,065
Consumption (iron ore and agglomerates)	98,879	104,385	63,916	70,629	72,514
Stocks, Dec. 31:					
At mines[2]	11,725	12,734	12,129	r [3]4,122	[3]5,265
At consuming plants	35,706	36,203	29,923	25,494	24,017
At U.S. docks	6,095	6,571	5,750	3,174	2,942
Manganiferous iron ore (5% to 35% manganese):					
Shipments	155	156	28	30	79
World: Production	r877,152	r843,152	767,491	p723,893	e789,440

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.

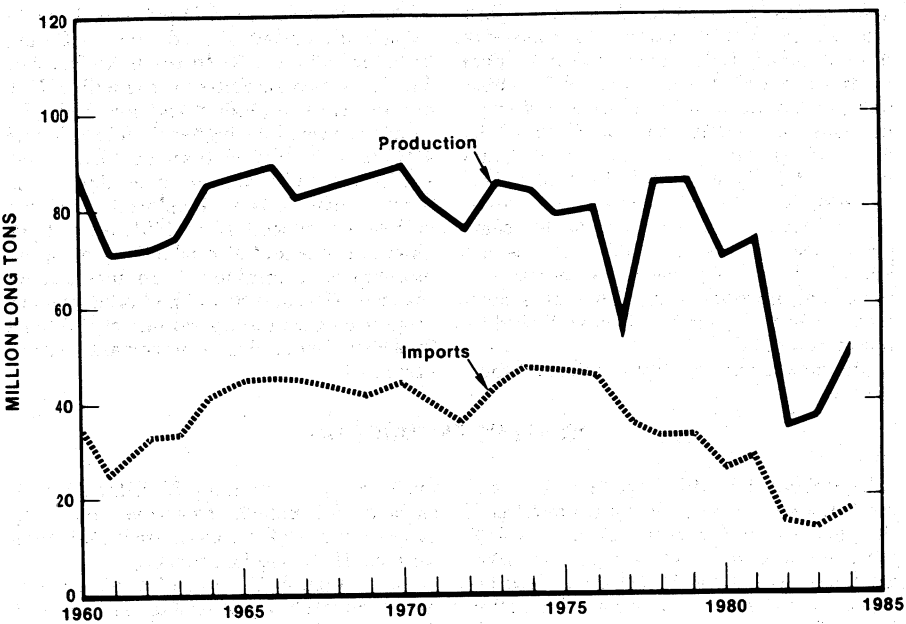

Figure 1.—U.S. iron ore production and imports for consumption.

Domestic Data Coverage.—Domestic production data for iron ore are developed by the Bureau of Mines from three separate voluntary surveys of U.S. operations. The annual "Iron Ore" survey (1066-A) provides the basic data used in this report. Of 60 addressees to whom the 1066-A form was sent, 49 responded, representing 99.9% 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.

Legislation and Government Programs.—Under the Tax Equity and Fiscal Responsibility Act of 1982, depletion allowances for domestic and foreign operations of the iron ore industry were reduced by 15%, effective January 1, 1984. The allowance for domestic operations was therefore reduced to 12.75%, and that for foreign operations to 11.9%.

H.R. 3678, called the Water Resources Conservation, Development, and Infrastructure Improvement and Rehabilitation Act, was passed by the House of Representatives in July 1984 but expired at yearend owing to lack of Senate approval. The bill would have continued the Federal Government's responsibility for the full costs of operating and maintaining general cargo ports, thus preventing imposition of "user charges" on U.S. shippers of iron ore.

EMPLOYMENT

Statistics on employment and productivity in the U.S. iron ore industry in 1984, 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 approximately 970 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 one year to the next should be reasonably valid.

Average quarterly employment and total hours worked in 1984 increased 9% and 17%, respectively, compared with those of 1983, while output of crude and usable ore increased about 36%. In the Lake Superior district, which accounts for the bulk of U.S. output, average productivity for crude and usable ore was 13% higher than in 1983 and 43% to 48% higher than in 1982. These significant gains appear to be due to the drastic reductions in employment by the principal producers since 1981, 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

Increasing demand from the iron and steel industry during the first 5 months of the year was largely responsible for a 36% increase in iron ore production in 1984, compared with that of 1983. Increased demand from Canada was also a contributing factor. By the end of May, output of usable ore was 65% higher than in the comparable period of 1983, shipments were up 42%, production of pig iron had increased 25%, and exports of pellets to Canada were up 28%. In June, however, domestic demand fell sharply, and during the last 4 months of the year monthly production of pig iron was below 1983 levels. Several mines and pelletizing plants were closed for periods of 2 to 7 weeks during the last half of the year, and by December 2, five of the eight taconite operations in Minnesota had been closed for an indefinite period. The patterns of production, demand, and plant closings in 1984 were similar to those experienced in 1983 and reflected a continuing weakness in demand for domestic iron and steel. Total output of usable ore in 1984 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. Fourteen mines produced ore for the iron and steel industry, but only four mines were operated throughout the year and only one mine produced at its rated capacity. One taconite mine and associated pelletizing plant remained idle, and two of the larger "natural ore" mines were permanently closed; neither had been operated for several years. Installed production capacity for usable ore at yearend was estimated at 88 million long tons[2] per year, including 82 million tons of capacity for pellets. Effective production capacity for pellets was at least 12 million tons less than installed capacity.

An average of 3.1 tons of crude ore was mined 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 five. Low-grade ores of the taconite type mined in Minnesota and Michigan accounted for 97.8% of total crude ore production. U.S. production of pellets totaled 50 million tons, 98% of usable ore output. Average iron content of usable ore produced was approximately 64.6%, while that of usable ore shipped was 63.8%.

Ownership of several major producers in Minnesota and Michigan was affected by the merger of Republic Steel Corp. with LTV Corp. The merger combined the holdings of Jones & Laughlin Steel Corp., a subsidiary of LTV, with those of Republic Steel under a new company, LTV Steel Co. Ownership shares of LTV Steel in U.S. iron ore producers are now as follows: Reserve Mining Co., 50%; Erie Mining Co., 35%; Hibbing Taconite Co., 16%; McKinley Extension Mine, 100%; Empire Iron Mining Partnership, 35%; and Tilden Mining Co., 12%. The merger also affected ownership of two major Canadian iron mining operations. Other corporate actions directly or indirectly affecting ownership of iron ore producers in these States included the following acquisitions: 50% of National Steel Corp. by Nippon Kokan K.K. of Japan; 10% of Wheeling-Pittsburgh Steel Corp. by

Nisshin Steel Co. Ltd. of Japan; and 10% of the Empire Iron Mining Partnership by McLouth Steel Products Corp.

Minnesota produced 72% of the national output of usable ore. Production of pellets totaled 35.8 million tons, equivalent to about 57% of installed production capacity of the State's eight taconite plants. The remainder of 1984 output consisted of hematite concentrates produced from "natural" ores by LTV Steel and Rhude & Fryberger Inc. All of the taconite plants were operated in 1984, but most were idle for part of the year. National Steel Pellet Co. was operated throughout the year and produced 4.5 million tons of pellets, about 12% more than capacity reported in 1983. Butler Taconite was operated from March 5 to November 10 and produced 2 million tons of pellets, about 75% of annual capacity. Reserve Mining resumed production of pellets on January 3, after being idle since the previous April, and produced about 3.6 million tons, less than 40% of capacity. Erie Mining also resumed production of pellets on January 3, after a 3-month shutdown, and produced 4.8 million tons before being shut down again on December 2. Hibbing Taconite was operated from mid-February to November 10 and produced 6.2 million tons of pellets. The Minntac facility of United States Steel Corp. was operated from January 1 to August 5 and from September 23 to November 18, producing about 8.7 million tons of pellets or 47% of installed capacity. Eveleth Mines produced about 3.9 million tons of pellets, 65% of capacity, and was operated all year except for 2 weeks in October. The Minorca Mine of Inland Steel Mining Co. was operated from mid-February to July 22 and from August 11 to November 10 and produced nearly 2.1 million tons of pellets. The shutdowns of five taconite plants between November 10 and December 2 resulted in a temporary layoff of more than 4,000 employees through yearend.

Minnesota tax legislation enacted in April 1984 provided for the return by the State of $17.9 million in taconite production taxes to producers of pellets. The repayment is to be made over a period of 5 years. The legislation also provided for elimination of the tax on iron content of pellets, froze the current production tax on pellets for 2 years, and required the State to base production taxes on the annual average of 3 years' production. Previously, the State could base the production tax on the latest year's production or on the average of 3 years, whichever was higher. Enactment of the legislation was contingent upon signing of an agreement by the State's taconite producers to suspend for 3 years all lawsuits challenging production taxes levied by the State.

Michigan produced 25% of U.S. output of usable ore in 1984. Production consisted entirely of pellets produced by the Cleveland-Cliffs Iron Co. (CCI) from ores mined at the Empire and Tilden Mines. The company's Republic Mine remained idle in 1984. Production of pellets totaled 12.9 million tons, of which 7.2 million tons was produced at the Empire plant and 5.7 million tons at Tilden. The Empire facility was operated all year and produced at 90% capacity. Average operating rate at Tilden was 72%, as only one of the pelletizing lines was operated for most of the year and operations were shut down from July 21 to August 13. CCI's ownership share in the Empire Iron Mining Partnership was reduced to 5% in 1984, owing to acquisition of 10% of the venture by McLouth Steel.

In Missouri, Pea Ridge Iron Ore Co. produced about 1.3 million tons of iron ore products, including 1.25 million tons of self-fluxing "olivine" pellets, from magnetite ore produced at its underground mine near Sullivan. The mine and plant were operated throughout 1984.

In Wyoming and Utah, U.S. Steel sold its mine and equipment at Atlantic City, WY, to Universal Equipment Co. of Fremont, OH, and auctioned off equipment at its Desert Mound Mine near Cedar City, UT. CF&I Steel Corp. also auctioned off plant and equipment of the Sunrise Mine near Guernsey, WY. The U.S. Steel mines were officially closed in April, while permanent closure of the Sunrise Mine was probably effective by January 1.

CONSUMPTION AND USES

Consumption of iron ore was about 6% greater than in 1983, owing to increased demand from the iron and steel industry. Consumption for ironmaking and steelmaking totaled about 65.5 million tons, including 54.3 million tons in blast furnaces, 10.8 million tons in sintering plants, 0.2 million tons in steelmaking furnaces, and 0.2 million tons for production of direct-reduced iron (DRI). 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 5.5 million tons, compared with 5.2 million tons in 1983. The increase in consumption occurred mainly in the first 5 months, as the number of operating blast furnaces increased by 10 to meet rising demand for pig iron. Monthly consumption averaged 6.1 million tons during this period and reached 6.5 million tons in May. In June, however, demand fell sharply, and by October, monthly consumption had fallen to 4.6 million tons and remained low for the rest of the year. During the last 7 months of 1984, 14 blast furnaces were taken out of production, and monthly consumption of ore averaged 5.1 million tons.

Consumption of iron ore and agglomerates reported by integrated producers of iron and steel totaled 71.3 million tons, including 52.4 million tons of pellets, 16.7 million tons of sinter, and 2.2 million tons of natural coarse ore. Of the primary ore consumed, an estimated 69% was of domestic origin, 18% came from Canada, and 13% came from other countries.

Consumption of other materials in sintering plants included 2.4 million tons of mill scale, 0.8 million tons of flue dust, 3.8 million tons of limestone and dolomite, 1.9 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 75,000 tons of manganiferous iron ore, 1.3 million tons of steel-furnace slag, 0.3 million tons of mill scale, and 0.9 million tons of slag scrap. Consumption of bentonite and coal in iron ore pelletizing plants was estimated at 378,000 tons and 190,000 tons, respectively. Approximately 55,000 tons of olivine was consumed in the production of pellets.

STOCKS

Stocks of iron ore and agglomerates reported at U.S. mines, docks, and consuming plants at yearend continued to decline in 1984, although the net reduction was slight compared with that in 1983. Mine stocks increased, as the quantity of ore shipped from most Minnesota mines was less than production, but the overall decline was due to reduction of stocks of imported ore at U.S. docks and furnace yards. Stocks reported at the latter facilities at yearend included 19.4 million tons of domestic ores, 4.1 million tons of Canadian ores, and 3.4 million tons of other foreign ores.

End-of-month stocks reported at mines peaked at 13.7 million tons in April and declined to 5.2 million tons at yearend, while stocks of ore reported at consuming plants ranged from a low of 12.2 million tons in March to a high of 25.5 million tons in November. 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 477,000 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 for 1983 and 1984 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 45.8 million tons, about 12% greater than in 1983. 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 6.9 million tons and accounted for about 40% of U.S. imports. The balance of imports, about 10.3 million tons, was shipped through ports on the east and gulf coasts.

Ore shipments from five of the seven U.S. ports on the upper Great Lakes increased from the levels of 1983, with the largest increase at Superior, WI. Shipments from Two Harbors and Taconite Harbor declined. Tonnage shipped from each port in 1984 follows:

Port	Date of first shipment	Date of last shipment	Total tonnage (thousand long tons)
Duluth, MN	Apr. 4	Dec. 13	7,764
Two Harbors, MN	Mar. 27	Nov. 12	6,805
Silver Bay, MN	Apr. 12	Dec. 14	3,628
Taconite Harbor, MN.	Apr. 10	Dec. 12	3,399
Superior, WI	Apr. 4	Dec. 22	11,150
Marquette, MI	May 2	Dec. 27	4,457
Escanaba, MI	Mar. 8	Dec. 24	8,619
Total			45,822

Source: Lake Carriers Association, 1984 Annual Report.

The number of vessel shipments from all seven ports totaled 1,399, indicating an average cargo of 32,753 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 22,512 tons at Marquette to 58,519 tons at Silver Bay. The largest cargo shipped during the year was 67,026 tons, loaded on the 1,013-foot carrier *William J. DeLancey* at Escanaba.

In April, lake freight rates for iron ore were increased for the first time in 3 years. The new rates, about 4% higher than those in effect since April 1981, were as follows, per ton: from the Head of the Lakes to lower lake ports, $7.41; from Marquette, MI, to lower lake ports, $6.11; from Escanaba, MI, 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.

Unusual delays in ore shipping during 1984 were caused by an ice jam in the St. Clair River in April, and by malfunction of a bridge over the St. Lawrence Seaway at Valleyfield, Quebec, Canada, in November. The ice jam, which lasted for 2 weeks and was finally cleared by May 1, caused a backup of more than 80 vessels waiting to transit the 39-mile channel between Lake Huron and Lake St. Clair. The bridge failure halted Seaway traffic between Montreal and Lake Ontario for 18 days and caused a backup of more than 100 vessels. In addition, a 41-hour malfunction of a bridge at Sault Ste. Marie caused a backup of 12 U.S.-flag vessels waiting to transit the Soo locks.

The principal issues concerning U.S. lake shipping in 1984 were proposed construction of a second Poe-class lock at Sault Ste. Marie, and proposed taxes (user charges) on shippers to recover the cost of operation and maintenance of shipping facilities and most of the cost of new construction, which historically have been paid for by the Federal Government. Owing to construction of larger vessels in the last 13 years and retirement of smaller vessels, about one-third of the vessels in the U.S. lake fleet, comprising more than one-half of the fleet's carrying capacity, must use the Poe lock to transit the the St. Mary's River Canal. A malfunction of this lock could seriously disrupt lake shipping and increase costs. Estimated cost of constructing a second lock was about $226 million. The U.S. Army Corps of Engineers, which has studied the problem for many years, now estimates that the benefits would outweigh the costs of construction. Although the Lake Carriers Association advocates construction of a second lock, it is opposed to the imposition of user fees because this could cost shippers at least $100 million per year for operation and maintenance; charges for new construction could greatly increase this figure, and the Association believes that taxes of this magnitude would be an unfair burden on the lake shipping industry. 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 continued to increase in Michigan in 1984 but were essentially unchanged in Minnesota, compared with rates in late 1983. For pellets from the Marquette Range, the rate to Presque Isle rose about 9%, to $2.46 per ton, while the rate to Escanaba rose about 4% to $2.68 per ton. In Minnesota, the rate for pellets from the western Mesabi Range to the Allouez docks at Superior, WI, was $4.87 per ton, up 2 cents per ton from that of 1983. Dock charges at Duluth, Superior, and Escanaba increased about 4%. At Lake Erie ports, ore transfer charges from rail-of-vessel or dock receiving area direct into railway cars ranged from about 92 cents to $1.14 per ton, unchanged from 1983. 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 increased about 2% to $10.16 per ton. Single-car rates for ore imported through east coast ports to inland consuming points were mostly unchanged, but the rate to Pittsburgh from Baltimore and Philadelphia increased about 15% to $14.93 per ton. All-rail rates from mines to consuming points were mostly unchanged, but the volume rate to Granite City, IL, from the Mesabi Range rose sharply to $18.82 per ton, while the rate from Pea Ridge, MO, remained at $6.41. 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 1.8 million tons in 1984; 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 $1.80 to $4.00 per ton. A few shipments reported from Brazil to east coast ports indicated freight rates of $6 to $7 per ton.

PRICES

Producers' published prices for Lake Superior iron ores in 1984 were unchanged from those quoted in August 1983. The price of pellets thus ranged from 80.5 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, The Hanna Mining Co., Oglebay Norton Co., and U.S. Steel. The range in unit price was equivalent to approximately $50.71 to $54.75 per ton of pellets containing 63% iron.

Late in 1984, Mineral Services Inc. 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 published price for pellets was quoted by a nonproducer at a level below those quoted by producers in the Lake Superior district. The Mineral Services price was equivalent to about $41.58 per ton of pellets containing 63% iron.

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.

The average f.o.b. mine value of usable ore shipped from domestic mines in 1984 was $44.17 per ton, about 1% higher than in 1983 as the share of pellets in total production continued to increase. The average f.o.b. value of pellets was about $45 per ton, while that for concentrates was about $21 per ton. These average values were based on producers' statements and should approximate the average commercial selling price less the cost of mine-to-market transportation.

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, Canada, 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 the Census, was $37.05 per ton. Data from this source indicated average f.o.b. values of $14.48 per ton for Liberian ores and $22.04 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 1983 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 $68 to $90 per ton.

FOREIGN TRADE

U.S. exports of iron ore increased 32%, compared with exports in 1983, largely because of increased 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. Exports to Canada also included about 200,000 tons of fluxed pellets shipped from Minnesota to Hamilton, Ontario, Canada, for blast furnace tests by Dofasco Inc.

U.S. imports for consumption of iron ore increased 30%, after declining for 2 years. Tonnage increased by 3.9 million tons compared with that of 1983. Imports of ore into the Philadelphia, Baltimore, and Mobile customs districts accounted for nearly 90% of the increase. Imports from Canada rose 27% from the 1983 level and imports from Brazil nearly doubled. Brazil increased its share of U.S. imports to nearly 15%, from about 10% in 1983.

On December 20, 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. Companhia Vale do Rio Doce (CVRD), representing Brazil, said the lower price of Brazilian pellets was due to the higher grade of ore mined in Brazil, which resulted in production costs about $20 less per ton than in the United States. CVRD also said that about 75% of its pellet shipments to the United States in 1984 were made under long-term contracts negotiated with U.S. steel companies in the mid-1970's. A hearing of the case was scheduled by the ITC for January 10, 1985.

WORLD REVIEW

World production, trade, and consumption of iron ore increased sharply in 1984, compared with the levels of 1983, as output of iron and steel increased in most industrialized countries and in many developing countries as well. Production increased 9%, trade increased 15%, and consumption as measured by output of pig iron increased about 6%.

World trade was estimated at 355 million tons, of which about 86% was oceanborne. Brazil was the leading exporter, followed by Australia, with each country shipping more than 84 million tons to world markets. Japan remained the principal importer, receiving 123 million tons in 1984, while countries of the European Community (EC) imported about 109 million tons.

World production of pellets was estimated at 186 million tons, about 70% of installed capacity. Some plants remained idle because of high fuel costs, and many others were operated below rated capacity owing to relatively weak demand from their principal markets. New plants were completed in Bahrain, Mexico, and the U.S.S.R., and others were nearing completion in India and the Republic of South Africa.

World output of DRI was estimated at slightly more than 9 million tons, about 45% of installed capacity, as lower prices for ferrous scrap continued to limit production. About 60% of the total output was produced in Mexico, Venezuela, and other countries in Latin America. New plants were completed in Malaysia and the Republic of South Africa, and others were under construction in at least six countries.

Iron ore prices under Japanese and West European contracts were reduced for the second consecutive year. The prices were 5% to 13% lower than those for 1983. Because of increasing valuation of the U.S. dollar relative to most other currencies, the cost of ore to consumers was not commensurate with the decline of iron ore prices, and for some European consumers the cost of ore was higher than it was in 1983. Iron ore prices continued to be quoted in U.S. currency. Prices in 1984, f.o.b. per dry ltu of contained iron, ranged from about 30 to 38 cents for pellets, 23 to 30 cents for lump ore, 20 to 28 cents for sinter fines, and 20 to 21 cents for pellet fines. The f.o.b. price for New Zealand beach sand magnetite concentrates was 16.7 cents per ltu.

Ocean freight rates for iron ore, as indicated by published rates for spot charterings, increased in 1984, but most declined by yearend. Rates to Western Europe from Australia were consistently about $2 per ton higher than in 1983, while rates from Brazil, Canada, Liberia, and Norway (Narvik) increased 10% to 30% during the first 6 months of 1984 but declined to 1983 levels by yearend. The number of spot charterings reported was unusually high and represented about 32 million tons of oceanborne shipments; about 50% of this tonnage was shipped in cargoes of 100,000 to 150,000 tons. For cargoes of this size, freight rates on various routes ranged as follows, per ton: to Western Europe, $5 to $6 from Brazil, $2.60 to $3.25 from West Africa, $2.15 to $2.80 from Norway, $3.50 to $4.50 from eastern Canada, and $7 to $10 from Australia; and to Japan, $4.30 to $5.25 from Western Australia and $8 to $10 from Brazil. Rates for cargoes of 220,000 to 250,000 tons from Brazil were about $4.75 to Western Europe and $8.50 to $9.00 to Japan.

Under the auspices of the United Nations Committee for Trade and Development (UNCTAD), the Third Preparatory Meeting on Iron Ore was held at Geneva in April 1984. It was decided at the meeting that the UNCTAD secretariat would prepare reports on the adequacy of statistical reporting for iron ore, and on possible areas of cooperation between exporting and importing countries. A fourth meeting was tentatively scheduled for late 1985.

Australia.—Shipments of iron ore by Australian producers in 1984 totaled about 95 million tons, including 87 million tons for export and 8 million tons for domestic consumption. Actual exports totaled about 84 million tons, of which about 85% was destined for Japan and other Asian countries and 15% was destined for Europe. Exports consisted of about 59% sinter fines, 38% lump ore, and 3% pellets.

Shipments by individual producers follow, in million tons: Hamersley Iron Pty. Ltd., 37.8; Mt. Newman Mining Co. Pty. Ltd., 30.4; Cliffs Robe River Iron Associates, 15.9; Broken Hill Pty. Ltd. (BHP), 5.3; Goldsworthy Mining Ltd., 4.6; and Savage River Mines, 1.9. About 5 million tons of Hamersley shipments came from stocks.

The Mt. Newman company began deepening its ship channels at Port Hedland in 1984, to allow loading vessels of 225,000 deadweight tons. The Cliffs Robe River company completed a similar project at Port Walcott. Goldsworthy Mining's ore contracts with Japanese buyers were extended for 2 years, to 1987. Savage River's mine and pelletizing plant were shut down for 6 weeks by a strike that began in July. In corporate actions, CRA Ltd. became sole owner of the Hamersley company in 1984, and BHP acquired Utah International Inc. from General Electric Co. Utah's holdings included one-third of Goldsworthy Mining.

Several Australian companies were interested in developing a new iron ore mine as a joint venture with the Chinese Government. Hamersley announced that it had reached agreement with the Chinese to study the feasibility of producing 5 to 10 million tons of iron ore per year from the Channar deposit, about 12 miles east of Paraburdoo.

Bahrain.—The iron ore pelletizing plant of Arab Iron & Steel Co. was completed, and production began in November. Pellet feed was imported from Brazil, India, and Peru. The plant has a production capacity of 4 million tons of pellets per year and uses a grate-kiln pelletizing system fueled by natural gas. The port can accommodate vessels of 100,000 deadweight tons. Cost of the project was reported to be $310 million. The first shipment was 20,000 tons of pellets, barged to the direct-reduction plant of Saudi Iron & Steel Co. at Jubail.

Brazil.—Shipments of iron ore for export and domestic consumption rose to record levels. Exports totaled about 87 million tons, 25% more than in 1983, while net shipments for domestic consumption increased more than 30% to 22 million tons. Exports included about 42 million tons to Europe and 28 million tons to Japan. Total shipments of pellets were estimated at about 20 million tons.

CVRD produced 54.3 million tons of iron ore products and exported 48.2 million tons. CVRD also exported 19.3 million tons for other companies, including about 9 million tons of pellets for its joint ventures at Tubarão with Japanese, Italian, and Spanish companies, 7.7 million tons of ore products for Ferteco Mineração S.A., and 2.6 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 7.5 million tons of ore from the Capanema Mine for beneficiation at the Timbopeba plant. CVRD's Carajás project in northern Brazil was about 70% completed by yearend, but the mine and railroad were closer to completion and limited production was scheduled to begin in 1985.

Minerações Brasileiras Reunidas S.A. (MBR) shipped 14.4 million tons of ore in 1984, including 12 million tons for export. Most of the ore was produced at the Aguas Claras Mine. Bethlehem Steel Corp. acquired an indirect interest of about 5% in MBR through an exchange with the CAEMI Group, in which Bethlehem relinquished its 49% interest in the Serra do Navio manganese property in Amapa.

Ore shipments by other producers, in million tons, follow: Ferteco (sales), 10.1; SAMITRI, 7.7; Samarco Mineração S.A., 6.7; and Cia. Siderúrgica Nacional, 4.0 (estimated).

Canada.—Shipments of iron ore products increased to 40 million tons in 1984, 23% more than in 1983, as demand increased in domestic and export markets. Exports totaled about 30 million tons, of which 44% was destined for EC countries and 39% was destined for the United States. Domestic consumption was estimated at 14.7 million tons.

Shipments of ore by individual producers, in million tons, follow: Iron Ore Co. of Canada, 15.3 including 8.2 of pellets, 5.7 of concentrates, and 1.4 of direct-shipping ore; Quebec Cartier Mining Co., 9.3 of concentrates; Pickands Mather, 7.2 of pellets including 6.2 from Wabush Mines; Sidbec-Normines Inc., 4.3 of pellets including about 0.7 of low-silica pellets; Cliffs of Canada Ltd. (for Dofasco), 2.1 of pellets from the Adams and Sherman Mines; and Inco Ltd., 0.2 of pellets from stockpile. Algoma Steel Corp. Ltd. shipped 1.3 million tons of superfluxed sinter from Wawa to its steelworks at Sault Ste. Marie. Feed to the sinter plant included 1.7 million tons of siderite ore produced at the MacLeod underground mine.

Following several years of financial losses, Sidbec-Normines permanently closed the Fire Lake Mine and terminated production of concentrates at Gagnon, effective December 31, 1984. The company's pellet plants at Port Cartier were leased to Quebec Cartier, which will use the plants to pelletize concentrates produced at Mount Wright. Sidbec-Normines was owned 8.23% by Quebec Cartier, 41.67% by British Steel Corp., and 50.1% by Sidbec-Dosco Inc. The latter company produced 500,000 tons of DRI at Contrecoeur in 1984.

Stelco Inc. announced that the Griffith Mine and pelletizing plant at Red Lake, Ontario, would be closed permanently in April 1986. The mine is operated for Stelco by Pickands Mather.

China.—Production of crude iron ore in 1984 was estimated at 118 million tons, about 6% more than in 1983. Official statistics on production of beneficiated ore were not available.

Imports of iron ore increased to about 5.6 million tons. Australia continued to be the principal supplier. Imports were expected to increase in 1985 as the first stage of the Baoshan steelworks was nearing completion. Iron ore requirements for Baoshan were estimated at 4.5 million tons per year. An agreement was reportedly signed in 1984 for imports of 3.4 million tons from Brazil over a 3-year period beginning in 1985, and Indian sources were also being considered.

A need for mining equipment of greater productive capacity was indicated by a Chinese report. To date, only the Nanfen Mine of the iron and steel complex at Benxi, Liaoning, was being equipped with trucks of 100- to 120-ton haulage capacity and electric shovels with bucket capacity of 10 cubic yards; other iron mines used trucks of 8- to 31-ton haulage capacity and shovels with bucket capacity of 1 to 6 cubic yards. The report also indicated that the cost of producing ore containing 65% iron ranged from about $13 per ton in the Qianan and eastern Hebei districts to about $25 per ton at the Ekou Mine in Shanxi.

European Communities.—Production of iron ore continued to decline. Output was about 65% of effective production capacity. Imports increased sharply, however, as output of pig iron was about 10% more than in 1983. Imports were estimated at 109 million tons, and consumption was estimated at 126 million tons. Reduction of pig iron production capacity during the last 4 years was estimated to have reduced the potential market for iron ore in the EC by at least 10%.

Imports of iron ore in 1984 by individual countries (excluding intra-Community trade) were estimated as follows, in million tons: the Federal Republic of Germany, 41; Italy, 17; France, 16; Belgium-Luxembourg, 15; the United Kingdom, 14; and the Netherlands, 6.

In France, plans were announced to close five mines and to reduce annual output of ore by 3 million tons by 1987. The mines proposed for closure are located in the western part of the Briey Basin, produce ore of the lime-rich type, and include the Bouligny, Joudreville, Mairy, Anderny, and Droitaumont properties. Plans to close the

Anderny Mine at yearend led to a 12-day strike by miners in November.

India.—Production, exports, and consumption of iron ore increased in 1984, compared with 1983 levels. Exports totaled about 23 million tons, and domestic consumption was estimated at 14.7 million tons. Exports included 15.4 million tons to Japan, 3.4 million tons to Romania, and 2.7 million tons to the Republic of Korea. Shipments from Goa totaled 11.6 million tons, and shipments from east coast ports by the National Mineral Development Corp. (NMDC) totaled 7.4 million tons. Exports were hampered by a 29-day strike by 300,000 port workers in March, and by sharply increased port charges at Mormugao, which caused diversion of some ore carriers to other countries.

The Steel Authority of India Ltd. (SAIL) reported production of 9.9 million tons of ore from eight mines and mine groups that supply ore to five SAIL steelworks, including the Burnpur plant of Indian Iron and Steel Co. Ore consumed at these plants totaled 12.1 million tons, including 7 million tons of lump ore and 5.1 million tons of fines. Ore consumption in the private sector was estimated at 2.6 million tons, most of which was consumed by Tata Iron and Steel Co. Ltd. at Jamshedpur.

NMDC produced 8.1 million tons of ore products, including 5.4 million tons of lump ore and 2.7 million tons of fines. The ore was produced at Bailadila No. 5, Bailadila No. 14, and Donimalai Mines in eastern India.

The pelletizing plant of Kudremukh Iron Ore Co. Ltd. (KIOC) at Mangalore was scheduled for completion by mid-1985, and exports of pellets were expected to start in September. KIOC shipped about 1.5 million tons of pellet feed in 1984, and a contract to supply up to 8 million tons to Bahrain over a 5-year period was reportedly signed with Arab Iron & Steel.

Japan.—Imports of iron ore in 1984 increased 15% compared with those of 1983, as production of pig iron increased 10%. Imports included about 108 million tons of lump ore and fines, 10.8 million tons of pellets, and 4 million tons of sinter. The principal suppliers continued to be Australia, Brazil, and India. Production of agglomerates in Japan was estimated at 93 million tons of sinter and 3 million tons of pellets. Consumption of ore was estimated at 112 million tons.

Liberia.—Exports of iron ore products totaled 16.5 million tons, of which 78% was destined for EC countries and 8% was destined for the United States. Exports included 12.3 million tons of sinter fines, about 2.9 million tons of pellets, and 1.4 million tons of lump ore. All of the pellets and one-third of the sinter fines were shipped by Bong Mining Co.

Shipments by the LAMCO Joint Venture (LJV) totaled 9 million tons, about 30% more than in 1983. The company planned to resume production near Tokadeh in 1985 and was seeking loans for purchase of mining equipment. Bethlehem sold its 25% interest in LJV to the Liberian Government in 1984 and agreed to purchase 2 million tons of ore annually for 3 years.

The National Iron Ore Co. produced about 900,000 tons of ore products in 1984. Although recently assisted by a loan from the International Bank for Reconstruction and Development, the company indicated that its financial condition was poor and that closure was imminent.

Malaysia.—The direct-reduction plant of Sabah Gas Industries Sdn. Bhd. on Labuan Island was completed in 1984, but owing to a problem in the briquetting plant, production did not get underway until late in the year. At Trengganu, construction of the direct-reduction plant of Perwaja Trengganu Sdn. Bhd. was almost completed by yearend, and orders for iron ore pellets were placed with Brazilian and Swedish producers for delivery in early 1985. Designed production capacity of each plant is about 600,000 tons of DRI per year.

Mauritania.—Exports of iron ore in 1984 increased to 9.3 million tons, about 25% more than in 1983. As in previous years, more than 80% of shipments were destined for EC countries.

The Guelbs project was inaugurated. Production of magnetic concentrates began from crude ore mined at El Rhein, about 15 miles north of the Kedia d'Idjil district. Owing to scarcity of water, the ore was beneficiated in the dry state, using semi-autogenous mills and low-intensity magnetic separators. Shipments of concentrates were scheduled at 2 million tons in 1985, rising to 6 million tons in 1988.

Operating status of high-grade hematite mines in the Kedia d'Idjil district was reported as follows: Tazadit No. 1, currently the principal producer, is expected to be exhausted by 1986; Tazadit No. 5 is to be closed in 1985; Tazadit No. 6 may continue operating until 1995. The Azouazil and

Seyala Mines are expected to operate until about 1992. The Rouessa Mine was inactive in 1984, and the F'Derik Mine was closed in 1983 owing to exhaustion of ore reserves.

Mexico.—Production of crude ore in 1984 totaled about 14 million tons, of which about one-third was produced in each of the States of Colima and Michoacan, 20% in Chihuahua, and most of the remainder in Jalisco and Durango. Shipments of ore products by the principal producers, in million tons, follow: Altos Hornos de México S.A. (AHMSA), 1.9 from La Perla; Consorcio Benito Juárez Peña Colorada S.A. (estimated), 1.7 from Manzanillo; Las Encinas S.A., 1.4 from Alzada; Siderúrgica Las Truchas S.A., 1.4 from Ferrotepec Mines; and Cía. Fundidora de Hierro y Acero de Monterrey S.A., 0.4 from Cerro de Mercado.

Construction of the new concentrator at AHMSA's Hércules Mine in Coahuila was about 90% completed by yearend, and production was expected to begin by mid-1985. Planned shipments of concentrates by pipeline to Monclova in 1985 included 1.8 million tons from the Hércules Mine and 1.2 million tons from La Perla. About 75% of the concentrate was to be pelletized at Monclova, and the rest was to be pelletized at Monterrey. Production of pellets in Mexico in 1984 was 7 million tons, about 60% of installed capacity.

HyLSA S.A. reported production of 1.64 million tons of DRI. Construction of a 2-million-ton-per-year direct-reduction plant at Lázaro Cárdenas was nearly completed by yearend.

New Zealand.—Shipments of titaniferous magnetite concentrates included exports of about 2.2 million tons to Japan and 200,000 tons for domestic consumption. New Zealand Steel Ltd. completed its mine expansion project at Waikato North Head; mining capacity was increased to about 11 million tons of beach sand per year, and capacity for concentrates was increased to 1.4 million tons per year. The concentrates will be transported to the iron and steel works at Glenbrook by an 11-mile underground pipeline.

Peru.—Exports of iron ore by Empresa Minera del Hierro del Perú in 1984 totaled 4 million dry tons, of which 49% consisted of sinter fines, 29% consisted of pellets, and the remainder was pellet feed. About 1.7 million tons of products was shipped to the Republic of Korea and 1.3 million tons was shipped to Japan.

South Africa, Republic of.—Production and exports of iron ore increased more than 40%, compared with the levels of 1983. Exports totaled 11.7 million tons, mostly to Japan and the EC. Domestic consumption was estimated at 9 million tons, as production of pig iron increased 10%, and output of DRI rose to about 265,000 tons. All four of the new reduction kilns built for Iscor Ltd. at Vanderbijlpark were completed by yearend.

Iscor produced 17.8 million tons of ore products at the Sishen Mine and about 2.3 million tons at the Thabazimbi Mine. Shipments totaled 19.6 million tons, including 10.8 million tons for export. Exports of iron ore were expected to continue, as market conditions improved and the Government assumed Iscor's debt to South Africa Railways, but shipments were being closely monitored by the Government. Early in 1984, rising freight charges on the railway from Sishen to Saldanha Bay, reduced ore prices, and nonrenewal of several sales contracts in Europe had increased financial burdens on Iscor to the point where the company said that exports had become totally unprofitable. At the Sishen Mine, the South plant, which accounted for one-third of the mine's production capacity of 27 million tons per year, was reportedly closed.

Spain.—Production of iron ore products in 1984 included 3.6 million tons by Cía. Andaluza de Minas S.A. (CAM), 1.4 million tons by Cía. Minera de Sierra Menera S.A., and 1.7 million tons by the Agruminsa subsidiary of Altos Hornos de Vizcaya S.A. Agruminsa's production included 1.2 million tons of siderite concentrates from ore mined underground at Bodovalle and 521,000 tons of oxide ores from four other locations in Spain. CAM's production came from the Marquesado Mine.

Exports of iron ore totaled about 2 million tons, of which CAM shipped 1.6 million tons from Almería and most of the remainder was shipped from Sagunto by the Sierra Menera company. Imports totaled 4.1 million tons, mostly from Brazil.

Ensidesa S.A. reported consumption of about 6.5 million tons, of which 3.8 million tons was imported and 2.7 million tons was obtained from domestic sources.

Sweden.—Production and exports of iron ore products increased 37% and 21%, respectively, from 1983 levels. Exports totaled 17.6 million tons including 4.1 million tons of pellets. About 3 million tons was shipped for domestic consumption. Stocks of ore were reduced by 2.9 million tons, to 4.5

million tons at yearend.

Luossavaara-Kiirunavaara AB (LKAB) produced 15.1 million tons including 6.4 million tons of pellets. Of the company's output, 59% was produced at Kiruna, 38% was produced at Malmberget, and the rest was produced at the Svappavaara pelletizing plant, which resumed production in November. Shipments totaled 18.1 million tons, mostly for export. LKAB was increasing capacity of its pelletizing plant at Kiruna to 4 million tons per year, and a steel-belt pelletizing plant was scheduled to begin production at Malmberget in 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. Shipments totaled 2.7 million tons including 1.5 million tons for export.

Reduction of the phosphorus and alkali content of Swedish ores continued to be major objectives. Apatite concentrates recovered from beneficiating plants totaled 131,000 tons, of which 83% was recovered at Grangesberg. Production of low-phosphorus fines was scheduled to increase by 45% at Kiruna in 1985. The alkali content of low-phosphorus fines has been reduced to 0.1% at Kiruna and to 0.05% in coarse concentrate at Malmberget.

U.S.S.R.—The second of three pelletizing plants at the Kostomus project in Soviet Karelia was reportedly operating in 1984, and the third was nearing completion. Each plant was designed to produce about 2.9 million tons of pellets per year. Soviet production of pellets was estimated at 59 million tons in 1984. Exports of pellets were estimated at about 10 million tons, in addition to 31 million tons of other iron ores. Most exports were destined for Czechoslovakia, Poland, and Romania.

The Stoylensk open pit mine and ore beneficiation plant in the Kursk Magnetic Anomaly were reportedly commissioned. The plant's production capacity for concentrates was 1.7 million tons per year.

Venezuela.—Shipments of iron ore products by CVG Ferrominera Orinoco C.A. totaled 12.8 million tons and included about 8.4 million tons for export. Domestic consumption was estimated at 4.1 million tons. Production of DRI was about 2.5 million tons, of which 52% was produced by the Midrex process, 35% 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 to use the Midrex process. The HIB plant has been closed since 1982.

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.

The use of fluxed pellets to improve efficiency of smelting continued to be investigated. Although regular production of olivine pellets has been instituted by LKAB of Sweden, Pea Ridge Iron Ore of the United States, and to some extent by CVRD of Brazil, olivine is a less suitable additive for more siliceous concentrates such as those pelletized in the Lake Superior district. On the Mesabi Range, Hibbing Taconite used limestone and dolomite to produce 200,000 tons of fluxed pellets in 1984 for blast furnace tests by Dofasco at Hamilton, Ontario, Canada. The fluxing material, consisting of 60% dolomite and 40% limestone, was added in the proportion of 10.6% by weight per ton of magnetite concentrate. Although heat requirements for pellet induration increased about 66% and the feed rate to the kiln was reduced by 15%, these disadvantages were expected to be offset by savings at the blast furnace because pellet reducibility improved by 37% and the melting temperature was raised by 145° F. The tests by Dofasco were reportedly successful.[3]

Six U.S. pellet producers were reportedly testing the use of an organic binder as a substitute for bentonite. Inland Steel used the material to produce 311,000 tons of pellets at the Minorca Mine in 1984 for tests in the company's blast furnaces at Chicago. Results indicated that reducibility of the pellets increased about 25% as the organic binder burns off completely during induration; that pellet composition was improved owing to elimination of contaminants such as alkalies and silica which are introduced by bentonite; and that possible savings at the blast furnace were 11 to 14 kilograms of coke per metric ton of hot metal produced. Although the organic binder costs more than bentonite, decreases in pellet strength and reduced heat efficiency in induration appeared to be correctable, and net savings possible were estimated at 43 to 67 cents per ton of pellets consumed.[4]

The developments outlined above indicate the importance of blast furnace tests in evaluating changes in pellet composition, structure, and production technology. The need for blast furnace operators to evaluate pellets in terms of hot metal cost is leading to changes in North American pellet specifications and will influence purchasing practices as well. In many cases, specifications have been based on what could be produced at the pellet plant, rather than on what would be the optimum product for the blast furnace. Whereas typical specifications for physical properties of pellets have been based on measurements at the pelletizing plants, additional specifications are being set for the proportion of fines received at the blast furnace as well as for physical properties at low and intermediate temperatures. This is increasing requirements for control of chemical composition and physical structure, and for more precise correlations between pellet quality and blast furnace performance, the bottom line being the least cost for quality hot metal.[5]

Solid fuel was being used to reduce costs in some oil-fired pelletizing plants. At the Carol Lake plant of the Iron Ore Co. of Canada, substantial savings in fuel oil consumption were achieved by adding 0.7% to 0.8% by weight of coke breeze to the pelletizing mix. Charcoal was successfully used for the same purpose by CVRD in pelletizing plants at Tubarão, Brazil. Coal-water slurries were also being investigated as substitutes for oil.

On the Mesabi Range, investigation of the feasibility of producing pig iron from local iron ore concentrates by a plasma arc process was begun at Hibbing, MN, by Pickands Mather in association with Westinghouse Electric Corp., Minnesota Power, and the Electric Power Research Institute. Fifty test runs completed by November indicated that metal production was possible using bituminous coal, subbituminous coal, or peat; that the metal produced met market specifications for low-phosphorus pig iron; and that no environmental problems were encountered. It was therefore decided to proceed with a second series of tests designed to establish optimum process parameters and economics necessary for scaleup to a semicommercial plant. A new reactor was completed in December, and the second series of tests was scheduled for completion by April 1985. The project was supported by a $1.37 million grant from the State of Minnesota, while the participating companies contributed manpower, equipment, and funds to build a 0.5-ton-per-hour pilot plant.[6]

Direct reduction of several thousand tons of Minnesota pellets was tested in the Federal Republic of Germany in November 1984 using a coal-based process developed by Korf Engineering GmbH. The tests were conducted to investigate the economic feasibility of producing iron in Minnesota for electric-furnace production of steel, and were partly supported by grants from the States of Minnesota and West Virginia, the U.S. Department of Energy, the American Iron and Steel Institute, and the Bureau of Mines. The tests were said to be successful, but no details were announced.

A Bureau of Mines study of corrosion rates of eight types of ferrous grinding media, using ultrasonic abrasion in simulated mill water, concluded that corrosion causes less than 10% of media wear in typical commercial grinding mills.[7] Research was also continued to improve the selective flocculation-desliming process for beneficiation of oxidized taconite by flotation. As the presence of more than 15 milligrams per liter of dissolved calcium, magnesium, or iron in the feed water will cause undesirable metallurgical results, an index based on the concentration of calcium ions was devised to monitor quality of the feed water and to help control the excess ion concentration to 10 milligrams per liter or less. This can permit use of water from several sources, including reclaimed water.[8]

Improvements in worker training at two taconite mines, to keep pace with the increasing complexity of mine operations and to meet requirements of the Mine Safety and Health Act, were described in a Bureau report.[9]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Unless otherwise specified, the unit of weight used in this chapter is the long ton of 2,240 pounds.

[3]Bymark, J. V. Fluxed Pellet Production at Hibbing Taconite Company. Proc. 58th Annu. Meeting MN Sec. AIME and 46th Annu. Min. Symp. Univ. MN, Duluth, MN, Jan. 16-17, 1985, pp. 4-1 to 4-16.

[4]Shusterich, F. Production of Peridur Pellets at Minorca. Proc. 58th Annu. Meeting MN Sec. AIME and 46th Annu. Min. Symp. Univ. MN, Duluth, MN, Jan. 16-17, 1985, pp. 16-1 to 16-12.

[5]Ranade, M. G. Blast Furnace Pellets—Present and Future. Skillings' Min. Rev., v. 73, No. 38, Sept. 22, 1984, pp. 4-11.

[6]Fatum, J. H. Plasma Mesabi—Metal Project. Proc. 58th Annu. Meeting MN Sec. AIME and 46th Annu. Min. Symp. Univ. MN, Duluth, MN, Jan. 16-17, 1985, pp. 7-1 to 7-35.

[7]Tolley, W. K., I. L. Nichols, and J. L. Huiatt. Corrosion Rates of Grinding Media in Mill Water. BuMines RI 8882, 1984, 13 pp.

[8]Green, R. E., and A. F. Colombo. Dispersion-Selective Flocculation-Desliming Characteristics of Oxidized Taconite. BuMines RI 8867, 1984, 19 pp.

[9]Couillard, D. T., and B. C. Nelson. Task Training in the Iron Mining Industry: Two Approaches. BuMines IC 8994, 1984, 11 pp.

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 1984, 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	2,129	4,306	39,450	12,982	8,374	64.5	9.16	3.01	1.94
Minnesota	5,713	11,706	116,994	36,697	23,748	64.7	9.99	3.13	2.03
Total or average	7,842	16,012	156,444	49,679	32,122	64.7	9.77	3.10	2.01
Other States[1]	373	692	2,614	1,590	988	62.1	3.78	2.30	1.43
Grand total or average	8,215	16,704	159,058	51,269	33,110	64.6	9.52	3.07	1.98

[1]Includes California, Missouri, Montana, Nevada, and Texas.

Table 3.—Crude iron ore[1] mined in the United States in 1984, 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	39,450	--	39,450
Minnesota	10	116,994	--	116,994
Total	12	156,444	--	156,444
Other States:				
Missouri	1	--	1,967	1,967
Other[2]	7	647	--	647
Total	8	647	1,967	2,614
Grand total	20	157,091	1,967	159,058

[1]Excludes byproduct ore.
[2]Includes California, Montana, Nevada, and Texas.

Table 4.—Usable iron ore produced in the United States in 1984, 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
Lake Superior:				
Michigan	--	--	12,982	12,982
Minnesota	--	853	35,844	36,697
Total	--	853	48,826	49,679
Other States:				
Missouri	--	67	1,257	1,324
Other[1]	51	215	--	266
Total	51	282	1,257	1,590
Grand total	51	1,135	50,083	51,269

[1]Includes California, Montana, Nevada, and Texas.

Table 5.—Shipments of usable iron ore from mines in the United States in 1984

(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	37	--	13,226	13,263	64.1	W
Minnesota	--	1,193	34,409	35,602	63.8	1,561,516
Total reportable	37	1,193	47,635	48,865	63.9	1,561,516
Other States:						
Missouri	--	65	1,305	1,370	65.7	W
Other[1]	95	553	([2])	648	54.8	13,191
Total reportable	95	618	1,305	2,018	62.2	13,191
Total withheld	--	--	--	--	--	672,979
Grand total	132	1,811	48,940	50,883	63.8	2,247,686

W Withheld to avoid disclosing company proprietary data; included in "Total withheld."
[1]Includes California, Colorado, Montana, Nevada, New Mexico, New York, and Texas.
[2]Included in concentrates.

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]
1854-1977	463,586	322,987	320,334	103,528	3,127,196	70,336	8,149	6,561	4,422,674
1978	14,472	2,280	--	--	55,316	--	--	660	72,727
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
Total	552,311	329,344	320,334	103,528	3,424,869	70,336	8,149	9,713	4,818,582

[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
1980	61,536	62.98	0.023	5.88	0.18	0.32	2.57
1981	64,925	63.13	.020	5.70	.17	.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

[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 1984, 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	578	W	6,840	W	W	7,418
Illinois, Indiana, Michigan	34	--	33,156	W	W	33,190
Maryland, New York, Pennsylvania	1,353	W	13,586	W	W	14,939
Ohio and West Virginia	95	W	15,267	53	W	15,415
Undistributed	--	111	--	[4]239	1,203	1,553
Total[5]	2,059	111	68,849	[4]292	1,203	72,514

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Excludes pellets or other agglomerated products.
[2]Includes approximately 43,236 units of pellets produced at U.S. mines and 9,013 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]Includes an estimated 176 units of ore and agglomerates used for production of direct-reduced iron for steelmaking.
[5]Data may not add to totals shown because of independent rounding.

Table 9.—Iron ore consumed in production of sinter at iron and steel plants in the United States in 1984, by State

(Thousand long tons)

State	Iron ore consumed[1]	Sinter produced
Alabama, Kentucky, Texas	W	W
California, Colorado, Utah	W	W
Illinois, Indiana, Michigan	3,679	7,146
Maryland, New York, Pennsylvania	5,429	6,814
Ohio and West Virginia	1,159	2,139
Undistributed	496	826
Total[2]	10,764	16,926

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Includes domestic and foreign ores.
[2]Data may not add to totals shown because of independent rounding.

Table 10.—U.S. production of iron ore agglomerates,[1] by type

(Thousand long tons)

Type	1983	1984
Sinter	[2]15,859	[3]16,926
Pellets	36,291	50,083
Total	[4]52,151	67,009

[1]Production at mines and consuming plants.
[2]Includes 7,648 units of self-fluxing sinter.
[3]Includes 7,983 units of self-fluxing sinter.
[4]Data do not add to total shown because of independent rounding.

Table 11.—U.S. exports of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3,173	150,200	3,780	182,490	4,988	238,856
India	1	25	(1)	12	(1)	2
Iraq	--	--	(1)	76	--	--
Mexico	1	67	(1)	4	(1)	24
Netherlands	--	--	--	--	3	262
Saudi Arabia	--	--	(1)	34	--	--
United Kingdom	(1)	21	(1)	5	(1)	32
Venezuela	(1)	67	(1)	10	(1)	15
Other	3	r142	1	r113	1	66
Total	3,178	150,522	3,781	182,744	[2]4,993	239,257

rRevised.
[1]Less than 1/2 unit.
[2]Data do not add to total shown because of independent rounding.

Table 12.—U.S. imports for consumption of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	(1)	4	--	--	--	--
Brazil	972	26,339	1,276	30,192	2,533	55,132
Canada	9,281	359,708	8,832	339,472	11,190	413,473
Chile	47	673	--	--	--	--
Liberia	2,399	43,036	1,732	31,487	1,745	25,270
Peru	35	1,057	(1)	5	7	76
South Africa, Republic of	52	1,083	--	--	--	--
Sweden	71	2,171	68	1,540	84	1,659
Venezuela	[2]1,643	[2]36,768	[3]1,333	[3]42,934	[4]1,524	[4]31,377
Other	(1)	7	5	102	104	2,078
Total[5]	14,501	470,847	13,246	445,731	17,187	529,065

[1]Less than 1/2 unit.
[2]Excludes approximately 175,000 long tons of direct-reduced iron valued at $24,000,000, originally reported as iron ore.
[3]Excludes approximately 82,000 long tons of sponge iron valued at $6,516,000, originally reported as iron ore.
[4]Excludes approximately 64,000 long tons of sponge iron valued at $5,016,000, originally reported as iron ore.
[5]Data may not add to totals 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	1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore	3,451	118,425	3,062	63,216	4,668	133,448
Buffalo	299	5,791	195	8,862	(1)	(1)
Chicago	2,667	91,454	1,625	52,357	2,574	59,705
Cleveland	2,087	77,001	4,491	179,771	3,859	136,654
Detroit	228	4,873	182	4,480	393	12,927
Houston	376	14,654	37	1,169	133	2,758
Mobile	1,278	49,584	525	25,778	1,548	68,283
New Orleans	423	9,915	573	12,369	643	12,315
Philadelphia	3,497	92,002	2,463	93,963	3,250	98,777
Wilmington, NC	76	2,949	--	--	--	--
Other	118	4,198	91	3,768	119	4,198
Total[2]	14,501	470,847	13,246	445,731	17,187	529,065

[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]				
	1980	1981	1982	1983[p]	1984[e]	1980	1981	1982	1983[p]	1984[e]
Albania[5]	541	591	591	[e]640	640	190	197	197	[r] [e]197	197
Algeria	3,399	3,425	3,646	[e]3,642	[6]3,602	1,836	1,849	1,968	[r] [e]1,968	[6]1,944
Argentina	430	392	578	599	[6]504	271	245	383	384	335
Australia	94,025	[r]83,324	86,309	70,494	88,579	59,483	[r]52,518	54,688	45,461	56,297
Austria	3,149	3,002	3,277	3,484	3,494	970	933	1,028	1,090	1,092
Bolivia	6	6	8	11	--	4	4	5	7	--
Brazil	112,920	[r]97,928	92,416	87,791	88,600	73,398	[r]63,673	60,070	[r] [e]57,064	57,600
Bulgaria	1,856	1,726	1,527	1,775	1,476	581	529	467	545	443
Canada[7]	47,984	51,164	35,030	29,847	37,188	30,316	32,126	22,279	18,977	23,566
Chile	[r]8,451	7,621	5,713	5,092	[6]5,496	[r]5,206	[r]4,687	3,520	3,071	3,314
China[e]	67,000	65,000	68,000	70,000	74,000	33,500	32,500	34,000	35,000	37,000
Colombia	498	412	463	449	502	[r]224	[r]192	209	202	226
Czechoslovakia	1,938	1,904	1,832	1,873	1,870	504	494	475	482	482
Denmark[e]	8	8	8	([8])	--	3	3	3	([8])	--
Egypt	1,748	1,912	2,106	2,188	2,461	874	[r]956	1,053	1,094	1,230
Finland[9]	1,153	1,211	1,218	1,257	1,279	743	777	774	809	817
France	28,523	21,257	19,085	15,714	[6]14,793	8,956	6,693	6,088	5,090	[6]4,734
German Democratic Republic[10]	39	39	39	39	39	20	20	20	20	20
Germany, Federal Republic of	[r]1,914	[r]1,547	1,291	961	[6]962	588	469	380	276	[6]288
Greece[5]	1,428	1,252	508	1,310	1,279	[r]614	538	218	563	536
Hungary	419	415	460	434	[6]377	[r]100	[r]99	110	104	[6]91
India	41,274	[r]40,698	40,256	[e]38,187	[6]40,378	25,837	25,479	25,201	23,905	[6]25,276
Indonesia	62	86	142	131	84	36	49	82	76	48
Iran[e 11]	590	590	[r]740	[r]840	840	360	360	390	[r]440	440
Italy[12]	182	121	3	--	--	72	49	2	--	--
Japan[13]	469	435	356	293	[6]320	289	270	221	182	[6]199
Kenya[14]	15	[r] [e]4	4	([8])	--	9	[r] [e]2	[r] [e]2	([8])	--
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	609	585	610	645	591	342	328	342	361	295
Liberia	17,900	19,393	17,878	14,701	[6]14,862	11,000	12,000	11,082	9,114	9,212
Luxembourg	551	422	--	--	--	165	148	--	--	--
Malaysia	365	524	331	112	177	223	320	205	69	108
Mauritania	8,795	8,567	8,125	7,268	[6]9,377	5,248	5,160	4,675	[e]4,183	[6]5,663
Mexico[15]	7,510	7,893	8,026	7,913	8,420	5,007	5,209	5,297	5,222	5,556
Morocco	77	72	220	248	246	49	44	137	155	153
New Zealand[16]	3,581	3,202	2,747	2,168	2,264	2,041	1,825	1,566	1,236	1,279
Norway	3,823	[r]4,073	3,489	3,479	[6]3,664	2,434	[r]2,648	2,268	2,262	[6]2,382
Peru	5,614	5,973	5,683	4,278	[6]4,012	[r]3,341	3,944	3,751	2,824	[6]2,676
Philippines	--	6	6	3	2	--	3	3	2	1
Poland	102	103	48	([8])	--	30	29	14	([8])	--
Portugal[17]	56	36	27	33	[6]35	25	13	9	11	12

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]				
	1980	1981	1982	1983[p]	1984[e]	1980	1981	1982	1983[p]	1984[e]
Romania	2,296	2,268	2,112	1,956	1,968	597	591	551	607	512
Sierra Leone	--	--	64	349	349	--	--	40	219	219
South Africa, Republic of[18]	25,896	27,872	24,166	16,343	[6]24,109	16,574	17,837	15,467	10,459	[6]15,429
Spain[19]	9,081	8,430	8,139	7,331	[6]7,145	4,303	4,151	4,065	3,457	3,555
Sweden	26,755	22,858	15,888	13,003	[6]17,838	17,364	14,835	10,324	8,452	[6]11,003
Thailand	84	61	27	39	[6]60	46	33	15	22	[6]32
Tunisia	383	390	270	311	295	211	202	140	162	[6]154
Turkey	2,538	2,889	2,810	4,085	[6]3,973	1,292	1,560	1,518	2,207	2,146
U.S.S.R	240,849	238,589	240,551	241,327	243,100	130,787	129,001	129,970	131,454	132,380
United Kingdom	902	719	463	378	[6]377	234	158	101	80	[6]81
United States	69,613	73,174	35,433	37,562	[6]51,269	43,888	46,539	22,642	24,167	33,110
Venezuela	15,848	15,286	11,023	9,562	12,522	9,826	9,477	6,834	5,924	7,782
Yugoslavia	[r]4,407	4,718	5,025	4,939	[6]5,237	1,391	[r]1,486	1,653	1,575	1,673
Zimbabwe	1,596	1,079	824	909	885	973	658	503	555	540
Total	[r]877,152	[r]843,152	767,491	723,893	789,440	[r]505,575	[r]487,110	440,205	414,986	455,328

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 2, 1985.
[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]Revised to zero.
[9]Includes magnetite concentrate, pelletized iron oxide (from roasted pyrite), and roasted pyrite (purple ore).
[10]Includes "roasted ore," presumably from pyrite, not separable from available sources.
[11]Year beginning Mar. 21 of that stated.
[12]Excludes iron oxide pellets produced from roasted pyrite.
[13]In previous editions of this Yearbook, production included concentrate derived from iron sands, which ceased in 1979.
[14]For cement manufacture.
[15]Gross weight calculated from reported iron content based on grade of 66% Fe.
[16]Concentrates from titaniferous magnetite beach sands.
[17]Includes manganiferous iron ore.
[18]Includes magnetite ore as follows, in thousand long tons: 1980—4,221; 1981—4,175; 1982—4,253; 1983—3,414; and 1984—3,633.
[19]Includes byproduct ore.

Iron Oxide Pigments

By William I. Spinrad, Jr.[1]

U.S. mine production, shipments, and value of crude iron oxide pigments and total domestic shipments and value of natural and synthetic finished iron oxides increased in 1984. Unit values for all categories of finished iron oxides increased. Synthetic iron oxide comprised 59% of all shipments. Combustion Engineering Inc. sold its iron oxide pigment producing plant in Camden, NJ, to American Minerals Inc., and Pfizer Inc. closed its Valparaiso, IN, plant indefinitely. Regenerator oxide producer Republic Steel Corp. merged with Jones & Laughlin Steel Corp., forming LTV Steel Co., and the Weirton Div. of National Steel Corp. was purchased by its employees and now operates as Weirton Steel Division. Ferro Corp., a consumer of regenerator oxide, was purchased by Hoosier Magnetics Inc.

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 announced for the fourth quarter of 1983 took effect during the first three quarters of 1984 as contracts expired and temporary discounts were lifted. Price increases announced by some major producers in the fourth quarter, to counter increased production costs, never materialized because of competitively priced imports.

The United States imported 18% more iron oxide pigment than it exported, although U.S. exports of pigment-grade iron oxides increased dramatically compared with those of 1983. This was attributed to the strength of the U.S. dollar against foreign currencies. U.S. imports of synthetic iron oxides increased dramatically compared with those of 1983, while imports of natural iron oxides declined slightly. World mine production of natural iron oxide pigments for reporting countries increased compared with that of 1983.

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

Table 1.—Salient U.S. iron oxide pigments statistics

	1980	1981	1982	1983	1984
Mine production short tons	r33,774	r28,731	r28,082	r26,499	29,307
Crude pigments sold or used do	r47,338	r49,732	r46,548	r41,875	53,017
Value thousands	r$1,758	r$1,743	r$2,059	r$2,427	$2,819
Finished pigments sold short tons	r125,371	r128,290	r104,951	r122,861	129,492
Value thousands	r$81,965	r$95,799	r$84,736	r$110,662	$122,620
Exports short tons	5,046	4,967	9,065	12,661	32,428
Value thousands	$9,132	$11,704	$17,795	$20,692	$31,832
Imports for consumption short tons	39,446	39,661	25,855	30,747	38,239
Value thousands	$20,035	$18,915	$13,330	$16,684	$21,523

rRevised.

the 17 companies canvassed for finished iron oxide pigments sales data in 1984, 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 regenerator oxide, 100% responded, representing 67% of the estimated production shown in the text discussion under Domestic Production. Data for nonrespondents were estimated through analysis of industry trends and practices and from information received from contacts within the industry.

DOMESTIC PRODUCTION

Mine production, shipments, and value of crude iron oxide pigments increased 11%, 27%, and 16%, respectively, over 1983 levels. 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, increased 5% in quantity and 11% in value compared with that of 1983. Synthetic iron oxides comprised 59% of total shipments, slightly less than that of 1983. Unit values for all categories of finished iron oxides increased. Natural iron oxides increased 8% in quantity and 14% in value compared with that of 1983. Raw umber and red iron oxide had notable increases of 19% and 11%, respectively, while raw sienna declined 15%. Of the 13 natural iron oxide producers canvassed, all but 2 reported increases in domestic shipments. Total synthetic iron oxide shipments increased 4% in quantity and 10% in value, with synthetic brown, red, and other iron oxide increasing 17%, 10%, and 1%, and synthetic yellow decreasing 11% in quantity, respectively. Two of the six synthetic iron oxide producers canvassed reported decreases in shipments.

Iron oxide for use in magnetic applications, not shown in table 2, was produced by three domestic companies, one being a captive operation. Production and shipment data are unavailable because of their proprietary nature.

An estimated 23,000 short tons[2] of steel plant byproduct iron oxides, in the form of regenerator oxide and steel plant dust, were shipped in 1984. Of the five plants canvassed, representing 67% of estimated shipments with a value of $1.4 million, three showed increases in shipments, and one continued to remain inactive.

In January, Combustion Engineering, CE Minerals Div., sold its iron oxide pigment producing plant in Camden, NJ, to American Minerals. Pfizer closed its Valparaiso, IN, plant, which produced magnetic iron oxides for audio and video applications, for an indefinite period in mid-April. The closure was attributed to diminished demand for magnetic particles made at the plant, and production of these materials was consolidated with Pfizer's East St. Louis, IL, and Easton, PA, plants. The Valparaiso plant will remain mothballed until market conditions warrant its reopening. In the first half of 1984, Republic Steel merged with Jones & Laughlin Steel, forming LTV Steel, a subsidiary of The LTV Corp., and employees of the Weirton Div. of National Steel purchased this plant, which now operates as Weirton Steel Div. Both steel companies produce regenerator oxides. Ferro, a major consumer of regenerator oxide for ferrite materials production, was purchased by Hoosier Magnetics, Washington, IN, in the third quarter of 1984.

Table 2.—Finished iron oxide pigments sold by processors in the United States,[1] by kind

Kind	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Natural:				
Black: Magnetite	r5,054	r$806	5,389	$877
Brown:				
Iron oxide[2]	W	W	W	W
Umbers:				
Burnt	3,451	2,626	3,432	2,903
Raw	1,311	901	1,559	1,151
Red:				
Iron oxide[3]	r22,196	r3,612	24,648	4,353
Sienna, burnt	r599	r499	631	561
Yellow:				
Ocher[4]	r16,318	r4,551	17,272	4,968
Sienna, raw	329	256	280	249
Total[5]	r49,258	r13,252	53,211	15,063
Synthetic:				
Brown: Iron oxide[6]	r13,994	r18,199	16,307	22,128
Red: Iron oxide	r30,506	r38,946	33,435	45,403
Yellow: Iron oxide	24,104	30,081	21,482	27,431
Other: Specialty oxides[7]	r4,999	r10,183	5,057	12,594
Total[5]	r73,603	r97,410	76,281	107,556
Mixtures of natural and synthetic iron oxides	W	W	W	W
Grand total[5]	r122,861	r110,662	129,492	122,620

rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Data (1983 revised and 1984) reflect elimination of sizable overstatements (including regenerator oxide), some reclassification, and elimination of magnetic iron oxide to avoid disclosing company proprietary data.
[2]These data are included with yellow ocher to avoid disclosing company proprietary data.
[3]Includes pyrite cinder.
[4]Includes yellow and brown iron oxides.
[5]Data may not add to totals shown because of independent rounding.
[6]Includes synthetic black iron oxide.
[7]Includes mixtures of natural and synthetic iron oxides.

Table 3.—Producers of iron oxide pigments in the United States in 1984

Producer	Mailing address	Plant location
Finished pigments:		
American Minerals Inc	Foot of Jefferson St. Camden, NJ 08101	Camden, NJ.
BASF Wyandotte Corp., Pigments Div	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	Box 37 Tulsa, OK 74102	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 Inc., Minerals, Pigments & Metals Div.	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 Service Inc	Box 1766 Springfield, IL 62705	Springfield, IL.
Sterling Drug Inc., Hilton-Davis Chemicals Div.	2235 Langdon Farm Rd. Cincinnati, OH 45237	Cincinnati, OH.

Table 3.—Producers of iron oxide pigments in the United States in 1984 —Continued

Producer	Mailing address	Plant location
Crude pigments:		
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 35% of all shipments and totaled 45,818 tons in 1984. Consumption increased slightly compared with that of 1983. Preliminary data developed by the U.S. Department of Commerce[3] indicate that 1.015 billion gallons of coatings valued at $8.9 billion was shipped, up 14% in volume over that of 1983. Architectural coatings comprised 50% of total shipments and totaled 503 million gallons; product coatings-original equipment manufacture (OEM) was 357 million gallons, or 35% of shipments; and 15%, or 153 million gallons, was special-purpose coatings.

Usage of iron oxide pigments in construction materials continued to grow in quantity and as a percentage of total shipments, approaching consumption patterns typical to Europe. Consumption increased 12% from 1983 levels, to 35,961 tons, and comprised 28% of all iron oxide pigments consumed. Construction showed large gains, according to the F. W. Dodge Div. of McGraw-Hill Information Systems Co., with new construction valued at $210 billion, 8% more than that of 1983. Commercial and industrial building led this increase, surging 24% from 1983 levels, and public works construction and institutional building increased 12% and 6%, respectively. Residential housing had its best year yet in the 1980's, increasing 8% in value to $101 billion and 3% in quantity to 1.75 million newly started units.[4]

Fourteen percent, or 17,358 tons, of all iron oxides was consumed as colorants for glass and ceramics, plastics, paper and textiles, and rubber, by order of ranking, representing a 6% increase in consumption from that of 1983. One published report indicated that 4,740 tons of iron oxide was consumed in plastics in 1984, 8% more than that of 1983. Iron oxides, which were 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.[5]

The remaining 23% 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 23,000 tons was shipped for consumption in 1984. 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 14,000 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	
	1983	1984	1983	1984	1983	1984
Animal feed and fertilizers	r6	6	r14	13	1	1
Coatings (industrial finishes, trade sales paints, varnishes, lacquers)	r36	35	25	25	r44	43
Colorants for plastics, rubber, paper, textiles, glass, ceramics	14	14	r14	13	r13	14
Construction materials (cement, mortar, preformed concrete, roofing granules)	r26	28	25	28	r27	27
Foundry sands	r6	5	14	13	--	--
Industrial chemicals (such as catalysts)	r5	5	2	3	r6	6
Other (including ferrites, cosmetics, and jewelers' rouge)	r7	7	r6	5	r9	9
Total	100	100	100	100	100	100

rRevised.
[1]Data do not include regenerator oxide, steel plant dust, and magnetic iron oxide usage.

PRICES

Price increases for natural and synthetic grades of iron oxides, announced by domestic producers for November and December of 1983, materialized over the first three quarters of 1984 as temporary discounts were lifted and contracts expired. Two major producers reportedly announced price increases for natural and synthetic iron oxides in the fourth quarter because of increased costs for raw materials, labor, and energy, but they never materialized because of the reluctance of other producers to follow these increases in light of competitive low-priced imports.

Table 5.—Prices quoted on finished iron oxide pigments, per pound, bulk shipments, December 31, 1984

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	--	.4500
Sienna, domestic, raw	.3600	.4400
Sienna, Italian, burnt	.4500	.7300
Umber, Turkish, burnt	.4350	.5200
Vandyke brown	--	.4000
Red:		
Domestic primers, natural, micronized	--	.2375
Pure, synthetic	--	.6600
Spanish	--	.2950
Yellow:		
Synthetic	--	.6800
Ocher, domestic	--	.2200

Source: American Paint and Coatings Journal.

FOREIGN TRADE

The United States imported 18% more iron oxide pigment than it exported in 1984, although U.S. exports of pigment-grade iron oxides increased 156% in quantity compared with those of 1983. This imbalance was attributed to low-valued imports, which were further discounted, in some cases, because of the exceptional strength of the U.S. dollar compared with foreign currencies. Total value of U.S. exports of iron oxide pigments was $31.8 million, or $10.3 million greater than that of U.S. imports, however.

U.S. imports for consumption of iron oxide pigments received from 22 countries, primarily European, increased 24% in quantity and 29% in value compared with those of 1983. Monthly import levels, which exceeded corresponding 1983 levels in all but January, November, and December of 1984, peaked in July. U.S. imports of synthetic iron oxides increased 34% in quantity and 32% in value and comprised 78% of all imports received. All synthetic iron oxides increased in quantity. The most notable, synthetic yellow, increased 70% to 12,978 tons. Average values of synthetic black and red grades increased 6 and 10 cents, respectively, to 31 and 41 cents per pound, while synthetic yellow and other grades decreased 5 and 2 cents to 29 and 33 cents per pound, respectively. Synthetic iron oxides were received chiefly from the Federal Republic of Germany, Canada, Japan, Mexico, and the United Kingdom, comprising 46%, 29%, 14%, 5%, and 3% of total imports, respectively. U.S. imports of natural iron oxides decreased slightly in quantity but increased 6% in value compared with 1983 levels. The most notable decrease, responsible for overall declines in natural imports, was in crude umber, which decreased 6% in quantity from 1983 levels. Unit values of all natural iron oxide imports increased except for Vandyke brown and other finished varieties. Cyprus, the Federal Republic of Germany, Spain, and the United Kingdom supplied 93% of all imports of natural iron oxides. Finished umber was primarily received from Cyprus and the United Kingdom, sienna from Cyprus and Italy, and all Vandyke brown imported was received from the Federal Republic of Germany. The United States also received 122 tons of micaceous iron oxide from Austria. Minor amounts of crude, finished, and synthetic iron oxide were received and stored in bonded warehouses for future consumption.

Periodically, iron oxide pigments also enter the United States under the combined classification, "Iron compounds, other." In 1984, minor amounts of iron oxide were received from Canada under this category.

U.S. exports of pigment-grade iron oxides and hydroxides reached historic high levels for the second consecutive year, increasing 156% in quantity and 54% in value compared with those of 1983. These exports were received by 49 countries, with Europe, Asia, and other North American countries representing the largest foreign markets. Chief destinations for iron oxide pigments, by order of ranking, were the Federal Republic of Germany, Japan, Canada, and the United Kingdom. Exports to the Federal Republic of Germany increased almost threefold over 1983 levels and had an average value of 27 cents per pound, a 13% decrease from 1983 values. Exports of other grades of iron oxides and hydroxides decreased 11% in quantity and 15% in value compared with those of 1983. Main destinations were Japan, Venezuela, the United Kingdom, and Australia.

Table 6.—U.S. exports of iron oxides and hydroxides, by country

Country	1983				1984			
	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	55	$37	--	--	115	$88	--	--
Argentina	12	36	1	$3	8	26	(1)	$2
Australia	159	207	246	645	97	148	263	598
Belgium-Luxembourg	92	161	381	664	250	357	113	207
Brazil	247	700	115	235	176	657	137	530
Bulgaria	--	--	20	78	(1)	1	27	59
Canada	1,920	2,888	324	490	2,521	3,659	186	372
China	--	--	112	363	--	--	(1)	1
Colombia	109	79	8	9	61	41	19	30
Czechoslovakia	• (1)	1	20	77	(1)	1	--	--
Denmark	32	121	2	2	17	54	2	2
Dominican Republic	1	3	--	--	(1)	2	28	25
Ecuador	38	40	7	7	60	105	8	9
Egypt	--	--	30	18	--	--	33	20
El Salvador	21	48	--	--	19	38	2	3
Finland	31	41	--	--	23	34	--	--
France	380	581	72	135	535	810	135	286
Germany, Federal Republic of	5,999	3,689	163	823	23,210	12,473	64	152
Hong Kong	425	912	--	--	325	575	18	62

See footnotes at end of table.

Table 6.—U.S. exports of iron oxides and hydroxides, by country —Continued

Country	1983				1984			
	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)
Indonesia	452	$629	--	--	--	--	--	--
Ireland	23	81	--	--	51	$163	--	--
Israel	--	--	62	$253	6	8	3	$6
Italy	286	2,167	39	140	301	1,744	62	128
Jamaica	8	48	1	2	4	6	1	4
Japan	486	1,119	1,914	5,896	2,732	3,985	1,658	4,833
Korea, Republic of	558	720	44	138	259	199	11	36
Malaysia	19	13	30	66	21	44	40	88
Mexico	47	89	167	666	236	369	188	394
Netherlands	51	100	269	849	60	200	56	201
New Zealand	4	12	3	6	8	14	11	26
Norway	--	--	19	34	--	--	--	--
Oman	--	--	--	--	--	--	204	164
Panama	4	9	10	9	30	38	--	--
Peru	11	7	7	6	22	19	1	1
Philippines	11	19	4	9	21	18	3	8
Saudi Arabia	6	11	--	--	--	--	--	--
Singapore	34	106	290	336	37	58	170	565
South Africa, Republic of	24	65	--	--	11	24	1	5
Spain	9	41	(1)	1	12	30	33	72
Sweden	--	--	5	11	6	43	4	10
Switzerland	3	4	--	--	24	84	1	4
Taiwan	16	44	2	4	42	168	21	46
Thailand	32	30	--	--	24	29	2	4
Tunisia	--	--	--	--	--	--	58	78
Turkey	--	--	--	--	16	160	--	--
United Arab Emirates	--	--	22	30	--	--	10	14
United Kingdom	892	5,583	317	618	896	4,920	313	732
Uruguay	3	3	--	--	10	11	6	4
Venezuela	137	197	77	233	158	361	340	1,029
Yugoslavia	--	--	6	11	--	--	48	84
Other	r26	r51	r9	r11	25	69	10	14
Total[2]	12,661	20,692	4,799	12,882	32,428	31,832	4,292	10,909

rRevised.
[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 iron oxide pigments, by type

Type	1983		1984		Major sources, 1984
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	
Natural:					
Crude:					
Ocher	(1)	(1)	7	$31	Canada 3; Japan 3; Switzerland 1.
Sienna	44	$18	38	22	United Kingdom 20; Italy 16; Japan 2.
Umber	6,317	898	5,963	860	Cyprus 5,415; United Kingdom 368; Portugal 117; Ireland 63.
Other	54	53	134	142	Mexico 46; West Germany 21; Cyprus 20; United Kingdom 19; Japan 13.
Total[2]	6,415	969	6,143	1,054	
Finished:					
Ocher	(1)	3	(1)	(1)	
Sienna	97	38	122	50	Cyprus 55; Italy 44; Mexico 22.
Umber	323	98	438	152	Cyprus 282; United Kingdom 149.
Vandyke brown	769	309	659	244	West Germany 659.
Other	787	289	862	302	Spain 655; Austria 122; Netherlands 51.
Total	1,976	737	2,081	748	

See footnotes at end of table.

Table 7.—U.S. imports for consumption of iron oxide pigments, by type —Continued

Type	1983		1984		Major sources, 1984
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	
Synthetic:					
Black	503	$255	614	$386	West Germany 524; Netherlands 40; United Kingdom 30; Japan 16.
Red	4,453	2,731	5,690	4,634	Japan 2,126; West Germany 2,004; Canada 752; United Kingdom 384; Mexico 152.
Yellow	7,640	5,121	12,978	7,525	West Germany 9,737; Mexico 1,446; Canada 745; Japan 490; United Kingdom 325; Brazil 156.
Other[3]	9,760	6,871	10,733	7,174	Canada 7,355; Japan 1,514; West Germany 1,413; Belgium-Luxembourg 176; Netherlands 134.
Total[2]	22,356	14,978	30,015	19,720	
Grand total[2]	30,747	16,684	38,239	21,523	

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.
[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			
	1983		1984		1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	20	$10	--	--	53	$23	--	--
Austria	59	37	122	$64	--	--	--	--
Belgium-Luxembourg	21	6	9	6	58	17	218	$65
Brazil	--	--	--	--	56	31	300	163
Canada	26	13	12	64	7,461	1,937	8,851	2,550
China	--	--	--	--	--	--	16	10
Cyprus	6,550	968	5,772	889	--	--	--	--
France	24	61	2	27	3	14	2	10
Germany, Federal Republic of	793	318	688	269	10,198	6,084	13,678	6,936
Ireland	--	--	63	9	--	--	--	--
Italy	48	22	80	40	--	--	16	12
Japan	3	17	18	76	3,127	6,086	4,146	8,176
Mexico	23	9	68	47	786	313	1,603	789
Netherlands	24	17	52	52	20	6	194	79
Norway	([1])	([1])	--	--	--	--	24	19
Portugal	76	23	117	17	--	--	--	--
Spain	556	127	660	121	160	29	116	22
Sweden	--	--	--	--	4	102	20	378
United Kingdom	147	73	559	119	424	239	817	482
Other	21	5	1	1	[r]6	[r]97	14	30
Total[2]	8,391	1,706	8,224	1,802	22,356	14,978	30,015	19,720

[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.

WORLD REVIEW

World mine production of natural iron oxide pigments for reporting countries increased compared with that of 1983. 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.

World synthetic iron oxide production capacity has been estimated at about 630,000 tons per year, with Europe accounting for roughly 66% of total capacity. Synthetic iron oxides comprise the largest percentage of colored inorganic pigment production and are estimated to make up 15.5% of total inorganic pigment production capacity, which includes titanium dioxide.[6] 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 to natural grades. Principal world producers of synthetic iron oxides include the Federal Republic of Germany, the United States, Japan, Mexico, and Brazil.

Cyprus.—Umber, ocher, and sienna deposits are found in upper Cretaceous sediments of the Perapedhi Formation in areas surrounding the Troodos Massif and the Troulli inlier. Umber Corp. of Larnaca Ltd. holds leases to nearly all the umber mines in Cyprus. In 1983, the company reportedly mined 14,900 tons of crude umber, which was sold to local producers for further processing. Another company, Cyprus Umber Industrial Co. Ltd., has the capacity to mine 11,000 tons of umber per year and produces raw and burnt crude, finished, and micronized grades of umber and sienna. These products are mainly marketed in the United States, Egypt, and Denmark. Mantovani Umber Industries Co. Ltd. is Cyprus's largest exporter of raw and burnt crude umber. Between 6,600 and 8,800 tons of umber are mined per year and blended into 10 different colors from 5 basic grades. Main exports are to the United States and the United Kingdom. Oryktaco Ltd. also produces and exports limited quantities of raw and burnt umber to the United Kingdom. Total production of umber declined from a high of 29,800 tons in 1980 to 17,600 tons in 1983, and exports, which varied greatly over this period, were 9,400 tons in 1983 according to statistics from the Cyprus Mines Service. Exports were expected to remain at about the same levels in 1984 for most of these companies.[7]

Japan.—Fuji Titanium Industry Co. Ltd. has produced a superfine iron oxide as a result of the company's development work in powders for ceramic capacitors and high-technology industries. The iron oxide, which has granules of submicrometer diameter, offers the highest ultraviolet absorptivity ever found in inorganic materials, according to the company, and can add transparency to paints and resins when used in them.[8]

Toda Kogyo Corp. announced plans to begin construction of a 550-ton-per-month iron oxide facility in Otake City. The facility will be built at a cost of $4 million and is scheduled for completion in November 1985. The product iron oxide will be used in ferrite manufacture, specifically, in plastic magnets.[9]

Dowa Mining Co. Ltd., a producer of iron oxide for ferrite manufacture, was scheduled to resume operation of a 1,100-ton-per-month iron oxide line during the summer of 1984, thus bringing its operating level to 3,700 tons per month.[10]

According to the Japan Inorganic Chemical Industry Association, sales of iron oxide were forecast to increase 9% from 156,000 tons in 1983 to 170,500 tons in 1984. Magnetic material end uses were expected to dominate these sales, increasing 13% to 125,600 tons, as strong sales in office automation, audio, and video equipment increased demand for hard and soft ferrites and magnetic material. Other major sales areas for domestically produced iron oxides and their projected end-use increases were paint, 4% to 15,100 tons; printing inks, 6% to 1,700 tons; synthetic resins, 5% to 1,400 tons; and ceramics and paper, 2% and 1% to 1,200 and 800 tons, respectively. Engineering, building, and other end uses were estimated to decrease 5%, 2%, and 3% from 1983 levels to 3,500, 2,500, and 1,700 tons, respectively. Exports were expected to decrease 6% to 17,000 tons. Major iron oxide producers in Japan include Rikon Sangyo Co., Chemilite Kogyo Co., Morishita Bengara Kogyo Co., Toda Kogyo, Nippon Benhei Kogyo Co., Nishiumi Kogyo Co., and Titan Kogyo Co. Ltd. Nisshin Ferrite Co. began production of an intermediate calcined powder for use in ferrite magnets in the third quarter of 1984. Production within the year was expected to be 165 to 220 tons per month.[11]

Reportedly, shortages of iron oxide suitable for soft ferrite manufacture are beginning to be felt, and the threat of growing shortages are of concern as sales of these ferrites continue to grow at large but cyclical rates, and stocks of raw materials for iron oxide manufacture dwindle. Furthermore, shortage of materials for hard ferrite manufacture may occur as iron oxides suitable for use in higher valued soft ferrites are diverted from their manufacture. Stocks of hydrochloric acid waste, feedstock for about 75% of available iron oxide used for ferrite manufacture in Japan, have been severely depleted and, to compound matters, many steel manufacturers have plans to convert from hydrochloric acid bath treatment of thin sheet steel to abrasive methods. Other suitable methods of iron oxide manufacture exist but are not presently cost-effective because of the lower cost regenerator oxides. One promising method, iron oxide production from sulfide ores, is presently limited by the cost of removing silica impurities to meet soft ferrite specifications. Present manufacturers of regenerator oxide are Tetsugen Co., Toda Kogyo, Rikon Sangyo, Kashima Denshi Zairyo Co., Nishiumi Kogyo, Santetsu Kogyo Co., and Chemilite Kogyo. Iron sulfide producers are Dowa Mining, Toda Kogyo, and Rikon Sangyo.[12]

Table 9.—Natural iron oxide pigments: World mine production, by country[1]

(Short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina	1,053	815	1,027	940	990
Australia	58	925	--	--	--
Austria	12,080	12,478	10,549	12,935	12,700
Brazil	7,126	4,578	5,811	r e6,600	6,600
Canada[e]	3,100	3,100	3,100	3,100	3,100
Chile	4,906	5,390	2,695	7,442	6,600
Cyprus	r29,983	22,046	22,046	17,637	16,500
Egypt	139	e140	e160	(3)	--
France[e]	17,600	16,530	r17,600	r17,600	16,500
Germany, Federal Republic of[4]	27,193	24,828	20,491	21,921	22,000
India	95,017	87,778	93,464	97,701	99,200
Iran[e 5]	550	550	550	660	660
Italy[e]	1,100	1,000	900	1,000	900
Morocco	133	--	--	--	--
Pakistan	359	r491	2,082	848	1,100
Paraguay[e]	220	220	r130	r200	190
South Africa, Republic of	1,510	r1,430	2,355	1,861	1,100
Spain:					
Ocher	15,097	17,110	12,907	10,890	11,000
Red iron oxide[e]	27,600	27,600	25,000	22,000	22,000
United States	r33,774	r28,731	28,082	26,499	6 29,307
Zimbabwe[e]	1,100	1,320	1,100	1,100	1,100

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table prepared by Audrey D. Wilkes, Division of International Minerals; includes data available through Apr. 9, 1985.
[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]Revised to zero.
[4]Includes Vandyke brown.
[5]Iranian calendar year (Mar. 21 to Mar. 20), beginning in the year stated.
[6]Reported figure.

TECHNOLOGY

At the 1984 American Foundrymen's Society Casting Congress, a panel discussed the effects of iron oxide additions in metal casting practices. It was noted that black and red iron oxides affected gas content, veining, and other undesirable conditions found in these processes. Red iron oxides were noted to be more beneficial than black when used in steel castings. Addition of 1% to 3% iron oxide in sand molds for gray iron castings suppressed circumferential and midline veining, with red iron oxide again being more effective than black. Iron oxide additives release oxygen on a controlled basis minimizing surface defects.[13]

A study has been completed on the history, usage, testing, and evaluation of micaceous iron oxide (MIO) in anticorrosive paints. MIO has been used extensively in undercoats and finishing paints over the last 80 years for corrosion protection of engineering structures all over the world. Many of these structures have lasted up to 20 years between coatings. The performance of MIO has been attributed to the parallel orientation of its lamellar particles to paint film surfaces that form a protective barrier, reducing water penetration and ultraviolet degradation of the paint film. Of currently available lamellar and granular natural iron oxide pigments tested, MIO from Waldenstein, Austria; France; and South Devon, United Kingdom, were found to give the best protection. Pigment volume concentrations of 40% to 50% were found to be ideal for good corrosion protection and weather resistance when used in a urethane oil modified alkyd medium. Various extenders such as barites, china clay, mica, talc, and titanium have been used with high levels of MIO with no effect on pigment orientation or corrosive protection.[14]

Along with 137 other technical committees of the American Society for Testing and Materials (ASTM), Committee D01 on Paint and Related Coatings and Materials is addressing the quality of testing and materials through standardization to conform with environmental, producer, and user needs and requirements. D01 consists of 28 technical subcommittees with subcommittee D01.31 dealing with pigment properties. At the subcommittee level, representatives of affected interests are recruited to form voluntary task groups to attain an ethical balance of interests among producers, users, and regulators in the identification and adoption of standards. Presently, about 500 ASTM paint standards exist, of which 300 are test methods; 140 cover specifications of identity, not performance, of 60 volatile solvents, 50 pigments, and 30 drying oils and their derivatives; and practices or guides for selection and use of test methods comprise 60. These standards are available in volumes 6.01, 6.02, and 6.03 among ASTM's 66 volumes of standards. ASTM is complimentary to other domestic standards groups, and D01 subcommittees are in direct contact with counterpart subcommittees of various foreign standards groups such as the British Standard Institution, the Federal Republic of Germany Deutsche Industrie Normen (DIN) organization, and with Technical Committee 35 on paints of the International Standards Organization (ISO).[15]

The second edition of Outlines of Paint Technology, a two-volume set, was published. Volume 1 addresses materials including pigments, solvents, plasticizers, drying oils, resins, varnishes, and aqueous media. The second volume contains information on finished products. Among the topics covered are fundamentals; pigmentation; pigment dispersion; protection of metals; primers; decorative and building paints; industrial, marine, and miscellaneous finishes; performance and weathering; and testing and evaluation.[16]

The Institute of Glass Science and Engineering was established at Alfred University, in the College of Ceramics, for the purpose of conducting research on new methods of glass production, strengthening and reducing the weight of glass containers, and the use of glass casings to store nuclear wastes. Glass is one of the minor end uses for oxide pigments.[17]

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[1] Physical scientist, Division of Ferrous Metals.

[2] Unless otherwise specified, the unit of weight in this chapter is the short ton.

[3] Bureau of the Census (Dep. Commerce). Paint, Varnish, and Lacquer. Rep. M28F (monthly), 1984.

[4] American Paint and Coatings Journal. '84 Construction Value Sets Record. V. 69, No. 34, Feb. 4, 1985, pp. 16-18.

[5] Modern Plastics. Special Report: Additives. The Unending Stream: Over 200 New Ones Just This Year Alone. V. 61, No. 9, Sept. 1984, pp. 61-85.

[6] Koxholt, P. M. Iron Oxide Pigments—"The Largest Color." Pres. at Int. Conf. on Pigments and Extenders, Atlanta, GA, Nov. 29-30, 1984, 13 pp.; available from P. M. Koxholt, Mobay Chemical Corp., Pittsburgh, PA.

[7] Industrial Minerals (London). The Industrial Minerals of Cyprus. No. 207, Dec. 1984, pp. 21-35.

[8] Japan Chemical Week. Fuji Titanium Develops Super-Fine Iron Oxide. V. 25, No. 1291, Dec. 27, 1984, p. 11.

[9] ———. Toda Kogyo To Build New Factory for Iron Oxide for Ferrite. V. 25, No. 1260, May 24, 1984, p. 2.

[10] ———. Dowa Will Resume Iron Oxide Plant Operation. V. 25, No. 1256, Apr. 26, 1984, p. 6.

[11] Roskill Information Services Ltd. (London). Roskill's Letter From Japan. Iron Oxide: 1984 Sales Forecast To Rise 9% to 155,000 Tons. RLJ No. 104, Dec. 1984, pp. 10-13.

[12] ———. Iron Oxide: Shortage of Raw Materials for Soft Ferrites. RLJ No. 102, Oct. 1984, pp. 17-21.

[13] Foundry Management and Technology. Highlights: 1984 AFS Casting Congress—Part IV. V. 112, No. 9, Sept. 1984, pp. 86-94.

[14] Bishop, D. M., and F. G. R. Zobel. Micaceous Iron Oxide Paints. J. Oil Colour Chem. Assoc., v. 66, No. 3, 1983, pp. 67-86.

[15] Weaver, J. C. What Does ASTM Mean to Coatings Research and Development? Mod. Paint and Coatings, v. 73, No. 9, Sept. 1983, pp. 51-54.

———. ASTM Environs Are Worldwide. Am. Paint and Coatings J. Conv. Daily, v. 69, No. 19, Oct. 26, 1984, pp. 21-24.

[16] Morgans, W. M. Outlines of Paint Technology. V. 1, Materials; v. 2, Finished Products. Wiley, 1984, 534 pp.

[17] Chemical and Engineering News. V. 62, No. 22, May 28, 1984, p. 25.

Iron and Steel

By Frederick J. Schottman[1]

Steel production and shipments continued to recover from the very low levels of 1982. However, capability utilization remained low, and strong competition restrained prices. Many companies continued to lose money on steel operations.

The structure of the U.S. industry was changed by a merger of two of the largest companies and by closings of older plants. Japanese steel companies made significant investments in the U.S. industry through joint ventures or purchase of stock in domestic steel companies.

Imports rose to record-high levels and U.S. companies sought protection through the trade laws. Late in the year, the Administration began a 5-year program to control injury to the U.S. industry and to restrict unfairly traded imports. In the program, agreements to restrict exports of steel to the United States were negotiated with major supplier countries.

World production increased but remained below capacity. Competition between exporters was strong, and in many countries there were complaints of unfairly traded steel. Companies in most mature industrialized countries, including Japan, made cutbacks in capacity because of imports or lost export markets.

Table 1.—Salient iron and steel statistics

(Thousand short tons unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Pig iron:					
Production	68,699	73,755	43,342	48,770	51,961
Shipments	69,445	74,218	43,449	49,081	52,164
Annual average composite price, per ton[1]	$203.00	$204.66	$213.00	$213.00	$213.00
Exports[2]	73	16	54	6	57
Imports for consumption[2]	400	468	322	242	702
Steel:[3]					
Production of raw steel:					
Carbon	94,689	101,462	64,143	73,783	79,918
Stainless	1,701	1,743	1,235	1,750	1,772
All other alloy	15,445	17,623	9,198	9,082	10,838
Total	111,835	120,828	[4]74,577	84,615	92,528
Capability utilization[5] percent	72.8	78.3	48.4	56.2	68.4
New shipments of steel mill products	83,853	88,450	61,567	67,584	73,740
Finished steel annual average composite price cents per pound[1]	21.655	24.224	25.271	26.190	27.313
Exports of major iron and steel products[2]	4,729	3,557	2,367	1,589	1,413
Imports of major iron and steel products[2]	16,355	20,818	17,385	17,964	27,488
World production:					
Pig iron	[r]566,650	[r]553,632	504,352	[p]510,506	[e]539,216
Raw steel (ingots and castings)	[r]789,528	[r]779,625	709,927	[p]730,291	[e]778,928

[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 40 steel operations to which a survey request was sent, 93% responded, representing 91% of the total pig iron production shown in table 1. Production for nonrespondents was estimated using data from prior year reports and from published information.

Legislation and Government Programs.—Several legal issues were settled to allow the iron and steel industry, as well as other industries, to use "bubble" plans to reduce the cost of achieving pollution control standards. Under a bubble plan, total emissions of a pollutant from an entire plant are regulated rather than from each source in the plant. The owner is allowed to choose the least costly means to achieve control for the entire plant even if emissions for particular sources exceed source standards. In one case, the U.S. Supreme Court upheld the use of bubble plans for air pollution in geographical areas that have not yet attained clean air standards. The Environmental Protection Agency (EPA) had approved such plans for steel companies beginning in 1981. The EPA also issued rules for bubble plans for control of water pollution from iron and steel plants. In a compromise that settled lawsuits by an environmental group and by steel companies, the new rules require that total emissions under the bubble plan of toxic and "conventional" (nontoxic) pollutants be reduced 15% and 10%, respectively, below the quantities permitted under point source rules.

The EPA was studying stronger regulations for certain coke oven emissions that were suspected of being dangerous to public health. New rules were proposed for benzene emissions from coke-byproduct recovery plants. Those rules were estimated to cost owners of coke plants about $24 million for capital costs.

An omnibus trade law contained several sections specific to the iron and steel industry. The law gave the President authority to enforce bilateral steel trade agreements negotiated with exporting countries, but required that steel companies with annual raw steel production over 1.5 million short tons reinvest in the steel industry substantially all of their net cash flow from steel operations. In addition, they were required to spend 1% of net cash flow on retraining for laid-off steelworkers. The law also required country-of-origin markings on all imported iron and steel pipe and fittings.

DOMESTIC PRODUCTION

Raw steel production and steel shipments increased again in 1984 recovering from the very low levels of 1982. However, raw steel production remained below 93 million tons for the third straight year. As in 1983, raw steel production increased early in the year but declined in the second half. Capability utilization, as reported by the American Iron and Steel Institute (AISI), exceeded 80% in April and May but dropped below 60% in the last quarter. AISI reduced its estimate of domestic raw steel capability to 135.3 million tons in 1984 compared with 150.6 million tons in 1983.

Although production in basic oxygen furnaces (BOF) was little changed, production in electric furnaces increased to near record-high levels. Despite a long-term decline, production in open-hearth furnaces also increased significantly. Uncertain markets and relatively low-priced scrap favored the use of the more flexible open-hearth and electric furnaces rather than restarting idle blast furnaces to increase BOF production. Open-hearth furnaces, BOF's, and electric furnaces produced 9.0%, 57.1%, and 33.9%, respectively, of domestic raw steel. Several new continuous casters began operation, and the percentage of steel that was continuously cast rose to 39.6 from 32.1 in 1983.

Total shipments increased about 9% compared with those of 1983, but gains in shipments to various industries were uneven. After large increases in 1983, shipments to the automotive, appliance, and construction industry were little changed in 1984. Shipments to the machinery and industrial equipment industry increased 18% as the economic recovery led to increased capital investment. However, shipments for machinery and equipment for the depressed agricultural sector continued to decline. After 2 years of steep decline, shipments to the oil and gas industry increased 61% after large excess inventories were worked off. However, these shipments were still less than one-third of those in either 1980 or 1981.

Domestic shipments of ferrous castings increased 16% compared with those in 1983, according to U.S. Department of Commerce data. Steel castings reversed a decline that had continued in 1983 despite the overall recovery. Shipments included 8.01 million tons of gray iron, 2.61 million tons of ductile iron, 0.36 million tons of malleable iron, and 0.96 million tons of steel castings.

Despite higher shipments, continued low operating rates plus strong price competition prevented many steel companies from operating profitably. Of the five largest steel companies, which produce over one-half of domestic steel, only one was profitable in 1984. The industry continued to reduce costs by closing unneeded or inefficient capacity and by trying to raise productivity. Although production increased, total annual average industry employment reported by AISI declined from 243,000 in 1983 to 236,000 in 1984. Annual average hourly employment increased slightly from 1983 to 1984, but by December both hourly and salaried employment were at record lows. AISI reported that average employment costs for hourly employees declined slightly to $21.298 per hour for wages and benefits.

The Jones & Laughlin Steel Corp. (J&L), a subsidiary of LTV Corp., and Republic Steel Corp. merged to form the LTV Steel Co. To overcome antitrust objections from the U.S. Department of Justice, the companies agreed to sell the integrated steel mill at Gadsden, AL, and the stainless sheet finishing mill at Massillon, OH. By yearend, the Massillon plant was sold to CDH Metals Inc., owner of steel distribution centers. The Gadsden plant was spun off as an independent Gulf States Steel Corp. but a buyer was not immediately found. The new LTV Steel was the second largest domestic steel producer with a capacity of about 24 million tons per year of raw steel. However, capacity was expected to be reduced to about 19 million tons within a few years as operations from the two companies were consolidated.

United States Steel Corp. (USS) proposed buying the National Steel Corp. subsidiary of National Intergroup Inc. However, the deal was canceled because of antitrust objections. Later, however, National Intergroup sold a 50% interest in National Steel to Nippon Kokan KK, Japan's fourth largest steel company.

Another Japanese steel company, Nisshin Steel Corp., bought a 10% interest in Wheeling-Pittsburgh Steel Corp. (W-P) and planned a joint venture with W-P to build a $40 million steel sheet coating plant at Follansbee, WV, within 2 years.

USS completed a major consolidation of its operations and reduced its raw steel capacity about 20%. Closures affected various blast furnaces, BOF's, and rolling mills, and USS eliminated wire and rail from its product lines. A foundry at Johnstown, PA, which produced cast rolls, was to be closed but was instead sold to a new company, Johnstown Corp. The company was set up with the aid of a $4 million Federal urban development grant and $1 million loan from Pennsylvania. USS restarted ironmaking and steelmaking at its Fairfield, AL, plant after a 2-year shutdown. A new bloom caster at the mill was being built to supply blooms to the 600,000-ton-per-year seamless pipe mill opened at Fairfield in 1983. A new slab caster was also planned.

Rolling mills at the old Kaiser Steel Corp. plant in Fontana, CA, were restarted to roll imported slab into finished steel. The plant was bought by a new company, California Steel Industries Inc., which is owned 50% by a U.S. investor, and 25% each by Cia. Vale do Rio Doce (CVRD) of Brazil and Kawasaki Steel Corp. of Japan. CVRD and Kawasaki were also part owners of the new Cia. Siderúrgica de Tubarão plant in Brazil that was supplying much of California Steel's slab needs.

The steel industry began major additions to galvanizing capacity, largely in response to the automobile industry's need for better corrosion resistance. Most of the new capacity was for electrogalvanizing, which provides a better surface appearance than hot-dip galvanized. Bethlehem Steel Corp. was converting a 48-inch electrotinning line at Burns Harbor, IN, to start up in 1985. Other companies and partnerships were building new 72-inch wide electrogalvanizing lines intended to start up in 1986 in time for the 1987 automobile model year. These lines included a $50 million, 400,000-ton-per-year line at the Middletown, OH, plant of Armco Inc., and a $70 million, 400,000-ton-per-year line at the Ecorse, MI, plant of National Steel's Great Lakes Steel Div. Bethlehem Steel, Inland Steel Co., and Pre-Finish Metals Inc. were to jointly build an $80 million, 400,000-ton-per-year line at Pre-Finish Metals' Walbridge, OH, plant. USS and the Rouge Steel Co., a subsidiary of Ford Motor Co., formed the Double Eagle Steel Coating Co. to build a 560,000- to 700,000-ton-per-year line at Dearborn, MI. LTV Steel was to hold a 60% interest in a 400,000-ton-per-year joint venture line with Sumitomo Metal Industries Ltd. of Japan. Meanwhile, Metaltech Investments Inc., a new company, planned to reopen a hot-dip galvanizing line in Pittsburgh, PA, that was closed by J&L in 1981.

Integrated steel mills continued to add continuous casting capacity. Bethlehem started an $85 million caster to supply billets to its Steelton, PA, rail mill. Slab casters were planned to start up in 1986 at Burns Harbor, IN, and Sparrows Point, MD. These two casters will add 5.1 million tons per year of capacity and give Bethlehem the ability to continuously cast 90% of its production. Rouge Steel ordered a two-strand variable width slab caster for its plant in Dearborn, MI. The 1.8-million-ton-per-year caster will allow Rouge Steel to continuously cast about one-half of its production.

Specialty steel companies were expanding their capabilities in 1984. Babcock & Wilcox Co. completed a new electric-furnace melt shop at Koppel, PA. The $80 million shop includes an ultrahigh-power furnace, a ladle metallurgy station, and a four-strand billet caster and added 300,000 tons per year of raw steel capacity. Quanex Corp. started production at its 280,000-ton-per-year specialty bar mill in Fort Smith, AR. Timken Co. was continuing construction of a $500 million greenfield steel plant at Canton, OH. The plant will be able to produce about 500,000 tons of raw steel per year from a 106-megavolt-ampere, 160-ton electric furnace. The plant will use ladle refining and bottom poured ingots to produce special-quality steels. Allegheny Ludlum Steel Corp. bought the Lockport, NY, plant of the bankrupt Guterl Special Steel Corp. The plant includes vacuum furnaces and electroslag furnaces that Allegheny lacks in its other specialty steel plants. Ellwood Uddeholm Steel Co. will convert a closed foundry in Ellwood City, PA, to melt and cast bottom-poured forging ingots. A 35-ton electric furnace and vacuum ladle furnaces will be installed.

Two companies were preparing to build minimills to produce seamless pipe. National Tube Co., formerly York-Hanover Seamless Tube Inc., planned to begin construction in early 1985 on a 250,000-ton-per-year plant in Pine Bluff, AR. Tubular Corp. of America planned a $350 million, 450,000-ton-per-year mill in Muskogee, OK, where the company has a tube finishing plant.

Several minimills were expanding or adding equipment. New Jersey Steel Corp., Sayerville, NJ, planned to increase its melting capacity from 240,000 to 400,000 tons per year before the end of 1986. Improvements were to include a new electric furnace and scrap preheating equipment. Continental Steel Corp., Kokomo, IN, installed a used rod mill bought from USS and ordered an eight-strand continuous caster. Raritan River Steel Co., Perth Amboy, NJ, prepared to increase the speed of its rod mill by about 25% and planned to modify its electric furnace for greater capability in 1985. A continuous caster was also being installed by Thomas Steel Corp. in Lemont, IL.

Two unusual minimill projects were started. Ground was broken for a 600,000-ton-per-year coiled plate mill by Tuscaloosa Steel Corp., Tuscaloosa, AL. At least initially, the mill was to roll purchased semifinished slab. Connecticut Steel Corp., controlled by Korf KG, was to convert the former Yale Steel Corp. mill in Wallingford, CT, to a 200,000-ton-per-year micromill. The plant was to use a Korf Energy Optimizing Furnace (EOF). The EOF, which was developed and has been used in Brazil, uses pulverized coal and oxygen for fuel and is capable of melting a 100%-scrap charge.

Hunt Steel Co., Youngstown, OH, filed for bankruptcy. The company installed two electric furnaces, a continuous caster, and a pipe mill in a building of the old Brier Hill works in Youngstown, but ran into financial problems during startup. Meanwhile, Phoenix Steel Corp., which entered bankruptcy in 1983, continued to operate while searching for new financing. The company closed the two open-hearth furnaces at its Phoenixville, PA, plant.

Bethlehem sold its Seattle, WA, electric-furnace steel mill to CEM Associates. Bethlehem had announced that the plant would be closed unless a buyer could be found.

Materials Used in Ironmaking.—Domestic pellets charged to blast furnaces in 1984 totaled 48.8 million tons, and sinter charged amounted to 18.9 million tons. Pellets and other agglomerates from foreign sources amounted to 9.9 million tons. A total of 11.8 million tons of iron ore was consumed by agglomerating plants at or near blast furnaces in producing 19.0 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 4.3 million tons of fluxes.

Blast-furnace oxygen consumption totaled 24.3 billion cubic feet according to AISI. Blast furnaces, through tuyere injection, consumed 24.2 billion cubic feet of natural gas; 4.7 billion cubic feet of coke oven gas; 146 million gallons of oil; and 25.4 million gallons of tar, pitch, and miscellaneous fuels.

Materials Used in Steelmaking.—According to AISI, steelmaking furnaces consumed 0.25 million tons of fluorspar, 0.92 million tons of limestone, 4.16 million tons of lime, 0.79 million tons of other fluxes, and 130 billion cubic feet of oxygen. Metalliferous materials consumed in domestic steel furnaces, per ton of raw steel produced, averaged 1,109 pounds of pig iron, 1,046 pounds of scrap, 25 pounds of ferroalloys, and 6 pounds of ore and agglomerates. The comparable figures for 1983 were 1,142 pounds of pig iron, 1,070 pounds of scrap, 25 pounds of ferroalloys, and 5 pounds of ore and agglomerates.

PRICES

The annual average composite price for finished steel in 1984, as reported by Iron Age, was 27.313 cents per pound, up 4.3% from the average price in 1983. However, much of that increase reflects price increases in the second half of 1983. From the beginning to the end of 1984, the composite price increased only from 26.822 cents to 27.582 cents per pound, and prices for many products remained unchanged. The price for special-quality bars was increased 1.25 cents per pound in July. The composite price for pig iron remained unchanged since 1982 at $213 per short ton.

Most steel continued to be sold at a discount from list price because of strong competition among importers and domestic producers in a relatively weak market. Domestic integrated producers increased their transaction prices, especially on sheet and strip, early in the year, but after midyear they were forced to again reduce prices because of lower expectations for sales and because of abundant imports. Reported discounts of about 20% were common through the year.

Most minimill products such as merchant bar, wire rod, and reinforcing bar finished the year with slightly higher prices, generally after losing some gains made in the first half of the year.

FOREIGN TRADE

Exports of major iron and steel products from the United States declined for the fourth consecutive year. The strong U.S. dollar made U.S. products relatively expensive in foreign markets. Canada continued to be the most important importing country taking about one-third of U.S. exports. Exports to Mexico increased as Mexico's economy continued to adjust to problems created by the drop in prices of its oil exports. However, exports to most other countries declined.

Imports of iron and steel products increased 53% and took a record-high share of the U.S. market. Imports of steel mill products from Japan, which was again the leading supplier country, increased from 4.2 million in 1983 to 6.6 million tons, and those from Canada increased from 2.4 million to 3.2 million tons. Although imports of many steel mill products from the European Economic Community (EEC) were restricted by negotiated agreements, total imports from the EEC increased from 4.1 to 6.3 million tons. Much of the increase was in products such as pipe and tube and semifinished billets and slabs that were not covered by trade agreements. Among the individual EEC countries, the Federal Republic of Germany supplied 2.5 million tons; France, 1.1 million tons; Belgium-Luxembourg, 0.9 million tons; and Italy, 0.7 million tons. Outside of the EEC, the most important European supplier was Spain whose exports to the United States increased from 0.6 million tons in 1983 to 1.4 million tons. Imports from several important newly industrialized countries continued to increase; 2.2 million tons from the Republic of Korea, 1.5 million tons from Brazil, 0.8 million tons from Mexico, and 0.5 million tons from Venezuela.

The domestic steel industry continued to seek relief from allegedly unfairly traded imports by filing antidumping and countervailing duty complaints against foreign producers. After investigations by the U.S. Department of Commerce and the International Trade Commission (ITC), when required by the statutes, many cases were found in favor of the domestic industry. To avoid penalty tariffs, Brazil, Mexico, and the Republic of South Africa offered to voluntarily restrain their exports. In some of these cases, the U.S. companies withdrew their complaints.

In addition to countervailing duty and antidumping cases against individual foreign steel exporters, a major steel company and the United Steelworkers of America asked for relief under section 201 of the Trade Law of 1984. Under section 201, industries can be provided temporary protection against all foreign imports. In July, the ITC determined that imports were a substantial cause or threat of injury to the domestic industry for five classes of steel mill products and recommended that various types of restraints be applied covering those products. In September, the President decided not to provide relief under section 201, but instead to seek bilateral agreements with exporting countries to limit surges of imports and to prevent imports of unfairly traded steel. In addition, the Government was to initiate cases against unfairly traded steel rather than wait for industry to bring complaints. The objective of the program was to hold imports of finished steel to about 18.5% of the U.S. market. By yearend, at least preliminary voluntary restraint agreements (VRA) had been reached with seven countries, including Japan and the Republic of Korea. Together with the existing agreement with the EEC, the new VRA's restricted imports from countries that supplied about three-quarters of U.S. imports in 1984. Late in the year, the United States and the EEC were negotiating a limit on pipe and tube. In November, the United States embargoed imports of pipe and tube from the EEC for the remainder of the year and said that it would unilaterally set a quota for the EEC at 5.9% of the U.S. market unless agreement could be reached.

WORLD REVIEW

Australia.—Smorgan Consolidated Industries Pty. Ltd. began rolling operations at its new minimill near Melbourne. The mill is the only steelmaker in Australia that is not at least partially owned by The Broken Hill Pty. Co. Ltd. (BHP). The mill uses a 50-ton electric furnace and a bar mill that were bought from U.S. steel companies. A second minimill was to be built near Brisbane with the support of the Queensland government by the Quest Corp. This plant was to have an initial capacity of 110,000 tons per year with a planned expansion to 250,000 tons per year. BHP also proposed to build a bar mill in the Brisbane area with the possible addition of an electric-furnace melt shop later.

Belgium.—The Governments of Belgium and Luxembourg agreed to a 10-year plan to coordinate investments, production, and marketing of the three major steel companies in the two countries. As part of the agreement, state-controlled Cockerill-Sambre SA (CS) was to close a heavy section mill at Charleroi and a 5-year-old wire mill at Liege. In exchange, ARBED SA in Luxembourg would close a hot-strip mill in Dudelange. Together, the companies were to close over 3 million tons per year of rolling capacity. The Belgian Government will also increase its investment in ARBED's subsidiary in northern Belgium, Sidérurgie Maritime SA.

Brazil.—The new Siderúrgica Mendes Junior S.A. electric-furnace mill at Juiz de Fora, Minas Gerais State, started up. The one-furnace melt shop had a capacity of 500,000 tons per year of billets using scrap and pig iron. The plant will also buy billets for its 800,000-ton-per-year rolling mill to produce wire rod and bar.

The integrated Aço Minas Gerais S.A. (Açominas) steel mill near Belo Horizonte, Minas Gerais, was preparing to start up in 1985. The 2.2-million-ton-per-year plant had been delayed because of weak markets and financing. The company was seeking additional financing from equipment suppliers or future customers to complete the project. Production of semifinished billets will begin first while construction of finishing mills is completed. Açominas was part of the State-owned steel group Siderúrgia Brasileira S.A. (Siderbras).

Canada.—Dofasco Inc. planned a $450 million project for its Hamilton, Ontario, works that will permit direct rolling of slabs. The project includes a 2.4-million-ton-per-year slab caster, slab heating equipment, and modifications to the work's No. 2 hot-strip mill. Operation is planned for 1987. Stelco Inc. approved plans to spend $300 million for a slab caster and a billet caster for the Hilton works near Hamilton, Ontario. A second billet caster is planned to be added after 1987 when the two new casters are expected to begin production. Ipsco Inc., Regina, Saskatchewan, ordered a slab caster and reheating furnaces that will allow direct rolling. The caster will be able to handle about 90% of Ipsco's production.

QIT-Fer et Titane Inc. planned to build a steel shop at its Sorel, Quebec, ilmenite smelter. The shop was to open in mid-1986 with a BOF, a ladle refining facility, and a continuous billet caster. The plant will process pig iron that is a byproduct of the company's titanium slag production. QIT contracted to supply up to 225,000 tons of high-quality billets for wire rod to Ivaco Inc., Montreal, Quebec. Because of the new billet supply, Ivaco dropped its consideration of building a direct iron smelting plant using Inred technology developed in Sweden.

Canadian steel producers filed complaints against allegedly unfairly traded imports. There was also concern that steel from third countries shipped to the United States through Canada to avoid U.S. trade restrictions would upset relations between the United States and Canada. Unlike all other major suppliers of steel imports to the United States, Canada was not asked to restrain its exports.

China.—With phase one of the Baoshan steel mill nearing completion, China ordered a $430 million hot-strip mill for phase two. The plant will initially have a capacity of 3.3 million tons of raw steel per year, and the capacity will eventually be doubled. The capacity of the Anshan works was to be raised to 9 million tons per year in 1985.

China bought the equipment from a closed electric-furnace steel mill in the United Kingdom and was reportedly interested in other used equipment in Europe, Japan, and the United States.

European Economic Community.—The EEC continued to exercise various forms of control over the steel industries in its member countries including minimum prices and production quotas on certain products, limits on government aid to the industry, and controls on imports.

The EEC industry ministers agreed to extend production quotas, which were to expire at the end of January, until yearend 1985. The production controls together with the system of minimum prices that was instituted at the beginning of 1984 were considered to be responsible for the generally higher sale prices within the EEC.

Although several countries favored an extension for operating subsidies beyond yearend 1984, no extension was approved by the EEC by yearend. Subsidies for investments needed for restructuring, if specifically approved by the EEC, continued to be permitted until yearend 1985. Officially, the EEC held to the goal that all steel companies should be viable without government support or market controls by 1986.

The EEC continued to control imports of steel through bilateral agreements with 15 exporting countries. Trade cases were also brought against allegedly unfairly traded steel.

Negotiations were held with Spain about conditions for Spain's scheduled entry into the EEC. The two sides agreed on a 3-year transition period during which Spanish Government aid to the steel industry would be phased out and exports to other EEC members would be limited.

France.—The French Government announced a 4-year plan that was expected to eliminate about 25,000 of the 90,000 jobs in the French steel industry. Most of the job losses were to be in Lorraine in eastern France where the older plants built to use low-grade local ores now have relatively high costs. The plan includes replacing oxygen furnace capacity with electric furnaces at the Union Sidérurgique du Nord et de l'Est de la France (Usinor) plant at Neuves-Maisons and partial replacement at the plant at Longwy. A wire rod mill at Rombas operated by Société Aciéries et Laminoirs de Lorraine (Sacilor) and the relatively new specialty steel plant at Fos-sur-Mer were to be closed.

The two large state-owned steel companies, Usinor and Sacilor, merged parts of their bar and rod operations into two jointly owned companies, Ascométal and Unimétal.

Usinor and Sacilor continued to take over privately owned steel operations. Usinor took over the heavy plate plants and foundries of Creusot-Loire S.A. when that bankrupt company was liquidated. It also bought the large diameter pipe operation of Vallourec S.A. Vallourec will continue to produce seamless pipes. Sacilor acquired a small bankrupt bar producer, Forges et Laminoirs de Bretagne.

German Democratic Republic.—Steel production was started at a new oxygen furnace shop of VEB Eisenhüttenkombinat Ost (EKO) in Eisenhüttenstadt. The plant had two BOF converters with a capacity of 2.3 million tons per year, a slab caster, and a bloom caster. EKO has produced pig iron at the plant for over 30 years to supply other steelworks.

Germany, Federal Republic of.—After unsuccessful merger negotiations in 1983, several West German steel companies continued to seek partners to help in adjusting to smaller markets and capacity reductions required by the EEC. Two major producers, Krupp Stahl AG and Klöckner Werke AG, planned to merge into a new company with production of about 10 million tons per year. CRA Ltd. of Australia would also invest in the new company and would take a 35% interest. CRA would supply iron ore to the new company and was also interested in technology from the West German firms. The merger would involve the elimination of about 1 million tons per year of raw steel capacity and 3,000 jobs. The merger was dependent on approval from the West German Government and the EEC and on financial aid for restructuring.

India.—The Steel Authority of India Ltd. (SAIL) announced plans to modernize its Durgapur and Rourkela steelworks over the next 5 years. Oxygen furnaces and continuous casting plants are to be added at Durgapur. Rourkela is to receive new coking equipment, the addition of bottom blowing to the mill's oxygen furnaces, and modifications to rolling mills.

Two new 330-ton BOF's and a new blast furnace raised the capacity of SAIL's Bokaro works from 2.8 to 4.4 million tons per year. Construction continued at the new Visakhapatnam steel mill. The plant planned to begin operations with a capacity of 1.3 million tons per year in 1987. New integrated plants at Vijayanagar and Daitari were still planned but could be delayed by lack of funds.

The Sunflag Group, based in London, was licensed to build a 200,000-ton-per-year direct-reduction (DR) based steel mill near Bhandara, Maharashtra. Also, Gwalior Rayon was planning a 440,000-ton-per-year gas-fueled DR plant in Maharashtra. Ipitata Sponge Iron was to begin construction of a 100,000-ton-per-year DR plant at Joda, Orissa. Ipitata is 25% owned by India's largest private steel company, Tata Iron and Steel Co., which developed the coal-fueled process to be used in the new plant.

Indonesia.—Seamless Pipe Indonesia, a joint venture of Bakrie & Brothers of Indonesia and Asia Pipe Investments of Australia, planned to build a 330,000-ton-per-year seamless pipe plant at Cilegon. The $400 million plant will produce steel from DR iron from P.T. Krakatau Steel.

Iran.—Construction was reportedly resumed on a 1.3-million-ton-per-year Midrex DR iron plant at the Ahwaz plant of the National Iranian Steel Industries Corp. Construction had been interrupted by the revolution in Iran. Orders were also issued for four additional Midrex units to produce 2.6 million tons per year at Mobarakeh beginning in 1987.

Italy.—State-owned Nuova Italsider S.p.A. reopened the Bagnoli integrated steel mill near Naples after it had been inactive since 1982 during modernization and the addition of a new hot-strip mill. However, to meet EEC production quotas, Italsider closed a strip mill at Cornigliano near Genoa. To keep blast furnaces and oxygen furnaces at Cornigliano active, Ste. Finanziaria Siderurgica p.A. (Finsider) tried to lease that part of the plant to a group of minimill companies. Those companies, whose costs for electricity and scrap have risen, would shut down their electric furnaces and obtain billets for rolling from the Italsider plant.

Japan.—Japan's major steel companies were consolidating their operations to maintain international competitiveness. Of the six major integrated producers, only one increased capital investment in fiscal year 1984, and only one was expanding any capacity. Overall capital spending was cut 30%. Nippon Steel Corp., Japan's largest steelmaker, approved closure of six facilities and a 3.5% reduction in employment. Raw steel capacity was to be cut from 35 to 30 million tons per year. Japan's electric-furnace steelmakers were also reducing capacity, with the Ministry of International Trade and Industry (MITI) encouraging a reduction of 4.2 million tons per year between July 1983 and March 1987.

Steel imports continued to increase. In some markets, such as plates and hot-rolled coil, imports were reportedly high enough to force some reduction in prices. In response to the rising imports, MITI set a limit on imports of coil and plate that could be imported with preferential tariffs from less developed countries.

Korea, Republic of.—Orders were issued for equipment for a second Pohang Iron and Steel Co. Ltd. (Posco) integrated steel mill, which is being built at Kwang Yang. The first stage, with a 34-foot-diameter blast furnace and two 280-ton BOF's, will have a capacity of 3 million tons per year in 1988. Meanwhile, Posco's Pohang plant capacity was raised to 10.5 million tons per year.

Luxembourg.—The Government of Luxembourg reached an agreement with Belgium to coordinate the activities of ARBED with the steel industry of Belgium (see "Belgium"). The EEC approved about $480 million in state aid to ARBED including an increase of Government ownership from 24.5% to over 30%.

Mexico.—Siderúrgica Lázaro Cárdenas-Las Truchas S.A. (Sicartsa) continued construction on expansion of its plant at Las Truchas, Michoacán, which will increase capacity from 1.2 to 3.4 million tons per year. The expansion includes an HYL DR iron plant, electric furnaces, and a plate mill.

Pakistan.—Pakistan Steel Mills Corp. started a second blast furnace and began production of sheet at its new plant at Bin Qasim. The company ordered a second cold-rolling mill to increase the plant's capacity for black plate and cold-rolled sheet by 600,000 tons per year.

Philippines.—National Steel reportedly will not receive more Government funds for its new Iligan City steelworks. Although orders had been placed with equipment suppliers, the 1.5-million-ton-per-year project will probably be delayed indefinitely.

South Africa, Republic of.—South African Iron and Steel Industrial Corp. Ltd. (Iscor) started production of the world's largest coal-fired DR plant at Vanderbijlpark. The plant's four Lurgi SL/RN kilns have a combined capacity of 660,000 to 800,000 tons per year, depending on the type of ore. At another plant at Pretoria, Iscor planned to reduce the plant's capacity by about one-half when the blast furnaces and open-hearth furnaces are replaced by electric furnaces in 1986 or 1987.

Spain.—Spain proceeded with a restructuring plan to reduce its steel industry capacity by about 2.8 million tons per year of finished product. Between 1980 and 1986, 27,000 jobs will have been eliminated. All steelmaking will be ended at Altos Hornos del Meditarraneo S.A. with only processing of sheet remaining. The plant will retain a cold-rolling mill and build new galvanizing and heat treating lines. Meanwhile, Altos Hornos de Vizcaya S.A. was building a new BOF shop with continuous casting at Baracaldo-Sestao. Empresa Nacional Siderúrgica S.A., the largest steel producer in Spain, received approval to build a new BOF shop in Aviles to replace two old shops.

Sweden.—The Swedish stainless steel industry was restructured by the merger of the four major companies into two. A company, Avesta AB, was formed from Avesta Jernverks AB plus most of the stainless operations of Fagersta AB and Uddeholm AB. Sandvik AB would continue as a producer of seamless tubes and specialty strip and wire. Welded tube was to be produced by a new company jointly owned by Avesta and Sandvik. The stainless melt shop at Fagersta was expected to be closed permanently, probably in 1985.

Taiwan.—China Steel Corp. began an expansion of its plant that will raise capacity from 3.6 to 6.2 million tons per year. The project included a third blast furnace and two 165-ton BOF's. Completion was scheduled for mid-1988.

Turkey.—Cukurova Celik Endüstrisi AS was adding two 80-ton electric furnaces and continuous casting at its plant at Aliaga to raise the plant's capacity from 400,000 to 1.1 million tons per year. Another company, the Habas Group, was planning a minimill with two 30-ton furnaces at Izmir.

U.S.S.R.—The Austrian-Italian-designed Zhlobin minimill started operation in Byelorussia. The plant has two 110-ton electric furnaces and two continuous casters to produce 800,000 tons per year of raw steel.

Startup continued at the Oskol Electro-Metallurgical Combine plant in Kursk. Electric-furnace and continuous-caster operations were started. The four Midrex DR units had a capacity of 1.8 million tons per year.

United Kingdom.—Production at British Steel Corp. (BSC) was restricted by reduced supplies of raw materials caused by a coal miners strike. The miner's union and sympathetic transportation unions allowed some coal and iron ore into the BSC plants to maintain limited production and to prevent damage to coke ovens, and BSC at times used trucks to deliver raw materials to plants blockaded by rail workers.

TECHNOLOGY

Processes were under development to continuously cast thin slabs and thus reduce the rolling needed to produce sheet and strip. The U.S. Department of Energy agreed to provide $30 million over 5 years for pilot plant development of a caster to produce slab less than 1-inch thick based on a twin-belt design used commercially for nonferrous metals by Hazelett Strip-Casting Corp. The prime contractors were Bethlehem and USS under a research partnership. Independently, Allegheny Ludlum announced that it was ready to begin pilot plant tests of a process to cast thin stainless steel strip less than 1/10-inch thick.

New rolling technology was announced to reduce costs or improve quality. A system was described to roll billets using less expensive grooveless rolls. The system used special guides and process control to maintain proper billet shape.[2] Two systems to control flatness as sheet is rolled were described. In one, the axes of opposed sets of rolls were crossed rather than parallel. The angle between the axes could be varied to compensate for roll bending.[3] A second approach used a hollow backup roll that could be inflated by hydraulic pressure to adjust the shape of the roll.[4]

Modified cupolas for melting iron were tested. A 20-megawatt plasma torch was to be fitted in one tuyere of a cupola. The plasma torch was intended to allow better control.[5] The Bureau of Mines modified a cupola by inserting a gas-fired melting and/or preheating chamber above the level of the coke bed. The modification increased the melting rate while improving energy efficiency. Ultimately, pulverized coal was to be used in place of gas.[6]

The Bureau of Mines published research on reduced-chromium substitutes for conventional stainless steels.[7] The Bureau also conducted basic research on pickling stainless steel. Better understanding of the process could lead to lower costs, reduced loss of critical materials such as chromium and nickel, and reduced waste disposal problems.[8]

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[1]Physical scientist, Division of Ferrous Metals.
[2]Yanazawa, T., N. Hirai, T. Tanaka, and K. Aoyama. Development of Grooveless Rolling for a Billet Mill. Iron and Steel Eng., v. 61, No. 8, Aug. 1984, pp. 27-32.
[3]Tsukamoto, H. and H. Matsumoto. Shape and Crown Control Mill—Crossed Roll System. Iron and Steel Eng., v. 61, No. 10, Oct. 1984, pp. 26-33.
[4]Swanson, K. R., J. A. Grohowski, P. J. Erspamer, and W. G. Eckert. Application of the Blaw-Knox Inflatable Crown Roll to a 2-Stand Temper Mill. Iron and Steel Eng., v. 62, No. 4, Apr. 1985, pp. 21-26.
[5]33 Metal Producing. Plasma: An On/Off Switch for Tomorrow's Foundry. V. 22, No. 5, May 1984, pp. 51-53.
[6]Spironello, V. R. Evaluaton of a Gas-Assisted Cupola. BuMines RI 8891, 1984, 16 pp.
[7]Glenn, M. L., and D. E. Larson. Reduced-Chromium Stainless Steel Substitutes Containing Silicon and Aluminum. BuMines RI 8918, 1984, 13 pp.
[8]Covino, B. S., Jr., J. V. Scalera, and P. M. Fabis. Pickling of Stainless Steels—A Review. BuMines IC 8985, 1984, 15 pp.

Table 2.—Pig iron produced and shipped in the United States in 1984, 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
Illinois	3,042	3,042	$520,961	$171.26
Indiana	15,908	15,909	2,870,713	180.45
Michigan	5,055	5,054	866,513	171.45
Ohio	9,593	9,800	2,063,377	210.54
Pennsylvania	7,603	7,577	1,589,007	209.71
Alabama, Kentucky, Maryland, New York	6,440	6,460	1,375,304	212.90
Texas, Utah, West Virginia	4,323	4,321	908,309	210.21
Total[1] or average	51,961	52,164	10,194,185	195.43

[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	1983[1]	1984[2]
Brazil	12	679
Canada	2,185	256
Venezuela	1,157	994
Other countries	99	114
Total	3,453	2,043

[1]Excludes 8,862,921 tons used in making agglomerates.
[2]Excludes 10,054,084 tons used in making agglomerates.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grade[1]

Grade	1983			1984		
	Quantity (thousand short tons)	Value		Quantity (thousand short tons)	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Foundry	123	$25,969	$211.13	W	W	W
Basic	47,915	9,835,227	205.26	51,526	$10,065,652	$195.35
All other (not ferroalloys)	1,043	209,747	201.10	637	128,533	201.78
Total or average	49,081	10,070,943	205.19	[2]52,164	10,194,185	195.43

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	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
1983:																
Illinois	--	--	4,325	4,316	353	123	4,791	1,598	421	2,743	1.573	0.129	0.045	1.747	0.583	0.153
Indiana and Michigan	106	14	32,727	32,365	1,383	615	34,362	10,816	577	20,828	1.554	.066	.030	1.650	.519	.028
Ohio	98	1,970	13,384	15,326	433	693	16,452	5,225	887	9,291	1.650	.047	.075	1.771	.562	.095
Pennsylvania	292	1,207	9,755	11,107	452	116	11,676	3,773	632	6,962	1.595	.065	.017	1.667	.542	.091
California, Texas, Utah	540	20	2,316	2,850	105	69	3,024	955	211	1,634	1.744	.064	.042	1.851	.584	.129
Alabama, Kentucky, Maryland, New York, West Virginia	35	242	11,109	11,249	246	47	11,543	3,457	254	7,312	1.538	.034	.006	1.579	.473	.035
Total or average	1,071	3,453	73,616	77,213	2,972	1,663	81,848	25,824	[5]2,982	48,770	1.583	.061	.034	1.678	.530	.061
1984:																
Illinois	1	--	4,296	4,287	412	133	4,832	1,774	504	3,042	1.409	.135	.044	1.588	.583	.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	[6]3,214	51,961	1.525	.037	.034	1.596	.539	.062

[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: 1,362 thousand tons limestone, less than 500 tons burnt lime, 1,436 thousand tons dolomite, and 183 thousand tons other fluxes, excluding 2,175 thousand tons limestone, 15 thousand tons burnt lime, 1,869 thousand tons dolomite, and 21 thousand tons 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: 1,595 thousand tons limestone, less than 500 tons burnt lime, 1,444 thousand tons dolomite, and 173 thousand tons other fluxes, excluding 2,244 thousand tons limestone, 71 thousand tons burnt lime, 1,904 thousand tons dolomite, and 96 thousand tons 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	1983			1984		
	In blast[1]	Out of blast	Total	In blast[1]	Out of blast	Total
Alabama	1	5	6	2	2	4
California	2	2	4	--	--	--
Illinois	4	1	5	4	1	5
Indiana	11	7	18	10	8	18
Kentucky	2	--	2	2	--	2
Maryland	1	3	4	2	2	4
Michigan	6	3	9	6	3	9
New York	1	3	4	--	--	--
Ohio	12	6	18	11	10	21
Pennsylvania	9	12	21	8	14	22
Texas	--	2	2	1	--	1
Utah	1	2	3	2	1	3
West Virginia	2	2	4	3	1	4
Total	52	48	100	51	42	93

[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
1980	13,054	67,615	31,166	111,835
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

[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			
1980	45	244	111	50	65,543	1,603	61,930
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	1,161	48,415

[1]Basic oxygen converter, open-hearth, and electric furnace.
[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	1982		1983		1984	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Basic oxygen converter	38,553	86.8	44,330	88.5	45,551	85.6
Open-hearth	3,635	8.2	3,918	7.8	5,720	10.7
Electric	496	1.1	341	.7	368	.7
Cupola	481	1.1	425	.8	469	.9
Air and other furnaces[1]	141	.3	91	.2	92	.2
Direct castings[2]	1,102	2.5	965	1.9	1,002	1.9
Total[3]	44,409	100.0	50,070	100.0	53,202	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	1983	1984
Arkansas	1	1
Connecticut	5	5
Georgia	1	1
Illinois	3,285	2,884
Indiana	16,507	16,206
Iowa	27	30
Kansas	3	3
Maine	(2)	(2)
Massachusetts	13	16
Michigan	4,535	5,179
Minnesota	20	28
Missouri	5	6
New Jersey	2	2
New York	886	22
Ohio	9,528	10,309
Oklahoma	10	11
Pennsylvania	7,077	7,701
Texas	65	646
Virginia	16	14
Wisconsin	41	46
Undistributed[3]	8,043	10,092
Total	50,070	53,202

[1]Includes molten pig iron used for ingot molds and direct castings.
[2]Less than 1/2 unit.
[3]Includes Alabama, California, Colorado, Delaware, Florida, Kentucky, Maryland, New Hampshire, North Carolina, Oregon, Rhode Island, South Carolina, Tennessee, Utah, Washington, and West Virginia.

Table 11.—U.S. exports of major iron and steel products

Product	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	362,299	$82,066	102,756	$27,638	73,536	$19,165
Wire rods	25,150	13,374	6,346	7,246	8,744	10,187
Structural shapes, 3 inches and over	56,399	36,992	47,024	30,478	29,049	18,366
Structural shapes, under 3 inches	9,580	11,761	21,801	36,047	11,231	9,655
Sheet piling	5,623	3,406	2,097	11,527	3,355	2,655
Plates	121,930	89,111	101,982	61,875	88,185	54,162
Rails and track accessories	36,490	25,256	18,516	15,833	15,225	11,370
Wheels and axles	2,711	11,501	1,558	9,040	3,854	13,377
Concrete reinforcing bars	114,740	29,705	34,528	9,340	9,889	4,678
Bars, carbon, hot-rolled	31,014	18,083	36,592	17,759	32,162	16,377
Bars, alloy, hot-rolled	48,262	41,303	53,992	41,626	49,969	39,773
Bars, cold-finished	17,400	25,471	21,567	24,954	28,125	24,796
Hollow drill steel	1,447	3,523	1,378	3,279	2,123	2,920
Pipe and tubing	430,630	791,252	257,967	404,319	207,428	325,800
Wire	26,269	49,539	20,349	37,689	19,440	37,747
Nails, brads, spikes, staples	7,089	24,232	6,916	24,326	7,161	24,199
Blackplate	71,888	17,897	60,929	13,704	38,781	9,779
Tinplate and terneplate	240,127	118,870	188,628	83,826	138,764	70,149
Sheets, hot-rolled	62,191	42,744	42,544	32,934	51,580	39,220
Sheets, cold-rolled	50,770	52,198	50,431	47,126	51,202	46,236
Strip, hot-rolled	27,488	18,709	16,428	16,308	11,563	14,254
Strip, cold-rolled	25,421	42,991	26,152	42,255	26,182	46,696
Plates, sheets, strip, galvanized, coated or clad	67,395	51,447	78,142	55,665	69,736	62,450
Total	1,842,313	1,601,431	1,198,623	1,054,794	977,284	904,011
Other steel products:						
Plates and sheets, fabricated	23,216	52,335	21,990	39,922	11,371	22,955
Structural shapes, fabricated	119,303	268,678	65,803	133,037	86,854	141,849
Architectural and ornamental work	5,578	14,609	3,643	15,178	2,207	9,186
Sashes and frames	10,137	39,514	9,197	38,069	8,986	31,894
Pipe and tube fittings	41,578	293,573	22,831	141,646	11,426	98,915
Pipe and tubing, coated or lined	16,037	21,630	13,025	17,533	7,778	12,535
Bolts and nuts	70,601	114,964	72,913	106,242	86,897	127,017
Forgings	46,139	89,277	33,048	55,132	41,739	63,515
Cast-steel rolls	3,206	10,987	977	2,347	1,438	2,415
Railway track material	6,611	7,544	3,215	4,788	2,550	3,661
Total	342,406	913,111	246,642	553,894	261,246	513,942
Iron products:						
Cast-iron pipes, tubes, fittings	113,185	160,091	85,513	128,523	51,682	99,252
Iron castings	69,548	59,522	58,344	45,866	122,375	110,084
Total	182,733	219,613	143,857	174,389	174,057	209,336
Grand total	2,367,452	2,734,155	1,589,122	1,783,077	1,412,587	1,627,289

Table 12.—U.S. imports for consumption of pig iron, by country

Country	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Australia	8,506	$527	--	--	--	--
Belgium-Luxembourg	1,202	200	915	$129	--	--
Brazil	146,413	16,313	135,955	14,413	421,176	$43,703
Canada	127,337	26,995	94,802	16,004	171,708	29,638
China	17,116	1,560	--	--	--	--
France	1,624	329	772	101	1,704	253
South Africa, Republic of	19,445	2,966	9,650	1,259	31,489	4,593
Sweden	--	--	--	--	--	--
Venezuela	--	--	--	--	54,274	3,815
Other	57	49	20	10	22,004	1,983
Total[1]	321,702	48,940	242,114	31,917	702,355	83,985

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

Table 13.—U.S. imports for consumption of major iron and steel products

Product	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Steel mill products:						
Ingots, blooms, billets, slabs, sheet bars	716,588	$180,612	822,483	$176,621	1,515,734	$332,664
Wire rods	961,768	366,267	1,188,918	392,317	1,594,437	540,315
Structural shapes, 3 inches and over	1,483,486	544,550	1,489,226	425,557	2,075,027	587,961
Structural shapes, under 3 inches	59,711	21,732	88,288	29,298	174,787	60,846
Sheet piling	114,864	50,810	69,050	26,744	80,709	30,862
Plates	1,619,538	565,989	1,393,378	358,945	1,880,297	539,927
Rails and track accessories	320,353	135,445	168,933	56,528	350,300	113,724
Wheels and axles	19,936	18,682	6,500	7,030	23,591	18,184
Concrete reinforcing bars	51,675	12,700	208,304	39,126	434,147	87,581
Bars, carbon, hot-rolled	297,493	118,733	322,518	109,504	540,302	184,926
Bars, alloy, hot-rolled	164,414	112,848	139,806	87,275	216,421	118,633
Bars, cold-finished	218,317	211,012	204,575	160,887	338,754	213,840
Hollow drill steel	1,462	1,761	--	--	1,811	2,310
Welded pipe and tubing	2,124,745	1,124,642	1,728,716	595,175	2,753,108	1,051,932
Other pipe and tubing	2,984,566	3,021,885	1,124,266	650,002	2,676,358	1,394,148
Wire	346,520	271,039	478,776	316,761	702,493	472,053
Wire nails	264,388	140,491	374,039	188,544	458,326	235,270
Wire fencing, galvanized	8,457	5,825	10,762	6,991	12,276	7,591
Blackplate	119,395	50,482	170,420	66,939	278,003	116,068
Tinplate and terneplate	218,394	134,718	293,819	168,413	373,277	203,147
Sheets, hot-rolled	1,355,024	421,498	2,030,684	545,735	2,690,721	782,510
Sheets, cold-rolled	1,706,708	747,464	2,425,167	886,228	3,672,456	1,499,599
Sheets, coated (including galvanized)	1,227,867	553,108	2,059,275	863,471	2,899,825	1,319,928
Strip, carbon, hot-rolled	21,655	9,309	32,530	11,491	79,592	25,373
Strip, carbon, cold-rolled	49,209	45,368	66,090	55,159	145,333	95,717
Strip, alloy, hot- or cold-rolled (including stainless)	22,375	46,156	27,798	47,447	51,604	86,441
Plates, sheets, strip, electrolytically coated (other than with tin, lead, or zinc)	57,384	34,006	110,067	61,448	149,624	79,656
Total	16,536,292	8,947,132	17,034,388	6,333,636	26,169,313	10,201,206
Other steel products:						
Plates, sheets, strip, fabricated	4,016	5,447	5,536	4,430	13,085	11,805
Structural shapes, fabricated	146,596	139,589	206,296	155,308	235,950	136,717
Pipe fittings	112,680	192,912	71,161	92,146	105,095	136,475
Rigid conduit	105	488,282	282	2,187	373	15,826
Bale ties made from strip	1,197	1,028	643	546	675	510
Nails, brads, spikes, staples, tacks, not of wire	12,135	10,013	40,670	46,977	48,662	61,217
Bolts, nuts, rivets, washers, etc.	422,151	471,710	450,707	473,157	684,761	753,707
Forgings	45,910	33,897	28,800	20,730	57,267	38,997
Total	744,790	1,342,878	804,095	795,481	1,145,868	1,155,254
Iron products:						
Cast-iron pipes, tubes, fittings	28,565	31,517	30,629	32,155	40,471	42,211
Iron castings	75,817	72,768	94,742	76,693	132,078	96,675
Total	104,382	104,285	125,371	108,848	172,549	138,886
Grand total	17,385,464	10,394,295	17,963,854	7,237,965	27,487,730	11,495,346

Table 14.—Pig iron: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Algeria	737	989	992	[e]1,000	1,100
Argentina[3]	1,976	[r]1,896	2,090	2,052	[4]2,007
Australia	[r]7,671	7,529	6,565	5,561	[4]5,873
Austria	3,842	3,832	3,434	3,660	[4]4,128
Belgium	11,614	10,724	8,638	8,849	[4]9,886
Brazil[3]	[r]13,983	[r]11,901	11,935	14,269	14,900
Bulgaria	1,683	1,667	1,717	1,789	1,700
Burma	--	4	14	17	[4]9
Canada	[r]12,327	10,740	8,818	9,443	[4]10,630
Chile	714	642	500	595	[4]654
China	41,910	37,666	39,171	41,204	[4]44,070
Colombia	308	257	271	266	300

See footnotes at end of table.

Table 14.—Pig iron: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Czechoslovakia	10,824	10,354	10,500	10,434	[4]10,539
Egypt	[r][e]280	[r][e]240	125	216	230
Finland	2,226	2,180	2,157	2,092	[4]2,253
France	[r]21,119	[r]19,035	16,569	15,274	[4]16,239
German Democratic Republic[5]	2,709	2,691	2,369	2,433	2,400
Germany, Federal Republic of	37,339	35,137	30,447	29,319	[4]33,293
Greece[e]	[4]334	[r]400	330	330	330
Hungary	2,441	2,417	2,404	2,256	[4]2,310
India	9,362	10,443	10,582	10,016	10,300
Iran[e]	900	600	700	800	800
Italy	13,392	[r]13,514	12,717	11,399	[4]12,818
Japan	95,946	[r]88,238	85,603	80,398	[4]88,629
Korea, North[e]	[r]6,000	[r]5,500	[r]5,800	[r]6,100	6,300
Korea, Republic of	6,148	8,739	9,309	8,845	[4]9,660
Luxembourg[5]	3,933	3,185	2,852	2,553	[4]3,051
Mexico[3]	5,815	[r]6,011	5,625	5,549	[4]5,895
Morocco[e]	13	13	13	17	17
Netherlands	4,771	5,071	3,987	4,131	[4]5,430
New Zealand[e] [3]	148	165	165	[r]170	190
Norway	675	626	532	623	600
Pakistan	--	[r]422	[r][e]600	[r][e]600	900
Peru[3]	[r]326	[r]266	225	154	[4]68
Poland	[r]12,788	[r]10,307	9,395	10,710	10,700
Portugal	385	452	237	391	[4]411
Romania	9,934	9,763	9,521	9,028	8,900
South Africa, Republic of	8,284	8,119	7,454	5,746	[4]5,793
Spain	7,408	7,080	6,604	5,950	[4]5,884
Sweden[3]	[r]2,825	[r]2,131	2,076	2,325	[4]2,441
Switzerland[e]	32	[4]33	39	33	28
Taiwan	[r]1,900	[r]1,776	2,971	3,764	[4]3,704
Thailand	20	11	7	([6])	--
Trinidad and Tobago[3]	24	198	261	313	[4]263
Tunisia	166	176	[e]110	[e]165	165
Turkey	2,249	2,154	2,567	3,255	3,300
U.S.S.R	[r]117,460	[r]118,141	116,955	120,923	121,000
United Kingdom	7,068	10,439	9,179	10,447	[4]10,540
United States	68,699	73,755	43,342	48,770	[4]51,961
Venezuela[3]	2,609	2,458	2,598	2,476	2,700
Yugoslavia	2,673	3,105	2,980	3,136	[4]3,147
Zimbabwe[e]	660	440	[r]300	[r]660	770
Total	[r]566,650	[r]553,632	504,352	510,506	539,216

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

[1]Table excludes ferroalloy production except where otherwise noted. Table includes data available through June 18, 1985.

[2]In addition to the countries listed, Vietnam and Zaire have facilities to produce pig iron and may have produced limited quantities during 1980-84, 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]	1980	1981	1982	1983[p]	1984[e]
Algeria	423	575	[e]630	[e]660	770
Angola[e]	11	11	11	11	11
Argentina	[r]2,685	[r]2,784	3,211	3,244	[4]2,890
Australia	8,371	8,416	7,023	6,200	[4]6,845
Austria	5,097	5,132	4,694	4,862	[4]5,366
Bangladesh[5]	152	153	120	52	[4]80
Belgium	[r]13,696	[r]13,645	10,931	11,196	[4]12,447
Brazil	16,908	14,584	14,319	16,159	[4]20,266
Bulgaria	2,830	2,738	2,848	3,121	3,100
Canada	17,512	16,326	12,965	14,140	[4]16,220
Chile	776	710	542	681	[4]758
China	40,918	39,242	40,962	[e]44,040	47,800
Colombia	[r]463	[r]443	466	531	[4]550

See footnotes at end of table.

Table 15.—Raw steel:[1] World production, by country[2] —Continued

(Thousand short tons)

Country[3]	1980	1981	1982	1983[p]	1984[e]
Cuba	335	364	332	401	400
Czechoslovakia	16,783	16,832	16,526	16,561	[4]16,348
Denmark	809	675	617	543	[4]613
Ecuador	[r]19	[r]31	31	25	19
Egypt	882	992	529	138	220
El Salvador[e]	15	11	8	[r]17	17
Finland	2,766	2,676	2,661	2,663	[4]2,903
France	25,547	23,433	20,300	19,426	[4]20,939
German Democratic Republic	8,056	8,231	7,902	7,958	8,300
Germany, Federal Republic of	48,323	45,867	39,551	39,384	[4]43,419
Greece	1,031	1,002	1,003	[e]1,010	1,010
Hong Kong[e]	130	130	130	130	130
Hungary	4,149	[r]4,016	4,081	3,986	[4]4,134
India	[r e]10,387	11,442	11,811	11,359	11,116
Indonesia	397	551	551	882	1,100
Iran[e]	1,300	1,300	1,300	1,500	1,300
Iraq[e]	287	50	50	50	33
Ireland	2	35	61	[r e]150	150
Israel	127	126	[e]100	165	220
Italy	29,212	27,312	26,434	23,891	[4]26,484
Japan	122,792	112,078	109,733	107,121	[4]116,389
Jordan	95	149	154	[e]150	150
Kenya[e]	11	11	11	11	NA
Korea, North[e]	[r]6,400	[r]6,100	[r]6,400	[r]6,700	7,200
Korea, Republic of	9,434	11,854	12,955	13,134	[4]14,366
Luxembourg	5,092	4,178	3,869	3,631	[4]4,395
Malaysia[e]	230	230	230	[r]390	390
Mexico	7,888	[r]8,447	7,778	7,692	[4]8,315
Morocco[e]	7	7	7	7	7
Netherlands	5,811	6,032	4,791	4,935	[4]6,228
New Zealand	239	255	278	257	[4]315
Nigeria[e]	17	17	110	150	150
Norway	941	935	847	916	1,000
Pakistan[e]	[r]390	[r]390	[r]390	[r]600	770
Peru	493	401	302	330	370
Philippines	364	386	386	220	280
Poland	21,479	17,327	16,309	17,897	18,200
Portugal	720	607	556	734	[4]757
Qatar	485	499	524	526	538
Romania	14,523	14,358	14,391	13,881	14,300
Saudi Arabia[e]	55	80	[r]77	[4]303	[4]928
Singapore	375	386	386	386	390
South Africa, Republic of	9,996	9,925	9,117	7,721	[4]8,628
Spain	13,874	14,233	14,506	14,034	[4]14,864
Sweden	4,665	4,150	4,299	4,641	[4]5,254
Switzerland	1,024	1,065	1,047	[e]1,050	990
Syria[e]	120	120	[4]109	[r]90	90
Taiwan	3,767	3,465	4,495	5,530	5,500
Thailand	496	331	344	269	280
Trinidad and Tobago	3	58	202	231	[4]206
Tunisia	196	196	[e]121	[e]182	180
Turkey	2,795	2,605	3,081	3,904	3,900
U.S.S.R	163,077	163,632	162,221	168,118	170,000
United Kingdom	12,432	17,170	15,106	16,519	[4]16,668
United States	111,835	120,828	74,577	84,615	[4]92,528
Uruguay	[r]19	[r]17	31	51	45
Venezuela	1,967	2,003	2,531	2,820	2,850
Vietnam[e]	130	120	130	110	110
Yugoslavia	4,006	4,383	4,244	4,558	[4]4,669
Zimbabwe	886	762	582	741	770
Total	[r]789,528	[r]779,625	709,927	730,291	778,928

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

[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 18, 1985.

[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.

Iron and Steel Scrap

By Franklin D. Cooper[1]

Brokers, dealers, and other outside sources supplied domestic consumers with 34.3 million short tons of all types of ferrous scrap at a delivered value of approximately $2.82 billion, while exporting 9.5 million short tons valued at $918 million. In 1983, domestic consumers received 32.8 million short tons at a delivered value of approximately $2.34 billion, while exports of 7.5 million short tons were valued at $637 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, 69% responded, representing an estimated 85% 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 2% for the manufacturers of pig iron and raw steel and castings, 4% for the manufacturers of steel castings, and 1% 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)

	1980	1981	1982	1983	1984
Stocks, Dec. 31:					
Scrap at consumer plants	8,018	8,118	6,418	5,807	5,261
Pig iron at consumer and supplier plants	889	859	622	345	304
Total	8,907	8,977	7,040	6,152	5,565
Consumption:					
Scrap	83,710	85,097	56,386	61,782	65,702
Pig iron	69,053	75,040	44,409	50,070	53,202
Exports:					
Scrap (excludes rerolling material and ships, boats, and other vessels for scrapping)	11,168	6,415	6,804	7,520	9,498
Value	$1,225,941	$638,644	$610,302	$636,723	$917,981
Imports for consumption:					
Scrap (includes tinplate and terneplate)	582	556	r468	641	572
Value	$61,192	$62,126	r$37,572	$48,219	$46,946

rRevised.

Legislation and Government Programs.—Congress passed the Shipping Act of 1984, Senate bill 38, giving scrap exporters a tariff-filing exemption formerly given only to bulk-cargo shippers. Under the new legislation, exporters will be able to negotiate for more advantageous rates, and shipping terms and conditions. The legislation excluded dismantlers, which were not engaged in waterborne commerce, from current costly and unnecessary provisions. The President signed this legislation, entitled the "Longshore and Harbor Workers' Compensation Amendments of 1984," on September 28.

Luria Bros. and Co. Inc., a major U.S. ferrous scrap processor, asked the Federal Trade Commission to release it from an order imposed in 1963 that prevented the firm from concluding exclusive supplier arrangements with consumers and receiving preferential treatment as a supplier. Luria based its request on the changes in the structure of the scrap industry and Luria's market, which was the original reason for the order. Luria's share of the U.S. ferrous market dropped to 13% in 1982, from a former peak of 35%. Luria's petition noted that the company closed its Port Newark, NJ, export terminal in 1982 and did not own a terminal exclusively for handling and preparing scrap for export.

The International Trade Commission (ITC) published a report, "Competitive Assessment of the U.S. Foundry Industry." The ITC concluded that it was difficult for the foundry industry to pinpoint the causes of its recent decline of activity. The industry disagreed citing unfairly underpriced imports.

Also under section 332 of the Tariff Act, the ITC began an investigation of the impact of imported semifinished steel products on the domestic ferrous scrap industry.

The ITC unanimously approved the acquisition of American Commercial Lines Inc. by CSX Corp., the first merger of a railroad and a bargeline.

Congress amended the Resource Conservation and Recovery Act of 1980, thereby requiring all Federal Government agencies to maximize the procurement of goods produced from recycled materials.

AVAILABLE SUPPLY, CONSUMPTION, AND STOCKS

The ferrous scrap industry supplied 34.3 million short tons of products to all domestic consumers, up 6.7% from 1983, because of a stronger but not generally improved economic situation, which grew at an annual rate of 7.5% above the 1983 rate, while inflation receded to a 3.2% rate. Capital spending on plant and equipment was 6.5% more than in 1983. Inventory investment made only a small contribution to the gross national product (GNP) because the ratio of inventories to final sales of goods was 1.32, below the normal equilibrium of 1.40.

Raw steel production was 92.5 million short tons compared with 84.6 million in 1983 and 74.6 million in 1982. Production in 1984, representing 68.4% of the production capacity, resulted in 73.7 million short tons of shipments.

Steel mills accounted for 74.8% of all scrap received from brokers, dealers, and other outside sources; steel foundries received 3.5%, and iron castings producers and miscellaneous users received 21.7%, including 0.89% or 280,000 short tons for copper-recovery-leaching operations.

The apparent consumption of scrap, in million short tons, comprised 36.1 net receipts, 29.3 home scrap, 0.6 imports, and 0.5 withdrawals from stock for a total of 66.5.

Shipments of ferrous castings comprised 955,000 short tons of steel castings, compared with 729,000 short tons in 1983; and shipments of all ferrous castings totaled 10.9 million short tons, compared with 9.5 million short tons in 1983.

The 1983-84 status of major U.S. manufacturing sectors that were major consumers of iron and steel products was as follows:

Appliances.—In 1984, 35.8 million units were produced, 30% more than in 1983.

Automobiles.—Approximately 10.8 million were sold in 1984, of which about 8.0 million were produced by six U.S. manufacturers.

Castings, iron.—Shipments in 1984 were 10,974,000 short tons compared with 9,513,000 tons in 1983.

Castings, steel.—Shipments were 955,000 short tons in 1984 and 729,000 short tons in 1983.

Durable goods.—The value of 1984 shipments was 13% greater than in 1983.

Farm equipment excluding tractors.—Value of shipments was 10% to 15% more than in 1983.

Materials handling equipment.—Sales in 1984 were $4.5 to $5.0 billion.

Metalworking.—New orders were 8.7% more than in 1983.

Mining equipment.—Sales in 1984 were $83 million, 11% more than in 1983.

Oil country and tubular products.—Shipments in 1984 were 300,000 short tons and 165,000 short tons in 1983.

Railroad freight cars.—Deliveries in 1984 totaled 11,600 compared with 5,127 in 1983.

Shipbuilding.—The value of 1984 contracts was estimated as $530 million.

Steel.—Raw steel production was 92.5 million short tons in 1984 and 84.6 million short tons in 1983.

Steel service centers.—Total shipments in 1984 were 20.5 million short tons (28% of total U.S. shipments), 18.2% greater than in 1983. Service centers were the second largest market for both finished steel products and ferrous castings.

Tractors.—Units sold in 1984 were 1% more than in 1983.

In 1982-84, about 40 steel foundries terminated production. Many were large installations captive to the heavy equipment manufacturers. The remaining operating steel foundries generally attained better quality control and greater productivity.

The total tonnage of ferrous scrap consumed by domestic consumers and for the export market was 75.2 million short tons compared with 69.3 million short tons in 1983.

In 1984, the Birmingham, AL, area cast-iron pipe shops, although operating spasmodically and much below rated capacity, were consistent buyers of cut structural and plate grades of scrap. Minimills in Birmingham and nearby areas had near-capacity outputs except in the last quarter of the year. In March, Commercial Metals Co. resumed operation of the former Connors Steel Co. facility in Birmingham, AL, which was idle for several years. Demolition of the old Ensley, AL, steel mill produced about 4,000 short tons per month of cut structural and plate. Major brokers became more selective on receipts of raw scrap and tightened their inventories of processed scrap.

The Chicago, IL, scrap market was constrained by extended delivery contracts at fixed prices. Traders acknowledged that the price for No. 1 heavy melting scrap was no longer suitable for establishing market averages in the Chicago, IL, district where scrap buying and prices followed the steel industry's short-term needs. One winning bidder considered his 70-gross-ton receipts of bundles in gondola cars as an attractive inducement because most processors were unable to compactly load gondolas to obtain this payload weight.

The generation of No. 1 bundles and No. 1 busheling in the Pittsburgh, PA, area could not satisfy demands. As a result, these grades were brought in from western and southern sources. Customers in the Youngstown, OH, area obtained No. 1 busheling from Chicago, IL, and Detroit, MI, where several metal stamping and fabrication plants were in operation. Other grades of scrap generated and processed in the Pittsburgh, PA, area were barged to gulf coast consumers. Traders emphasized that industrial scrap must be sold soon after it is produced. Broken ingot molds brought $124 per short ton, f.o.b. Pittsburgh, PA, steel mills, and brought more than $134 per short ton on a delivered basis. Scrap demand in the Pittsburgh area was below normal because some major steelmakers restarted iron blast furnaces while their electric furnaces remained idle.

No. 1 heavy melting steel scrap was one of the "most-sought" grades purchased by steel mills, while foundries preferred structural and plate scrap. Shredded scrap was the only grade for which both steel mills and foundries competed. Foundries preferred "industrial" shredded and cupola-cast grades to control contaminants such as zinc, copper, and stainless steel.

The increased share of total raw steel from electric arc furnaces in recent years widened the specifications' variances between mills and created special grades of scrap. Some domestic scrap customers required uncoated black steel bundles, and other customers refused to buy painted, galvanized, and ferrous wire components. Turnings for export were required to be free of cast-iron borings, rags, oil, and short shoveling turnings, all of which have been associated with spontaneous combustion.

The David J. Joseph Co., Cincinnati, OH, stated that in 1983, purchased scrap averaged nearly 40 short tons per 100 short tons of raw steel produced compared with 27 per 100 short tons of raw steel produced between 1954 and 1970.

Some domestic consumers of scrap reduced their stocks expecting inventories to be maintained by scrap processors. This practice was feasible in several areas of the country where scrap delivery was on a "just-in-time" basis.

Stocks of ferrous scrap held by all domestic consumers at yearend totaled 5.26 million short tons compared with 5.81 million short tons at yearend 1983. In early 1984, some mills in the Great Lakes region had an insufficient supply of scrap; as a result, some east coast exporters filled the deficiency.

The fourth updated biennial study prepared by Robert R. Nathan Associates for the Metal Scrap Research and Education Foundation indicated a 743.9-million-short-ton backlog of ferrous metal discards in the United States at yearend 1983. This total was 60 million short tons over the 684-million-short-ton total on December 31, 1981. An official of the Institute of Scrap Iron and Steel (ISIS) predicted a faster annual increase because of the increasing introduction of hazardous materials into obsolete scrap that will inhibit its processing.

An ISIS survey indicated that less than 150,000 short tons of ferrous and nonferrous scrap was recovered in 1984 from municipal solid waste. About 100,000 short tons of these metals was marketed for recycling.

The 1982 Census of Wholesale Trade shows 2,029 U.S. iron and steel scrap processors with total sales of $3.6 billion and 1,864 dealers with sales of $2.7 billion.

Some activities of ferrous-scrap-related groups or institutes are noted. ISIS hailed the decision of European Community (EC) countries to reject controls of their ferrous scrap exports. ISIS submitted a proposal to the Office of Management and Budget to classify ferrous scrap processors as manufacturers in the Standard Industrial Classification manual on which no action developed by yearend, and ISIS developed a right-to-know compliance program for ISIS members regarding the toxic effects and the proper handling of hazardous materials in raw scrap. Commercial Metals, Dallas, TX, in June withdrew its memberships in ISIS and the National Association of Recycling Industries (NARI). The American Iron and Steel Institute (AISI) considered ways to interpret undifferentiated technical operating data from the LTV Corp. and the Republic Steel Corp. after their merger. The problem developed after the U.S. Department of Justice prohibited the two companies from providing plant-specific data on their outputs and capacity utilizations to the AISI. The American Society of Metals compiled and published in August 1984 a chapter on the "Basics of Scrap Recycling." The chapter comprised contributions from AISI, ISIS, NARI, Luria, and the U.S. Bureau of Mines.

A new company, Scrap Management International Inc., Pittsburgh, PA, offered a new concept of service to the ferrous scrap processing and the scrap generating industries to increase the return obtained from scrap sales. The new company provided this service on a "percentage-of-savings" basis.

Samuel G. Keywell Co., Detroit, MI, opened a new stainless steel scrap and alloy-scrap processing facility in Chicago, IL. The facility was formerly operated by the Stainless Steel Processing Co. Keywell had a total of three yards, all started in the past 3 years.

Diamond Scrap Yards Inc., Waukegan, IL, with a peak output of 12,000 short tons per month from 85 employees, terminated operations and converted its 15-acre property into a condominium site. The Joseph Co. opened a new district office in Omaha, NE, to coordinate brokerage activities and to control the firm's railcar dismantling operation in Norfolk, NE. The Joseph Co. closed its brokerage office in Los Angeles, CA, in February.

A 1984 NARI survey revealed the following:

1. U.S. scrap processors spent 50% more for capital investments than in 1983.
2. Many recyclers planned operations at minimum possible employee levels.
3. Scrap sold on a brokerage basis was 78% more than in 1981.
4. The typical processor obtained 41% of incoming scrap from dealers and industrial plants and 20% from carters, local recycling operations, government dismantlers, and metals recovered from municipal waste.
5. Of the total scrap obtained, 50% came from sources within a 50-mile radius of the processing yards.
6. Processors representing 57% of the industry reported 5-day, one-shift operations, and 6% of the industry operated on a 6-day, one-shift basis.
7. And about 25% of the processed scrap was shipped from the yards by railroad, and the remainder by trucks offering lower freight rates and more efficient delivery service.

Commercial Metals, Dallas, TX, (1) acquired yards in Austin, TX, Galveston, TX, and Chattanooga, TN, (2) closed its yard in Eagle Pass, TX, and (3) transferred its processing equipment to its Corpus Christi, TX, facility. At yearend 1984, Commercial Metals had one minimill in Seguin, TX, and another in Birmingham, AL, that was purchased from Connors Steel in December 1983. Commercial Metals subsidiary, Railroad Salvage Co., based in Dallas, TX, and specializing in railroad salvage and rail scrapping, was quite profitable because of the increased demand for scrap rail by Midwest minimills. Minkin Industries, Williamsport, PA, acquired Baker's scrapyard in Lewisburg, PA. Minkin had its own transportation and maintenance facilities. Georgetown Steel Corp., Georgetown, SC, a minimill owned by KORF Industries, sold its 30% share in Addelstone International Corp. to Addelstone in June. Addelstone continued supplying all of Georgetown Steel's scrap requirements. Prolerized New England Co. bought Metal Processing Co., a subsidiary of Steelmet Inc., Pittsburgh, PA, for $6.35 million in cash.

National Metal and Steel Corp. expanded its scrap-loading wharf at Terminal Island in San Pedro, CA, on land leased from Los Angeles, CA. The expansion, to be completed in mid-1986, will involve dredging to a 45-foot depth and increasing the length of the wharf to 1,000 feet to accommodate 40,000-ton scrap carriers.

Steelmet asked a Federal bankruptcy judge's approval to sell a subsidiary, Metro Iron and Metal Corp., Miami, FL. Steelmet (McKeesport, PA) and Metro filed for protection under chapter 11 of the Bankruptcy Code. Steelmet, a major processor and broker of stainless steel scrap, earlier had filed a reorganization plan whereby Steelmet would be purchased by ELG Haniel Metals Corp. of the Federal Republic of Germany.

Witte-Chase Corp., a major ferrous scrap processor, broker, and exporter, changed its name from Schiavone-Chase Corp. effective October 1. Witte-Chase established a new subsidiary, Nicromet Inc., to enter the stainless steel and nickel-alloy scrap market and to export these materials from its Port Newark, NJ, terminal that was purchased from Luria in 1983. Witte-Chase also had a scrapyard in Brooklyn, NY, operating under the name Newton Steel.

Illinois Scrap Processing Inc., Chicago, IL, bought an 8.5-acre industrial site on the Calumet River for $530,000. The firm will use the site to diversify into a boat, storage, and repair business.

Proler International Corp., Houston, TX, operated 20 U.S. processing plants to supply a substantial tonnage of scrap for export.

The Department of Justice announced in June that a grand jury indicted, for bid rigging and mail fraud, the Wilcoff Co., Youngstown, OH, H. Wolfe Iron and Metal Co., and New Castle Junk Co., both in New Castle, PA. A South Carolina court in midyear ruled that Ackerman Metals Inc., Sumter, SC, was a manufacturer and thus was exempt from the State's ad valorem property tax.

Cuyahoga Wrecking Corp., Great Neck, NY, and the Tube City Iron and Metal Co., Bala Cynwyd, PA, agreed that the latter, operating as a broker, would be the sole marketer for the scrap generated by Cuyahoga Wrecking, the contractor, most of which will be processed at the demolition site. This agreement could establish a precedent because scrap from dismantled domestic and industrial structures erected between 1900 and 1930 accounted for 25% of recoverable obsolete scrap in 1984, second only to the 35% from automotive scrap.

News relating to the purchase of steel minimills by scrap processing firms indicate a possible emerging trend. Commercial Metals operated minimills in Seguin, TX, and Birmingham, AL. Schnitzer Steel Products, Portland, OR, purchased Cascade Steel Rolling Mills Co.'s minimill in McMinnville, OR. Chapparal Steel Co., Midlothian, TX, in 1982, purchased the scrap metal operation of Schwartz Iron and Steel Metal Co., Texas City, TX, to produce scrap for Chapparal's minimill.

Costs of some scrap processing equipment were shown in the American Metal Market of February 1, 1984. A 1,500- to 3,000-short-ton-per-month shredder cost $400,000; auxiliary equipment for this size shredder, comprising conveyors, magnets, and antipollution devices, totaled $500,000; and total delivery and installation costs were $300,000. A medium-size shredder had a total installed cost of $1.7 million, and a large-output shredder had a total cost of $3.0 million. A medium-output shredder required 36 hammers, each weighing 250 pounds; their replacement cost after processing 6,000 automobile hulks was $8,000. A hydraulic guillotine shear cost $3.0 million excluding installation expense, and a large baler cost $1.7 million plus $200,000 for installation.

The third Scrap Age shredder survey compiled in July-September 1984 listed 182 U.S. shredders, 7 more than in 1980. Their total annual capacity was estimated at 13.3 million short tons. In 1984, there were 20 shredders in Canada having an estimated capacity of about 1.1 million short tons. The survey also listed 47 shredders in the world, other than the United States and Canada, for which the annual capacity was not stated.

Some newly developed processing equipment available to the scrap industry included (1) briquetting machines and systems from Bepex Corp., Chicago, IL; (2) the RB-120 Rail Breaker by the Harris Press and Shear Co., Cordele, GA; (3) dumping containers, for mounting on the user's truck body, from Able Body Co., Newark, CA; (4) portal cranes from the Harnischfeger Corp., Milwaukee, WI; (5) high-tonnage guillotine shears from Logemann Brothers Co., Milwaukee, WI; (6) Italian shear blades and shears distributed by Newell Industries Inc., San Antonio, TX; (7) a portable shear for use at demolition sites was available from U.S. Shear Machine Co., La Crosse, WI; (8) six models of the Scrap Snapper from Waltsco Inc., Special Products Div., Wallingford, CT; (9) the Zerdirator—an installation combining the advantages of the shredder, compactor, and separator—from Lindemann KG GmbH and Co., Dusseldorf, Federal Republic of Germany; (10) a mobile shredding system by the Saturn Shredders Div. of the MAC Corp., Grand Prairie, TX; (11) a mobile shear-type shredder from Shredding Systems Inc., Wilsonville, OR, and; (12) the Analyst 770, an energy-dispersive x-ray fluorescence spectrometer from the Kevex Corp., Foster City, CA.

Scrap processors increasingly encountered materials presenting safety or health hazards in the workplace and which in some situations posed a threat to public health. These materials include those having a direct physical danger and those inherently dangerous in composition. One category currently drawing attention is airbag inflation metal canisters containing a chemical, sodium azide, suspected of causing cancer. While not explosive in itself, sodium azide is easily converted to metallic and halogen azides that can be detonated by the slightest impact, electrical ignition, and arsonists.

ISIS requested a detailed review by the National Highway Traffic Safety Administration (NHTSA) of the hazards of chemical-containing canisters remaining in the auto hulks to be processed by the ferrous scrap industry.

Two new devices were tested in a Washington, DC, automobile dismantling yard for detecting unspent metal canisters containing chemicals for inflating safety bags in hulks destined for processing. The devices relied on an electronic system, requiring no additional power source, that continued to emit signals after two hulks were flattened. Further testing of the devices was planned to determine their costs and the longevity of their signals.

The U.S. Department of Transportation on July 11 mandated use of airbags or automatic seatbelts on new automobiles beginning in 1989. This mandate, with respect to the inflatable safety bags, augured a danger to the ferrous scrap industry and will create hazardous waste disposal problems unless preventative measures are established, according to the ISIS.

NARI formed a Toxic Materials Guidelines Committee that will develop industry guidelines and standards for the safe handling of metals that are potentially toxic.

Venti-Oelde, a leading West German manufacturer of shredder-dust-extraction and material-handling systems, developed shredding equipment to withstand a pressure surge up to 45 pounds per square inch (3 bars).

The second major hazard was radioactive materials. Radioactive materials most likely to be encountered by scrap processors are relatively weak isotopes contained in industrial gauging devices. Although these devices are under rather stringent Government control, they occasionally get into unprocessed scrap as the result of theft or improper disposal. If the radioactive processed scrap leaves the yard and gets into finished ferrous castings, these products may be later traced back to the processing yard. The yard must then be closed for decontamination and the remaining contaminated scrap must be disposed of, with the cost of both actions borne by the scrap processor.

ISIS, assisted by the Nuclear Regulatory Commission, published a new booklet, "Caution! It Could Be Radioactive Scrap," to give guidelines to ISIS members on the uses of radioactive materials, how to recognize equipment containing them, and what to do with them.

In mid-1984, the U.S. Navy had 9 decommissioned nuclear-powered submarines awaiting disposal, and another 100 were expected to be retired in the next 30 years. The Navy announced that the reactor components will be buried in low-level-radiation sites in Washington and South Carolina, and the nonradioactive hulks will be sunk at sea or sold for scrap.

The Federal Government and 21 States had adopted "right-to-know" laws that require all industries, including scrap processors, to inform workers and customers about any hazardous materials they might encounter in the scrapyard or its products. To protect itself, a scrapyard could obtain Material Data Safety Sheets from metal producers and vendors of each material likely to be handled in the processing yard. These safety sheets were also available to purchasers of the recycled scrap from the processing yard.

TRANSPORTATION

Use of trucks for ferrous scrap haulage increased significantly as railroad service deteriorated and railroad freight rates continued an upward trend. New, smaller tonnage steel mills were designated to take advantage of the more efficient and faster movement by truck of incoming scrap and shipments of their steel products.

The National Truck Rate Advisory Council on August 27 filed an action against the Department of Transportation and the Federal Highway Administration to overturn recently established Federal regulations governing truck weights on the Interstate Highway System.

Railroad transportation rates in 1984 could be negotiated, concluded, and made legal on an "on-the-spot" telephone call basis as a result of the Staggers Rail Act that permitted this freedom to react to the market with demand-sensitive rates.

One major railroad considered transporting briquetted scrap and shredded scrap in open-top hopper cars to compensate for the shrinking count of the gondola car fleet. High demand created spot shortages of gondola cars suitable for ferrous scrap and finished steel transportation.

Effective June 4, the Burlington Northern Railway Co. reduced its penalties for overloaded rail cars. The new tariff supplement eliminated fines for 4,000 pounds or less overloads and reduced other fines by $400 to $600.

Class I railroads on August 1, 1984, owned 125,401 gondola cars and a total of 975,204 freight cars. On August 1, 1983, Class I railroads owned 130,051 gondola cars and a total of 1,020,368 freight cars. At yearend 1984, about 150,000 freight cars were classed as surplus. The Trailer Train Co. converted 400 obsolescent G-85, 85-foot-long flatcars into container-only cars.

Several news items indicated an improved situation for the carbuilding business. The Consolidated Rail System (Conrail) in its Hollidaysburg, PA, car shop began construction of 250 52-foot-long, 100-ton-capacity gondola cars for scrap hauling costing $9.6 million. Bethlehem Steel Corp.'s Freight Car Div., Johnstown, PA, reopened its carbuilding shop in March to handle a 312-car order. The CSX System increased its freight car reconstruction activities in Raceland, KY, because of the greater need for hopper cars and boxcars. Duchossois-Thrall, a division of Duchossois Industries Inc., acquired the United-American Car Co., Cartersville, GA, rated at an output of 2,500 cars per year. Duchossois-Thrall's three plants in Chicago Heights, IL, had a 4,500-freight-car annual capacity. The Richmond Tank Car Co., Houston, TX, resumed production of covered hopper cars for plastic shipments and recalled 150 employees. The American Car and Foundry Co. (ACF) permanently closed its 4,000-car-per-year plant in St. Louis, MO, that was idle since May 1982. ACF continued operation of its other freight car plants in Huntington, WV, and Milton, PA.

In 1984, 15,460 freight cars were ordered, compared with 6,083 in 1983. In the first 10 months of 1984, 400 were delivered, compared with 198 in 1983.

The Ortner Freight Car Co., a subsidiary of Ogden Corp., New York, NY, in February obtained five contracts to build 757 all-steel cars costing $36.1 million, and options for 195 additional cars at an aggregate price of $14.9 million. In October, Ortner received orders for 150 flatcars costing $12.8 million for the U.S. Army and 253 lightweight steel, coal-hauling gondola cars costing $9.1 million for the Wisconsin Electric Power Co.

Lightweight aluminum-containing cars received more attention. Ortner received orders for 273 coal-hauling gondolas for Intermountain Power Project and 366 gondolas for the Detroit Edison Co. In December, the Alcan Aluminum Corp., Cleveland, OH, and Thrall Car Manufacturing Co., Chicago Heights, IL, formed a joint venture known as the Aluminum Railcar Co., to build aluminum-containing cars in Thrall's plant. The aluminum-containing railcar is 20% to 35% more expensive but 15% less in weight than its steel counterpart. Currently, aluminum components account for about 27% of the final car's weight. Investigations and new designs were continued in order to reduce the weight of the car and to permit larger payloads.

New freight car construction increased the demand for scrap used for producing steel products, steel castings, and forgings. The average monthly shipments, in short tons, of forged car wheels was 5,192 in 1984 and 4,116 in 1983. The monthly average tonnage of forged axles shipped was 2,762 in 1984 and 1,720 in 1983.

Orders for new rails increased in 1984 as the glut of reusable rail from abandoned railroads had diminished. New rails and track accessories shipped from U.S. mills in 1984 totaled 1.2 million short tons compared with 883,907 short tons in 1983.

Buckeye Steel Castings Co., Columbus, OH, obtained orders for 122 complete trucks for rapid transit and commuter cars built in Canada and Japan.

PRICES

The prices of most grades of scrap in the Pittsburgh area in midyear were established almost entirely on an appraisal basis; at the same time, the consumer demand in the Pittsburgh area for cupola-cast grade was nearly nonexistent, and short shoveling turnings were difficult to sell unless they could be guaranteed as alloy free.

The tonnages and delivered average prices in dollars per short ton, for all grades of scrap purchased from brokers, dealers, and other outside sources by manufacturers of pig iron and raw steel, manufacturers of steel castings, and manufacturers of iron castings were as follows:

Consumer	Quantity (thousand short tons)	Approximate delivered value	
		Total (millions)	Average
Steel manufacturers	25,675	$2,054	$80
Steel castings manufacturers	1,205	111	92
Iron castings manufacturers	7,445	596	80
Total or average	34,325	2,761	[1]80

[1]Average for the first 6 months was $84, and $76 in the second 6 months.

Receipts of all types of scrap accounted for $29 of the $547-per-short-ton average price of finished steel shipments; for $116-per-short-ton of steel castings shipped; and $73-per-short-ton of iron castings shipped.

The tonnages and values of the four major grades received by all domestic purchasers from brokers, dealers, and other outside sources were as follows:

Grade	Quantity (thousand short tons)	Value (millions)	Average
No. 1 heavy melting	8,195	$590	$72
No. 1 bundles	5,872	528	90
Shredded	3,085	278	90
No. 1 busheling	1,567	143	91
Total or average	18,719	1,539	XX

XX Not applicable.

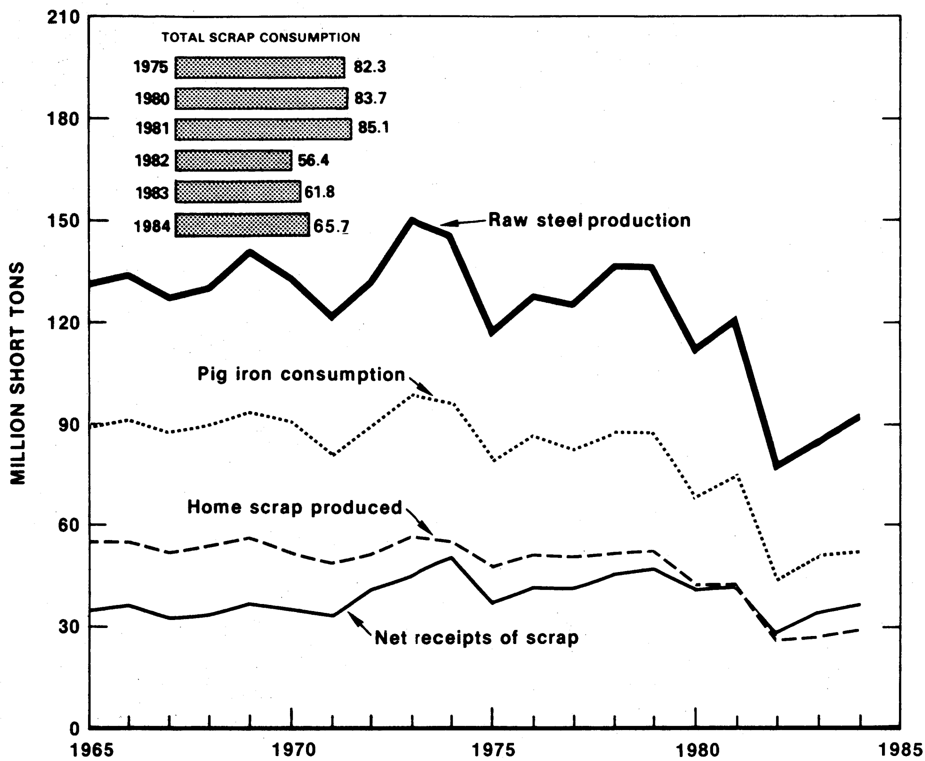

Figure 1.—Raw steel production (AISI), total iron and steel scrap consumption, pig iron consumption, home scrap production, and net scrap receipts.

FOREIGN TRADE

Ferrous scrap exports increased 26.3% over those of 1983 and were the largest tonnage since 1980 when 11.2 million short tons was exported. The tonnages and values of the 1984 exports, as released by the Bureau of the Census, were as follows:

Type	Quantity (short tons)	Customs value Total (thousands)	Customs value Average
Ferrous	9,234,503	$804,140	$87.08
Stainless steel	163,542	96,426	589.61
Alloy steel (excluding stainless)	100,231	17,415	173.75
Total or average	9,498,276	917,981	96.65

Canada, Japan, the Republic of Korea, and Turkey collectively received 6.1 million short tons valued at $554 million and averaging $90.97 per short ton.

Scrap exports from the Northeast United States were at a 4-year peak in midyear. The reduced tonnage of processed scrap available for consumers in the New York and New Jersey areas caused the price of the No. 1 heavy melting grade to reach $78.57 per short ton delivered, a $5- to $6-per-short-ton increase in a month.

The tonnages and customs value of the total ferrous scrap exported through the five leading customs districts were as follows:

Area and leading district	Quantity (short tons)	Customs value Total (thousands)	Customs value Average
East coast: New York, NY	1,787	$177,011	$99.05
Great Lakes: Detroit, MI	608	49,577	81.54
Gulf coast: New Orleans, LA	512	54,186	105.83
Inland: Laredo, TX	374	36,441	97.44
West coast: Los Angeles, CA	1,203	126,070	104.80
Total or average	4,484	443,285	98.86

Source: Bureau of the Census.

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)	Customs value: Average
Detroit, MI:			
Stainless steel	10,254	$4,483	$437.20
Alloy steel	17,024	1,876	110.20
Laredo, TX:			
Stainless steel	583	275	471.70
Alloy steel	2,010	239	118.91
Los Angeles, CA:			
Stainless steel	27,957	16,576	592.91
Alloy steel	6,065	2,284	376.59
New Orleans, LA:			
Stainless steel	21,665	12,683	585.41
Alloy steel	60	45	750.00
New York, NY:			
Stainless steel	25,276	15,846	626.92
Alloy steel	12,809	3,019	235.69
Total or average:			
Stainless steel	85,735	49,863	581.59
Alloy steel	37,968	7,463	196.56

The three countries that received the largest tonnages of U.S. stainless steel scrap were Japan, 51,686 short tons; Spain, 29,884 short tons; and Belgium, 25,054 short tons. Collectively, these countries received 65.2% of the total stainless steel exported.

Exporters of U.S. stainless steel scrap reportedly preferred selling to European mills that were accustomed to the meltdown purchase practice, rather than selling to Japanese mills that maintained the quality-inspection system.

The distribution and values of several major grades of scrap supplied by brokers, dealers, and other outside sources to domestic consumers and for exports, in thousand short tons, were as follows:

Type	Domestic consumers	Exports	Total
No. 1 heavy melting	8,195	2,512	10,707
No. 2 heavy melting	2,157	879	3,036
No. 1 bundles	5,872	77	5,949
No. 2 bundles	1,205	286	1,491
Borings, shovelings, turnings	1,193	800	1,993
Shredded	3,085	2,775	5,860
Total	21,707	7,329	29,036
Value, thousands	$1,659,179	[1]$615,122	$2,274,301

[1]Customs value, Bureau of the Census.

Shredded and No. 1 heavy scrap were the leading grades of scrap exported. No. 2 heavy melting was third with 0.88 million short tons, and borings, shovelings, and turnings was fourth with 0.8 million short tons.

In the first 8 months of 1984, the prevailing prices for the top grades exported were about $10 per short ton less than in the last third of 1984. Reportedly, this price decline was caused by a weaker domestic demand.

A proposed ban by EC countries of exports to non-EC countries was expected to increase U.S. exports to the Mediterranean area, India, and Japan.

Exports of U.S. scrap to China increased, even though Brazil contracted to deliver 670,000 short tons of pig iron to China.

The Tex Report, August 13, 1984, shows the estimated current annual export capacities for ferrous scrap at U.S. ports as follows, in thousand short tons:

Atlantic:	
New York City	1,000-2,000
Philadelphia	400
Boston	300- 400
Providence	300
Bridgeport	300
Southern Atlantic:	
Baltimore to Miami	700
Gulf coast	200
Pacific:	
Los Angeles	800
San Francisco	600- 700
Seattle	300
Other	200

Imports of ferrous scrap, excluding 5,242 short tons of scrap tinplate, totaled 572,010 short tons valued at $46.9 million. The Detroit district handled 249,147 short tons, and the Seattle, WA, customs district handled 185,978 short tons. Canada supplied 532,241 short tons valued at $41.7 million; Mexico supplied 20,990 short tons valued at $2.9 million; and 21 other countries supplied 18,779 short tons valued at $2.2 million.

WORLD REVIEW

Foreign shipbreaking activities continued to contribute significantly to the worldwide scrap supply. Major areas of shipbreaking activities were the Far East, the Indian subcontinent, the Mediterranean, Western Europe, and the Western Hemisphere. The Far East, the largest market for ships to be scrapped, comprises Taiwan, the Republic of Korea, and China, with vessels occasionally destined for Japan, Hong Kong, Singapore, Indonesia, and Thailand. Small tonnages are broken in Bangladesh, India, and Pakistan. Activity in Portugal, Italy, Yugoslavia, Turkey, and Greece is only intermittent. Spain occasionally purchases ships for breaking. In Western Europe, shipbreaking is insignificant in the Federal Republic of Germany, Belgium, the Netherlands, France, Sweden, Finland, and the United Kingdom. Breaking activities are minor in the United States, Canada, Colombia, Peru, Argentina, East Africa at Mombasa, the Republic of South Africa, and Saudi Arabia. Large vessels, chiefly in demand in Taiwan and the Republic of Korea, bring the highest price per lightweight gross ton (the displacement of a ship completely equipped but unladen). Next in demand are large bulk carriers, while smaller vessels at varying lower level prices tend to go to those areas in the Indian subcontinent that break ships on the beach.

A ship typically yields a 98-weight-percent-scrap content, the majority of which is good quality 1/2-inch plate salable in large pieces for direct further use or for rerolling into marketable steel products. Ships are sold directly or through third parties. Sales are often hampered because foreign currency is not readily available or there are restrictions imposed by import licenses or government purchasing agents who regulate tonnages and prices. Prices depend on the size and condition of the vessel and the distance from the last port of call or laidup location. Currently, there is an oversupply of ships, especially large tankers. Reportedly, total world oversupply is 90 million deadweight short tons, including about 1,680 laidup vessels, of which 425 are tankers totaling 75 million deadweight short tons. Deadweight tonnage is the carrying capacity of a ship in short tons (2,000 pounds). Because new ships are more fuel efficient, it is generally agreed that there are no prospects of a shortage of those ships that are unlikely to be operated profitably in the future.

Typical prices in dollars per lightweight short ton in 1983 were Far East, bulk carriers, $95, and tankers, $100; Indian subcontinent, bulk carriers, $75, and tankers, $78; and Mediterranean area, bulk carriers, $33, and tankers, $47. Variations in price may also be caused by factors other than supply and demand.

Fearnleys, a Norwegian shipping agent in its "Review 1983," reported that at yearend 1983, the world bulk fleet comprised 7,837 vessels totaling 560.7 million deadweight short tons, of which 56% was tanker tonnage. In 1983, the net reduction of the bulk fleet was 14.2 million deadweight short tons compared with 7.6 million deadweight short tons in 1982. In 1983, scrapping and losses were at a record-high 32.8 million deadweight short tons compared with 30.0 million deadweight short tons in 1982. Deletions from the fleet in 1983 mainly comprised very large cargo carriers (VLCC). The 64 VLCC broken in 1983 totaled 17.9 million deadweight short tons comprising 43 vessels built in 1972, 16 vessels built in 1973-74, and 5 built after 1974. Taiwan purchased 37; the Republic of Korea, 25; Pakistan, 1; and Japan, 1, for use as a breakwater. Petroleum companies sent 16 VLCC's for demolition. The largest vessel sold for breaking in 1983 was 616,000 deadweight short tons built in 1977.

The Tex Report of December 26, 1984, stated that in the first 11 months of 1984, 713 vessels totaling 30.1 million deadweight short tons entered the world demolition market. Included in the total were 12 tankers (and other oil carriers) totaling 1.3 million deadweight short tons and 59 bulk carriers (and other non-oil carriers) totaling 1,081,000 deadweight short tons.

A London broker, E. A. Gibson Ltd., stated that at yearend 1983, 356 tankers and dry carriers totaling 69.1 million deadweight short tons were laidup.

The London shipbroker Harley, Mullion and Co. reported that more ships were sold for scrap in 1984 than in 1983. However, the total tonnage of 29.6 million deadweight short tons sold in 1984 was 11.4% less than the 37.4 million deadweight short tons sold in 1983. This report recognized the emergence of China during 1984 as a major force in the shipbreaking market.

Far East shipbreakers in the last half of 1984 contracted for 27 VLCC's for demolition. Six ships for the Republic of Korea totaled 234,031 lightweight short tons; 4

ships for China totaled 158,426 lightweight short tons; 1 for Japan accounted for 36,235 lightweight short tons; and 16 for Taiwan totaled 672,078 lightweight short tons. The average contract price for these 27 VLCC's was $128 per lightweight short ton.

The Australian Government by April 19 had received 16 bids from Japanese and Chinese shipbreakers for the 14,280-lightweight-short-ton Her Majesty's Australian Ship *Melbourne*. This active response was apparently due to the high added value of materials obtainable from a warship.

A Brazilian steelmaker, Siderúrgica Aco-Norte S.A., imported four ships for scrapping at a cost of $68.04 per short ton. The tonnage of domestic scrap purchased by AcoNorte in 1984 was one-fourth of the domestic tonnage bought in 1983. Prices at yearend 1984 were $61.69 per short ton or $20.87 per short ton more than at yearend 1983. Brazil's 1984 consumption of scrap was forecast as 6.3 million short tons, 23% more than in 1983.

Chinese shipbreakers in 1983 broke 448,000 lightweight short tons of ships, all under 11,200 short tons, in Dalien, Shanghai, Tienjin, and Quingdo. In the first 9 months of 1984, China became third in world shipbreaking by handling 103 ships totaling 778,495 lightweight short tons. In June, the Nippon Shipbuilding Industries Association sent a mission to survey China's existing shipbreaking operations. In September, the Chian Shipbreaking Industry Corp. sent a research mission to Japan for technical guidance in breaking VLCC's and to observe the rerolling of scrap into bars.

The Liaoning Provincial Ship Scrapping Co. near Beijing started shipbreaking in June 1983. Ten berths of the company in the first 9 months of 1984 had broken 14 ships weighing 112,000 lightweight short tons received from the United Kingdom, Japan, Sweden, and the Netherlands. By yearend, the company planned to dismantle eight more ships totaling 78,400 lightweight short tons.

A West German broker in early 1984 purchased two ships for $70 per lightweight ton for resale to breakers in Yugoslavia and Bangladesh.

Indian shipbreakers were concerned because of the new breaking operation in Sri Lanka, India's unfavorable import duties, and the routing of all shipbreaking sales through the state-owned Metal Scrap Trade Corp. (MSTC) that discouraged the entry of ships into India for breaking. Reportedly, some of these ships were diverted to the Sri Lankan Port of Tricomales, before sending to the Lanka Shipbreaking and Industries (Pte.) at Galle for breaking. This new facility, the first in Sri Lanka, is jointly owned by Sri Lanka Ports Authority, 51%; East Prosper Industries of Singapore, 40%; and Taiwanese interests, 9%. The Galle facility can scrap vessels up to 11,000 lightweight short tons. Indian breakers feared that the movement of ships to Sri Lanka will further reduce the 336,000 lightweight short tons handled by Indian breakers in 1983. Indian breakers urged a drastic reduction of the 87% to 98% import duty on ships destined for breaking and the removal of restrictions that allowed only 1 ship for each of 40 breakers and the limiting of their work schedule to 4 months per year.

A proposal was advanced to construct a shipbreaking facility at Bandar Abbas, Iran, to handle 8,960- to 11,200-lightweight-short-ton ships. Meanwhile, the escalation of activities against tankers in the Persian Gulf owing to the war between Iran and Iraq increased the price of scrap paid by Iranian steelmakers by $8.04 per short ton to $125 in June 1984. The price increase resulted after some laidup VLCC's were returned to service rather than going to shipbreakers. This trend was economically attractive because of higher freight charges.

The Ministry of Transport requested Japanese shipbreakers to increase their activities to reach a 4.0-million-short-ton target by yearend 1985. However, shipbreaking was considered impractical because of its high-cost, labor-intensive nature. Major Japanese breakers formed the Joint Association for Ship Scrapping to take advantage of the Government's demolition subsidies system, amounting to $11.80 per short ton. Before March 1986, the Association planned to dismantle four VLCC's and some smaller vessels. Despite the subsidy, the breakers expected to incur an overall loss on the venture.

Hyundia Corp., the largest individual shipbreaker in the Republic of Korea, demolished 1.1 million lightweight short tons in 1983, or 80% of the total tonnage scrapped in the Republic of Korea that year. Many small breakers went out of operation in 1983 following a price increase to $116.07 per lightweight short ton. In the first 9 months of 1984, 52 ships totaling 997,183 lightweight short tons were broken in the Republic of Korea, the world's second largest breaking country. In early February, one South Korean breaker paid $114.29 per lightweight short ton for a 16,800-lightweight-short-ton turbine tanker. A major Japanese shipowner in May sold a 300,000-deadweight-ton ship to Hyundia for $130 per lightweight short ton; a 35,200-lightweight-short-ton VLCC brought $116.07 per lightweight short ton to two Japanese owners in September; and Yamashita-Shinnihon sold a 41,440-lightweight-short-ton VLCC to Dongkuk Steel Co. in the Republic of Korea for December 1984 delivery. The International Maritime Industries Forum (IMIF) suggested that a breaking yard be established in Monrovia, Liberia, where the labor force was abundant and a ready market existed for scrap and rerollable plate. IMIF discussed the financing of this proposal with the International Bank for Reconstruction and Development. IMIF also presented a proposal to Malta's Government for a full-scale shipbreaking venture. The proposal emphasized the cost advantage for breaking ships closer to their laidup sites in Western Europe rather than moving them to Far East breakers.

Breakers in Pakistan, who used beaching sites only, were only interested in smaller ships. Prices paid for 2,401- to 5,040-lightweight-short-ton ships ranged from $74.11 to $83.04 per lightweight short ton.

In 1983, Taiwanese breakers demolished ships totaling 3.60 million lightweight short tons purchased for $380 million. In the first 9 months of 1984, according to Lloyd's list, Taiwan headed the world's breaking activities by breaking 187 vessels totaling 2.36 million lightweight short tons. Prices paid per lightweight short ton ranged from $114.29 to $123.21 for large and medium tankers and about $103.57 per lightweight short ton for bulk carriers. The bankruptcy of the East Asia Steel Corp. and a decline in scrap plate prices concerned some Taiwanese breakers. After June 1, 1984, only two berths were in operation for dismantling 112,000- to 145,600-lightweight-short-ton VLCC's. Some Taiwanese buyers of ships for demolition were Chin Tai Steel Enterprise Co.; Chen Nan; Swiy Horng; Nan Eng; Kuo Dar; Len's; Yi Ho; Gi Hsiang; Nan Jong; Chin Tai; Gi Yuen; and Tung Ho Enterprise.

Following the Turkish Government's decision to ease import restrictions, the Aliaca area in the Izmir region was selected for development of shipbreaking facilities according to the Lloyd's list. When fully operational, 16 companies in the Izmir region will be able to scrap 20 to 25 vessels instead of 2 or 3 vessels that were scrapped prior to the Government's decision. The removal of import licenses was intended to reduce the imports of scrap currently at 2 million short tons per year. In February, prices were $44.64 per lightweight short ton, but year-end prices were $62.50 per lightweight short ton. Turkey did not plan to challenge the dominance of Far East breakers.

The General Accounting Office, in an April 19, 1984, report, claimed the U.S. Navy in 1981-82 sold 11 old destroyers for $5.2 million total. Three of the vessels went to Taiwan, two each to the Republic of Korea, Greece, and Mexico, and one each to Turkey and Pakistan. Prices ranged from $286,000 for four ships sold to Taiwan, the Republic of Korea, and Greece in early 1981 to $930,176 for the U.S.S. *Cone* sold to Pakistan in October 1982. The *Cone*, built in 1945, had been overhauled 22 months before the sale.

In 1984, U.S. exports of ships for scrapping totaled 282,777 short tons.

Australia.—In recent years, one-half of the obsolete scrap production was exported. However, a deficit of available scrap was expected because of the installation of raw steel continuous casters in the Port Kembla and Newcastle works of The Broken Hill Pty. Co. Ltd. (BHP) and a proposed caster for Comsteel Vickers at Waratah. A proposed minimill in Brisbane and another minimill by Smorgon will create an additional scrap demand of 200,000 short tons per year. BHP representatives visited the United Kingdom in September to talk to scrap processors and consumers and to observe the recycling of ferrous scrap from municipal waste.

Austria.—Ferrous scrap consumption by steelmakers and foundries in the first half of 1984 increased to 844,000 short tons compared with 753,000 short tons in the same period of 1983. Imports were 213,000 short tons, more than double the 101,000 short tons imported in the first half of 1983. Steelworks' stocks on June 30, 1984, totaled 211,640 short tons.

Belgium.—The country's restrictions on ferrous scrap exports to non-EC countries were continued as a means for lowering local scrap prices. Exports to non-EC countries were about 154,000 short tons per year. Scrap prices decreased about $8.62 per short ton between June and October.

China.—A trade mission, after a visit to

Brazil to contract for 670,000 short tons of pig iron, visited U.S. steel scrap exporters in the Atlantic and Pacific coastal regions and announced their interest in direct deals with the exporters. Philipp Brothers considered shipping scrap from the Great Lakes area where prices had declined and scrap collection was favorable. The Chinese mission was interested in pig iron procurement from Brazil because of its easier handling in the ports of Shanghai and Dalien, where the unloading rate of shredded scrap was only 1,500 short tons per day per cargo vessel. This unloading rate was lower than the 2,000- to 2,500-short-ton-per-day rate in the Republic of Korea and the 3,500- to 4,000-short-ton-per-day rate in Japan. Additionally, scrap unloading ports were hampered by bottlenecks in inland rail traffic. Southern Scrap, a U.S. exporter, chartered a 25,000-short-ton bulk carrier to move shredded scrap to Dalien from a gulf coast port for a $27.50-per-short-ton total for freight plus lay charges. This freight plus lay cost was about $8.50 per short ton more than for shredded scrap movements to Japan.

European Communities.—Industry ministers in a January 1984 meeting agreed to monitor exports of ferrous scrap but rejected Italian and Danish demands for export restrictions. The EC representatives in April rejected an outright ban of ferrous scrap exports. EC nations in 1983 exported 13.3 million short tons, of which 6.3 million short tons went to non-EC countries on a free trade basis. Imports from non-EC countries in 1983 to EC countries were 1.3 million short tons. The main EC importing countries were Belgium, Luxembourg, and Italy, where imports were reduced by increased domestic collection. Regional development grants to British scrap processors allocated by the EC Commission in 1972 need not be repaid following a ruling in October 1984.

In 1983, Italy exported no ferrous scrap; imports totaled 5.4 million short tons, of which 4.3 million short tons came from EC nations.

Spanish and Italian steelmakers in May rejected the $92.53-per-short-ton scrap from EC countries and started purchases from U.S. east coast brokers.

In October 1984, the EC Commission's survey indicated that EC countries held 46 million short tons of scrap, 12.5% more than a year earlier. The Commission forecast a 1.1-million-short-ton export in 1984 of EC scrap to non-EC countries, mainly Spain, the Republic of Korea, India, and Turkey. The EC Commission started an investigation in mid-November 1984 directed to imposing a 6.7-million-short-ton ceiling on 1985 scrap exports to non-EC countries. The French, West German, and British Governments strongly opposed such a ceiling.

France.—In 1983, of the 353,000 short tons of ferrous scrap imported, 347,000 short tons came from EC countries. Exports of scrap in 1983 totaled 3,547,000 short tons, of which 2,564,000 short tons went to EC countries. In the first half of 1984, French steelmakers received 14% more tonnage than in the same period of 1983, while exports in the first 6 months of 1984 were 32% more than in the first half of 1983. According to the French Ferrous Scrap Federation, the scrap industry faced a shortage of high-grade scrap although there was a surplus of scrap as a whole. Cie. Française de Ferailles in September 1984 started operation of a new $2.27 million shredder at Carros; output was to go to Italy.

The French steelmaker Société Aciéries et Laminoirs de Lorraine (Sacilor) tested the Sacilor Irsid Fusion Ferrailles (SIFF) process at its Rombas works. The SIFF process used a converted medium-size blast furnace to melt a 100%-scrap charge. During the 4-month test at Rombas, the burden comprised shredded scrap, heavy scrap, bundles, pig iron, and incinerated tin cans. The 28,800-cubic-foot, 12 tuyere blast furnace consumed 2,938 pounds of scrap and pig iron, 488 pounds of coke, and 268 pounds of fluxes per short ton of hot metal produced. The test showed that a medium-size blast furnace, transformed for the large-dimension charging of bundles and heavy steel scrap, could produce 1.1 million short tons of hot metal per year and that the process could offer integrated plants greater flexibility to take advantage of periods of low scrap prices and at a coke rate less than one-half the normal rate. The hot metal produced during the Rombas test was used as produced, or mixed with the usual hot metal (depending on the steel grade) at Sacilor's Grandrange converter shop.

German Democratic Republic.—VEB Kombinat Metallaunfbereitung of the German Democratic Republic announced offering of a license for a continuous process for crushing, sorting, and classifying commercial-grade cast scrap. This process separates feedstock into 60% normal foundry scrap, 20% small foundry scrap, 10% scrap steel, 0.5% nonferrous metals, and 2.5% nonmetals. More details on this process are available from the East German Embassy in Washington, DC.

Germany, Federal Republic of.—In 1984, prices of the basic No. 2 grade scrap to West German steelmakers ranged from $62.60 to $74.39 per short ton. Exporters in the southern border area of the Federal Republic of Germany obtained $71.67 to $72.57 per short ton for scrap exported to Italy after the Italian Government, acting for Italian steelmakers, agreed to a freight subsidy. Large tonnages of declassified scrap arrived in the West German market to supplement minor domestic collections. Domestic stainless steel scrap prices paced the increasing price of U.S. imports, and scrap ferronickel was in great demand. The West German Scrap Federation forecast 1984 sales of ferrous scrap, in million short tons, as 8.8 to domestic steelmakers, 2.2 to foundries, and 3.7 for exports.

The new D and J Press Co. became the exclusive agency for Thyssen Henschel scrap processing equipment in the United States and Canada. Lindemann Machinenfabrik GmbH, Dusseldorf, the Federal Republic of Germany, established Lindemann Recycling Equipment Inc. with an office in New York City to develop an active role in the U.S. market. Lindemann introduced its Zerdirator—an installation that combines the advantages of a shredder, compactor, and separator. Venti Oelde sold 10, 10- to 150-ton-per-hour-input-capacity windsifter plants and 2 recently developed pressure-shock-resistant dust control plants for use with shredders.

India.—MSTC attempted to conclude a new agreement on the sale of scrap from the Steel Authority of India Ltd. (SAIL). An earlier agreement that expired in May 1983 entitled SAIL to sell 22% of scrap from its own plants, and MSTC, the remainder. MSTC was reluctant to continue the agreement because no accurate knowledge of the tonnage was available. In the 1983-84 financial year, MSTC sold 236,000 short tons of scrap bought from SAIL for $107.96 per short ton.

The Indian National Shipowners' Association opposed the Government's plan to levy separate rates of duty on shipbreaking operations, one for Indian flag vessels and one for foreign flag vessels imported for breaking. Indian flag vessels were auctioned at higher prices than the cost-insurance-freight (c.i.f.) price of similar vessels imported for scrapping on which the duty was based on the highest auction value. The Government in August reduced the import duties on vessels for scrapping from 87% to 76%. MSTC handled all imports of ships for scrapping. Current imports of stainless steel scrap are assessed a 20% duty.

Nissho-Iwai Corp. in May procured 22,000 short tons of shredded steel scrap from the U.S. east coast exporter Phibro Bros. for $135 per short ton including a $34.50-per-short-ton freight charge. In August, MSTC contracted for 82,673 short tons of shredded scrap from Amalgamated Metals and 16,535 short tons from Krupp, all for $121.56 per short ton c.i.f. MSTC arranged for a September shipment to India comprising 76,059 short tons of shredded scrap destined for Bhavnagar, Kanda, New Mangalore, Calcutta, and Bombay, and 5,512 short tons of No. 1 and No. 2 bundles for delivery to Bombay.

Italy.—In 1983, ferrous scrap supplies available to steel mills, in million short tons, comprised 7.4 from collected domestic scrap, 3.9 from the mills' home scrap, 3.7 imported from EC countries, and 1.0 imported from non-EC countries.

The 7.4 million short tons of domestic scrap was collected by 2,000 firms, most of which were family-based concerns that sold their scrap to larger firms that could meet the demands of the country's steel mills. Scrap production employed 13,000 workers in the sorting and processing operations supplemented by 500 presses, 150 baling shears, and 14 shredder plants. Scrap collection in the past 5 years increased despite the waning demand by domestic consumers. As a result, imports have decreased about 1 million short tons annually. However, Italy remained heavily dependent on imports to meet its need for steel scrap. Assofermet, the 30-year-old Italian scrap association credited with the industrialization of the scrapyards, had 300 members representing most of the domestic scrap produced.

Steel mills in a 4-week period starting April 1 bought 150,000 short tons of scrap from the United States compared with a 70,000-short-ton combined total in the 3 years 1981, 1982, and 1983. Higher prices charged for scrap by EC countries and the inability to obtain larger quantities from the U.S.S.R. prompted the renewed interest in U.S. scrap, reportedly the better quality grades bringing $100 to $102 f.o.b. per short ton. The Italian Parliament in mid-December granted retroactively to October 1 a 22.7-lire-per-pound (U.S. 1.19 cents) subsidy of ferrous scrap imported from the United States and from non-EC countries. As a result, imports from non-EC sources were forecast to increase to 2.0 million short tons in 1984 compared with an average of 0.7 to 0.9 million short tons per year in recent years.

Japan.—Major ferrous scrap traders were Kanto Shredder, Marubeni, Mitsubishi, Mitsui & Co., Nakataya, Nissho-Iwai, and Sumitomo.

Kawasaki Steel Corp. continued the monthly sales of 3,300 to 4,400 short tons of high-grade steel scrap generated in its Mizushima and Chiba works to steelmakers Kawasaki Corp. and Kyoi. Also, about 33,000 short tons per month of surplus scrap in the Kanto area went to Kansai area steelmakers. Conversely, scrap was particularly deficient at the Owita and Nagoya plants, both of which produced sheet and plate in conjunction with continuous casting.

Some steelmakers were buying H-2 domestic steel scrap for $82.55 per short ton. Electric-furnace steelmakers were concerned after Nippon Steel Corp. contracted to export some of its home scrap to China.

In midyear, the steel industry was operating at a production rate of 116 million short tons per year of raw steel. The industry's blast furnaces, operating with 408,000 short tons more capacity than in 1983, could not satisfy the demand for hot metal. As a result, steelmakers' stocks at yearend 1984 comprised 5.04 million short tons of scrap and 1.64 million short tons of pig iron, reflecting a total 1.87-million-short-ton decrease of these materials from yearend 1983.

The Shredder Committee of the Scrap Iron Processors of Japan in late 1984 listed 50 shredders averaging 1,200 horsepower and 54 shredders in the 100- to 300-horsepower range that only processed steel cans and white goods. Japan's total annual shredding capacity was estimated at 3.9 million short tons per year.

The range of prices of stainless steel scrap delivered to Japan based on numerous quotations in the Tex Reports during 1984, in dollars per short ton, was U.S. (west coast) cargoes of SUS 18/8 Sabot, $558 to $564, and Hong Kong cargoes for the same type of stainless scrap, $558 to $562.

Japan continued the bulk cargo sampling of stainless steel scrap and alloy steel scrap, unlike the United States and Europe where sampling by melting approximately 10% of the total is acceptable. Consequently, the stainless steel scrap trade was restricted almost exclusively to container deliveries for Japan, resulting in higher freight costs.

The average delivered prices, in dollars per short ton, based on numerous contracts reported in the Tex Reports during 1984 for imported steel scrap were H-1—$103.42, H-2—$92.53, No. 1 bundles—$100.70, and shredded—$104.33.

Average f.o.b. prices and average freight charges by port, per short ton of ferrous scrap exported to Japan, were as follows:

Port	Price	Freight
United States:		
East coast	$87.72	$19.08
Gulf coast	96.42	16.96
West coast	90.71	14.44
Miami, FL	NA	17.41
St. Lawrence Seaway	NA	23.88
Netherlands: Rotterdam	105.36	18.42
United Kingdom	NA	20.09

NA Not available.

The exports of ferrous scrap from Japan in the first 11 months of 1984 were as follows:

	Quantity (short tons)	Average value per ton: Yen	Average value per ton: U.S. dollars[1]
Cast-iron scrap:			
Korea, Republic of	1,574	32,126	127
Taiwan	41	45,507	180
Total or average	1,615	32,463	128
Alloy steel scrap:			
Korea, Republic of	186	29,632	117
Taiwan	764	109,249	432
Other (3 countries)	132	219,858	869
Total or average	1,082	109,064	431
Ordinary steel scrap:			
China	16,363	29,134	115
Korea, Republic of	53,081	30,883	122
Taiwan	51,690	63,059	244
Other (9 countries)	12,533	38,783	153
Total or average	133,667	37,123	147

[1]Based on an average exchange rate for Japanese yen (Y) to U.S. dollars of Y253=US$1.00.

Source: Tex Report, Dec. 25, 1984, p. 5.

Japanese imports of ferrous scrap in the first 11 months of 1984 were as follows:

Grade and source	Quantity (short tons)	Value per ton	
		Yen	U.S. dollars[1]
Cast-iron scrap:			
Australia	24,377	28,866	104
Other (11 countries)	2,499	30,433	108
Total or average	26,876	29,104	104
Alloy steel scrap:			
Hong Kong	14,385	154,723	555
Taiwan	22,762	137,922	494
United States	58,232	172,027	617
Other (30 countries)	38,546	135,386	485
Total or average	133,925	153,891	552
Ordinary steel scrap:			
Australia	265,722	26,768	96
U.S.S.R	304,107	26,210	95
United Kingdom	275,615	25,867	93
United States	2,477,057	27,134	97
Other (34 countries)	637,847	25,405	90
Total or average	3,960,348	26,672	95
Sheet scrap:			
Korea, Republic of	9,905	35,335	127
Taiwan	3,976	50,656	181
Other (10 countries)	900	37,745	135
Total or average	14,781	39,602	142

[1]Based on average exchange rate for Japanese yen (Y) to U.S. dollars of Y253=US$1.00.

Source: Tex Report, Dec. 24, 1984, p. 13.

Exports of ferrous scrap from the United States to Japan in 1984 were as follows:

Scrap grade	Quantity (short tons)	Customs value	
		Total (thousands)	Average
No. 1 heavy melting	1,129,324	$98,569	$87
No. 2 heavy melting	307,192	25,639	83
No. 1 bundles	61,004	6,755	111
No. 2 bundles	18,586	983	53
Borings, turnings, etc	118,235	9,090	77
Shredded	619,027	56,303	91
Carbon steel, iron scrap	82,440	7,346	89
Carbon steel, other	281,441	24,346	87
Stainless scrap	51,686	31,862	616
Alloy scrap, excluding stainless	11,103	3,964	357
Total or average	2,680,038	264,857	99

Source: Bureau of the Census.

Korea, Republic of.—Imports, in short tons, in May, June, July, October, and November 1984 averaged 213,347 per month of melting scrap and 78,047 per month of rerolling scrap. Information was not available on how much of the rerolling scrap originated in the South Korean shipbreaking yards since such scrap is not an import. The price of imported No. 1 heavy melting scrap in 1984 averaged $108.86 per short ton according to 10 price citations in the Tex Reports. According to the Bureau of the Census, the customs value of No. 1 heavy melting scrap to the Republic of Korea from U.S. ports averaged $86.82 per short ton. The foregoing import data imply an average total freight rate from U.S. ports of $22.04 per short ton.

The Government reduced the payment period for imported steel scrap from the previous 120 to 150 days to 90 days effective August 1, 1984. Steelmills were therefore constrained by longer payment deadlines for exported finished products.

Inchon Iron & Steel Co. Ltd. in February received some dismantled-vessel scrap from Hyundai Corp. Inchon through the trader Hugo Neu bought 16,000 short tons of scrap originating in Hawaii for $123 per short ton f.o.b. Dongkuk Steel Mill Co. Ltd., through a major Japanese trader, bought 11,200 short tons of No. 1 heavy melting scrap, originating in Saudi Arabia, for $107.14 per short ton c.i.f. Most scrap imported from the United States was handled by the shippers Schnitzer, AMC, Legin, and Mitsui. In late June, Phibro, a U.S. trader, agreed to a $24.27-per-short-ton-freight-and-lay charge from St. Lawrence Seaway ports to Inchon.

Mexico.—In December 1983, a stolen cancer therapy unit was crushed along with ferrous scrap in a Juarez, Mexico, processing yard. Cobalt-60 isotope was released, exposing 200 persons to unsafe levels of radiation and contaminating 10 houses. The resulting processed steel scrap went to a Mexican minimill and several Mexican foundries from which about 4,000 short tons of products was distributed to parts of Mexico and several U.S. localities.

Netherlands.—This country had the largest surplus of exportable scrap within the EC countries. Exports from the Netherlands in 1983 totaled 1,473,775 short tons, up 25% from the 1,176,154 short tons in 1982. In late 1983, six 44,000-short-ton cargoes went to Japan at a $18-per-short-ton freight rate, and shredded scrap from eight processors went to India in 22,000-short-ton shipments. Two steelmakers, Hoogovens Ijmuiden BV near Rotterdam and the West German-owned Thyssen Nedstaal AG on the Rhine, produced less than 5.5 million short tons total of raw steel. The price of scrap, for which these steelmakers negotiated monthly, fluctuated by as much as $13.61 per short ton in the summer months of 1983 to a low of $3.15 in the autumn of 1983. Average freight rates from Rotterdam scrap processors to West German steelmakers on the Rhine River and in the Ruhr area were $1.8 to $2.7 per short ton.

Pakistan.—Most of the scrap requirements for the M/S Ittefaq Ltd. minimill in Lahore were met by 75,377 short tons imported from the United States.

Philippines.—In early June, the National Steel Corp. canceled plans to import 20,000 to 25,000 short tons of steel scrap because of a large de facto devaluation of the currency to approximately 19 pesos per U.S. dollar.

Romania.—Scrap was imported at a rate of 660,000 to 770,000 short tons per year, mainly from Brazil, India, and the U.S.S.R., although a small tonnage came from the United States and some African countries. Some special cargo vessels built in Romania were designed to load scrap at collection ports and for navigating the Danube River as far inland as Galati and Calarasio.

Spain.—Altos Hornos de Vizcaya S.A. (AHV) planned a new wharf at Le Benedicta near Bilbao to handle 16,535-short-ton vessels because AHV facilities on the Nervion River could only handle 5,500-short-ton vessels. Specialty steelmakers Eschevarria, Aceros de Llodio, Pedro Orbegozo, Forjas Alevesar and Allara formed an organization named Sociedad de Compras de Materias Primas Siderúrgicas located in Bilbao, to buy scrap on a joint basis. The organization made purchases in mid-1984 from the United States and the United Kingdom.

Spanish ferrous scrap imports reached record-high levels in 1984, rising 9.5% above the 5.05 million short tons reached in 1983 to 5.53 million short tons.

The United Kingdom remained the main supplier, exporting some 2.4 million short tons; France supplied 1.1 million short tons; the United States, 588,519 short tons; the U.S.S.R., 584,845 short tons; Morocco, 81,922 short tons; and Algeria, 52,470 short tons.

Sweden.—The continuing ban on scrap exports held prices for domestically originated scrap to $15.42 to $19.96 per short ton below prices in the free market.

Taiwan.—Reportedly, the storage of crude oil in tankers, of which 70 million barrels of Saudi Arabian crude alone was afloat in Japanese anchorages, slowed owners' sales of VLCC's to Taiwanese shipbreakers. This situation resulted in VLCC's costing as much as $117.86 per lightweight short ton on a gas-free basis to Taiwanese breakers, who countered by less costly purchases of 11,000-short-ton vessels. At the end of March 1984, shipbreakers' stocks of dismantled ships were 728,000 short tons; 504,000 short tons of vessels was being dismantled; and 224,000 short tons was under contract for near-future delivery. The prices of ship plate tended upward. Imported No. 1 heavy melting scrap cost $97 to $98 per short ton. Ocean freight rates to Taiwan from the U.S. west coast were $3 per short ton more than for similar cargoes destined for Japan. According to the Bureau of the Census, U.S. exports of all grades of ferrous scrap to Taiwan in 1984 totaled 405,283 short tons. The average customs value was $134.51 per short ton, 36% more than the average customs value of $98.83 per short ton for 2.7 million short tons exported to Japan, and 58% greater than the average custom value of $85.09 per short ton for the 1.8 million short tons exported to the Republic of Korea.

Turkey.—The annual ferrous scrap demand of 1.9 million short tons per year was met by 0.55 million short tons of domestically generated scrap and 1.3 million short tons of imported scrap. The Government was encouraging more shipbreaking in an effort to decrease imports.

U.S.S.R.—Scrap consumption showed a significantly increasing trend, according to the Federal Republic of Germany Federal Office for Foreign Trade Information (BFAI). Converter steelmaking was the core of the U.S.S.R.'s current efforts to increase the use of scrap in steel production. BFAI noted that a series of small steelworks are to be operated exclusively on a scrap basis, with three ministeelworks going into operation before yearend 1985.

United Kingdom.—Exports of ferrous scrap in 1984 totaled 4.7 million short tons valued at $380 million. Much of the scrap went to India and to Spain, resulting in smaller tonnages shipped to these countries from the United States. In midyear, the increasing weakness of sterling also favored exports to the European market. Shipments to the Far East were diminished because of competing shipments from European and U.S. sources. The dock strike in July effectively isolated scrap from the export market resulting in a $2.7 to $4.5 per short ton lower price charged British steelmakers. Large cargoes to the Far East, which normally accounted for 5% to 10% of all British exports, were particularly hampered because 88,000 to 100,000 short tons of scrap was immobilized in ports at Cardiff, Tilbury, and Liverpool. Other ports continued loading small cargoes for European markets. Negotiations for future exports to Japan were terminated during the dock strike. The scrap industry in 1984 shipped 2.4 million short tons to Spain and 187,000 short tons to Turkey. Surplus scrap available for exports totaled 3.5 million short tons. Four major British scrap shippers were Mayer Newman and Co. Ltd.; George Cohen Sons and Co. Ltd.; Sheppards Waste Recovery Ltd.; and Cooper's (Metals) Ltd. The British Scrap Federation (BSF) welcomed the rejection by the Council of European Community Ministers to control the exports of scrap from EC countries to non-EC countries. Non-EC countries in 1984 received about 80% of the British exports. In 1984, 41,440 short tons of stainless steel scrap was exported from the United Kingdom.

The BSF stated that British scrap prices, which were at low levels in December 1982, recovered significantly by June 1984 to world levels. Domestic consumers bought OA-grade scrap for $69 to $70 per metric ton. However, railroad freight charges from the Midlands to South Wales were $7.25 to $7.70 per short ton, up sharply from the normal $5.44 per short ton. Domestic consumption in 1984 was estimated as 4.6 million short tons. British steelmakers obtained scrap at $14.52 to $18.14 per short ton less than delivered prices to European markets. However, despite a 3.5-million-short-ton surplus of scrap, British steelmakers claimed that their needs were not fully met.

In 1983, a scrap processor received $550,000 to dismantle, for its scrap content, a $20 million formed coke plant at the Normandy Park steelworks, Scunthorpe, South Humberside, that never attained even semicommercial output because of poor design. Ironically, scrap from this poorly planned BSC venture was shipped to BSC's Linz-Donawitz converters in Scunthorpe.

Solidate Ltd. of Sandbach, Cheshire, introduced a 154,322-pound capacity shear-beam load cell ferrous scrap scoop with computer facilities to handle furnace charges at the Sheffield Forgemaster's River Don works. Spectro Analytical (UK) Ltd., in Farnham, Surrey, offered a microprocessor-controlled optical emission spectrometer to satisfy quality control and assurance in metal manufacturing and metal processing industries. Belgium's Presses and Cisailles Lefort firm supplied a second 550-short-ton shear to Pooles Lane Autospares in Highwood. Lindemann (UK) Ltd. introduced a new series of 500-short-ton hydraulic scrap shears.

The Midwest Scrap Associates reported that from August 1983 to August 1984, 5 new shredders were added to the 49 already in existence, resulting in a 1.65-million-short-ton-per-year capacity in the United Kingdom. As a result, the United Kingdom was the leading producer of shredded scrap in Europe and the third largest producer in the world. British scrap shredders produced 1.32 million short tons in 1983 despite a shortage of feed that reduced the overall capacity utilization. Mayer Pearse, Exeter, installed a 1,000-horsepower shredder, and the Bird Group acquired A.E.P. Piggott and Sons Ltd., in Leicester, thereby increasing its shredding capacity by 66,000 short tons per year to give the Bird Group's seven shredders a 441,000-short-ton-per-year total capacity.

Hartlepool and Cardiff Steels installed a new scrap terminal at Cardiff capable of handling vessels up to 39,000 short tons. The Bird Group and the MacWilliams Group formed a new scrap marketing company called Ward Scotland Ltd. The MacWilliams Group normally handled 3,300 to 4,400 short tons of scrap per year from its dismantling operation. The scrap merchant Howard and Pepperell Ltd. (H&P) formed Howard & Wheeler Ltd. to take over all H&P trading effective March 1. T. W. Ward's Steel and Alloys division was sold for $3.7 million to the Rohstoffhandel GmbH based in Krefeld, Federal Republic of Germany. This move ended Rio Tinto Zinc Corp. Ltd.'s (RTZ) participation in ferrous scrap. Since its acquisition by the Bird Group in 1984, Ward's Ferrous Metals handled 2.1 million short tons of scrap, of which 0.55 million short tons came from in-plant processing. Mayer Newman and Co. Ltd. expanded its operations in East Anglia by acquiring Norwich-based Thomson Bros. Newman had a scrap processing plant in Newmarket and export docks at Lowestoft and Yarmouth. The J. Seville Gordon Group acquired Parkfield Iron and Steel Co. Ltd., thereby increasing its baler count to five units. H. Stewart (Metals) Ltd. of Manchester, a subsidiary of the Norwegian company Elkem A/S, leased a 20-acre site near the Birkenhead dockland where Stewart will offer ship repairs and shipbreaking operations that will meet some of the scrap requirements of the Manchester Steel Group. Stewart also purchased processing facilities at Birkenhead and at Ardwick.

Lloyd Ewell ceased scrap trading in January, and the Ford Motor Co. closed its foundry in Digenham, Essex, and transferred its casting production to Cologne, Federal Republic of Germany. Competition from foundries in Spain and Portugal forced British foundries to terminate operations at the rate of one per week. Scrap merchants in the Midlands were concerned about the closure of Lloyd Dudley's steel minimill, the closure of F. H. Lloyd's two largest steel foundries in the United Kingdom, and the closure of the Caparo Group's Smethwick District steelworks.

The proposed United Kingdom Reclamation Council (UKRC) was intended to replace the British Reclamation Industries Confederation that was terminated in late 1984. Reportedly, the UKRC would affiliate with the Bureau International de la Recuperation because UKRC will encompass a wide range of reclamation associations. The Greater London Enterprise Board was established to reactivate the London Foundry Co. The EC Commission renewed the authorization for several British private sector steelmakers to jointly buy ferrous scrap. Steelmaking Supplies Ltd. was set up for this purpose in 1974 but had been inactive for several years.

The British Steel Corp.'s (BSC) Special Steels Group introduced a new scrap-surcharge system effective September 30, 1984, based on the quarterly average prices paid for scrap by the BSC and listings in the Metal Bulletin's Ferrous Scrap Master Index of prices for bars and billets. Private sector steelmakers hesitated to adopt the system.

To compete with the truck transportation of ferrous scrap, BSC, British Rail, and a private company, Standard Railfreight, started a new venture to speed the rail hauling of scrap. The Standard Rail Wagon Co. Ltd. was commissioned to build a fleet of 51-short-ton-capacity, air-braked rail cars. In the first phase of usage, these new cars will be supplemented by a reserve of 165, 16-short-ton, vacuum-braked cars. The system was expected to haul 413,000 short tons of scrap per year over long distances in Speedlink trains.

[1]Physical scientist, Division of Ferrous Metals.

Table 2.—U.S. consumer receipts, production, consumption, shipments, and stocks of iron and steel scrap and pig iron in 1984, 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	324	(1)	224	3	324	227	31
Cut structural and plate	821	121	397	5	1,375	14	122
No. 1 heavy melting steel	7,968	1,595	8,618	87	17,091	1,243	1,401
No. 2 heavy melting steel	1,983	107	640	2	2,665	65	230
No. 1 and electric-furnace bundles	5,791	327	1,882	6	8,111	225	619
No. 2 and all other bundles	1,010	30	8	--	1,060	12	92
Electric furnace, 1 foot and under (not bundles)	31	(1)	(1)	--	32	--	4
Railroad rails	156	2	2	--	254	3	32
Turnings and borings	780	14	163	1	954	12	63
Slag scrap (70% Fe content)	515	307	2,929	1	3,276	393	195
Shredded or fragmentized	2,223	883	32	--	3,134	4	189
No. 1 busheling	1,186	58	152	2	1,408	74	101
All other carbon steel scrap	1,420	565	5,974	19	7,129	615	515
Stainless steel scrap	500	48	469	(1)	1,009	28	81
Alloy steel (except stainless)	143	182	1,054	18	1,315	96	258
Ingot mold and stool scrap	238	411	490	947	1,594	409	365
Machinery and cupola cast iron	7	--	7	1	7	7	3

See footnotes at end of table.

Table 2.—U.S. consumer receipts, production, consumption, shipments, and stocks of iron and steel scrap and pig iron in 1984, by grade —Continued

(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—Continued							
Cast-iron borings	189	4	61	1	157	74	41
Motor blocks	5	--	--	--	6	--	1
Other iron scrap	195	76	356	2	554	177	71
Other mixed scrap	187	11	128	4	331	5	33
Total[2]	25,675	4,743	23,587	1,099	[3]51,786	3,683	4,448
MANUFACTURERS OF STEEL CASTINGS							
Carbon steel:							
Low-phosphorus plate and punchings	361	1	125	(1)	433	(1)	36
Cut structural and plate	131	3	15	(1)	150	1	9
No. 1 heavy melting steel	111	1	30	--	142	--	4
No. 2 heavy melting steel	54	--	1	--	57	--	5
No. 1 and electric-furnace bundles	11	--	2	--	10	--	(1)
No. 2 and all other bundles	1	--	--	--	1	--	(1)
Electric furnace, 1 foot and under (not bundles)	45	(1)	4	--	49	(1)	1
Railroad rails	6	(1)	--	--	4	--	(1)
Turnings and borings	23	--	14	--	29	4	1
Slag scrap (70% Fe content)	--	(1)	(1)	--	--	(1)	(1)
Shredded or fragmentized	18	--	--	--	23	--	(1)
No. 1 busheling	13	--	--	--	8	(1)	2
All other carbon steel scrap	248	10	166	(1)	407	6	24
Stainless steel scrap	14	(1)	20	(1)	35	(1)	6
Alloy steel (except stainless)	39	(1)	79	(1)	118	1	25
Ingot mold and stool scrap	1	--	(1)	--	2	(1)	(1)
Machinery and cupola cast iron	21	--	1	--	22	--	(1)
Cast-iron borings	68	--	16	--	73	--	6
Motor blocks	--	--	--	--	(1)	--	--
Other iron scrap	39	(1)	17	--	54	3	8
Other mixed scrap	--	--	7	(1)	7	--	(1)
Total[2]	1,205	16	495	1	[4]1,624	16	129
IRON FOUNDRIES AND MISCELLANEOUS USERS							
Carbon steel:							
Low-phosphorus plate and punchings	712	23	85	2	793	8	37
Cut structural and plate	1,022	81	52	1	1,171	1	82
No. 1 heavy melting steel	115	27	47	(1)	152	36	12
No. 2 heavy melting steel	120	--	51	(1)	172	1	3
No. 1 and electric-furnace bundles	70	237	40	--	336	--	21
No. 2 and all other bundles	194	2	--	--	196	--	26
Electric furnace, 1 foot and under (not bundles)	41	1	(1)	--	38	--	3
Railroad rails	117	--	6	(1)	111	1	9
Turnings and borings	390	4	7	2	419	8	31
Slag scrap (70% Fe content)	16	--	1	(1)	16	1	2
Shredded or fragmentized	844	132	--	--	1,091	--	59
No. 1 busheling	368	69	59	--	500	--	13
All other carbon steel scrap	388	6	101	3	486	20	29
Stainless steel scrap	14	--	1	(1)	14	(1)	2
Alloy steel (except stainless)	20	--	6	1	22	4	12
Ingot mold and stool scrap	149	(1)	99	1	233	1	45
Machinery and cupola cast iron	810	4	371	1	1,134	6	79
Cast-iron borings	743	162	101	1	973	33	35
Motor blocks	374	25	711	--	1,100	19	43
Other iron scrap	573	69	2,083	2	2,687	47	95
Other mixed scrap	364	23	257	3	648	3	47
Total[2]	7,445	866	4,078	16	[5]12,291	189	684

See footnotes at end of table.

Table 2.—U.S. consumer receipts, production, consumption, shipments, and stocks of iron and steel scrap and pig iron in 1984, by grade —Continued

(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
TOTAL—ALL TYPES OF MANUFACTURERS							
Carbon steel:							
Low-phosphorus plate and punchings	1,396	24	435	5	1,550	235	104
Cut structural and plate	1,974	205	464	6	2,696	16	213
No. 1 heavy melting steel	8,195	1,623	8,694	87	17,386	1,279	1,417
No. 2 heavy melting steel	2,157	107	691	2	2,894	66	238
No. 1 and electric-furnace bundles	5,872	564	1,924	6	8,457	225	640
No. 2 and all other bundles	1,205	33	8	--	1,257	12	117
Electric furnace, 1 foot and under (not bundles)	117	1	5	--	119	(1)	8
Railroad rails	279	2	8	(1)	369	4	41
Turnings and borings	1,193	19	183	3	1,402	25	95
Slag scrap (70% Fe content)	532	307	2,931	1	3,292	394	197
Shredded or fragmentized	3,085	1,015	32	--	4,248	4	248
No. 1 busheling	1,567	127	211	2	1,916	74	116
All other carbon steel scrap	2,055	581	6,241	23	8,022	641	569
Stainless steel scrap	528	49	491	(1)	1,058	28	89
Alloy steel (except stainless)	202	182	1,139	19	1,454	101	295
Ingot mold and stool scrap	388	412	589	948	1,828	410	410
Machinery and cupola cast iron	839	4	378	1	1,162	13	82
Cast-iron borings	1,001	166	177	1	1,202	107	82
Motor blocks	380	25	711	--	1,107	19	43
Other iron scrap	807	144	2,456	4	3,296	227	174
Other mixed scrap	552	34	391	7	986	8	81
Grand total[2]	34,325	5,624	28,160	1,116	[6]65,702	3,889	5,261

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.
[3]Internal evaluation indicates that scrap consumption is understated by approximately 4.9 million short tons.
[4]Internal evaluation indicates that scrap consumption is understated by approximately 560,000 short tons.
[5]Internal evaluation indicates that scrap consumption is understated by approximately 3.1 million short tons.
[6]Internal evaluation indicates that scrap consumption is understated by approximately 8.6 million short tons.

Table 3.—U.S. consumer receipts, production, consumption, shipments, and stocks of pig iron and direct-reduced iron in 1984

(Thousand short tons)

	Receipts	Production	Consumption	Shipments	Stocks, Dec. 31
MANUFACTURERS OF PIG IRON AND RAW STEEL AND CASTINGS					
Pig iron	1,280	51,961	51,969	1,425	237
MANUFACTURERS OF STEEL CASTINGS					
Pig iron	64	--	62	--	3
IRON FOUNDRIES AND MISCELLANEOUS USERS					
Pig iron	1,224	--	1,171	71	64
TOTAL—ALL TYPES OF MANUFACTURERS					
Pig iron	2,568	51,961	53,202	1,496	304
Direct-reduced or prereduced iron	305	W	406	13	51

W Withheld to avoid disclosing company proprietary data.

Table 4.—Consumption of iron and steel scrap and pig iron in the United States in 1984, 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]	2,724	--	--	--	--	--	2,724	--
Basic oxygen process[3]	16,447	45,551	--	--	--	--	16,447	45,551
Open-hearth furnace	3,724	5,718	W	W	--	--	3,724	5,718
Electric furnace[4]	28,244	22	1,523	61	3,638	287	33,405	370
Cupola furnace	50	120	95	--	8,315	350	8,460	469
Other (including air furnace)[5]	597	76	6	1	338	15	942	92
Direct castings[6]	--	482	--	--	--	519	--	1,002
Total	51,786	51,969	1,624	62	12,291	1,171	65,702	53,202

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]Internal evaluation indicates that scrap consumption in electric furnaces operated by manufacturers of pig iron and raw steel and castings is understated by approximately 4.9 million short tons.
[5]Includes vacuum melting furnaces and miscellaneous uses.
[6]Includes ingot molds and stools.

Table 5.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States in 1984

(Percent)

Type of furnace	Scrap	Pig iron
Basic oxygen process	26.5	73.5
Open-hearth furnace	39.4	60.6
Electric furnace	98.9	1.1
Cupola furnace	94.7	5.3
Other (including air furnace)	91.1	8.9

Table 6.—Iron and steel scrap supply[1] available for consumption in 1984, by region and State

(Thousand short tons)

Region and State	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.)	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, Vermont	1,247	36	370	4	1,658	133	1,525
Pennsylvania	4,910	1,248	5,157	279	11,593	1,507	10,087
Total[2]	6,157	1,284	5,527	283	13,251	1,639	11,612
North Central:							
Illinois	3,494	734	2,024	62	6,313	123	6,190
Indiana	3,006	88	6,366	257	9,717	943	8,773

See footnotes at end of table.

Table 6.—Iron and steel scrap supply[1] available for consumption in 1984, by region and State —Continued

(Thousand short tons)

Region and State	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.)	Total new supply[2]	Shipments of scrap[3]	New supply available for consumption
North Central —Continued							
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	4,474	780	3,128	35	8,417	182	8,235
Ohio	4,763	1,399	4,969	234	11,364	612	10,752
Wisconsin	585	15	440	--	1,040	19	1,021
Total[2]	16,323	3,015	16,927	588	36,852	1,880	34,972
South Atlantic: Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	3,898	356	2,265	96	6,616	118	6,499
South Central: Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	5,421	673	2,370	67	8,531	191	8,340
Mountain and Pacific: Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	2,526	296	1,070	82	3,974	59	3,915
Grand total[2]	34,325	5,624	28,160	1,116	69,224	3,889	65,336

[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 1984, by region and State

(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
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island	1,035	W	39	3	618	41	1,691	44
Pennsylvania	9,613	7,427	136	5	638	272	10,388	7,703
Total[2]	10,649	7,427	175	8	1,256	313	12,079	7,747
North Central:								
Illinois	5,187	2,676	167	(3)	717	208	6,072	2,884
Indiana	8,101	16,126	121	42	481	38	8,703	16,206
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	4,815	4,932	209	1	3,331	313	8,355	5,246
Ohio	7,861	10,157	101	4	2,779	148	10,741	10,309
Wisconsin	--	--	203	1	836	45	1,039	46
Total[2]	25,964	33,891	801	47	8,145	752	34,910	34,690
South Atlantic: Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	5,995	W	51	3	775	26	6,822	29

See footnotes at end of table.

Table 7.—U.S. consumption of iron and steel scrap and pig iron[1] in 1984, 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
South Central:								
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	5,972	[4]10,652	379	3	1,730	65	8,080	[4]10,720
Mountain and Pacific:								
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	3,206	W	218	1	385	15	3,810	15
Grand total[2]	51,786	51,969	1,624	62	12,291	1,171	65,702	53,202

W Withheld to avoid disclosing company proprietary data; not included in "Total."
[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, 1984, 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	100	17	18	24	2	160	26
Pennsylvania	806	47	151	109	17	1,130	100
Total	906	64	169	133	19	1,290	126
North Central:							
Illinois	450	([2])	5	49	([2])	504	14
Indiana	539	3	32	153	11	737	11
Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska	342	([2])	3	74	8	427	29
Ohio	463	10	44	125	8	649	57
Wisconsin	10	1	([2])	--	--	11	5
Total[1]	1,805	14	83	400	26	2,328	115
South Atlantic:							
Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia	388	6	11	39	5	449	24
South Central:							
Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, Tennessee, Texas	600	4	18	131	23	775	31
Mountain and Pacific:							
Arizona, California, Colorado, Hawaii, Montana, Nevada, Oregon, Utah, Washington	306	1	15	90	6	418	6
Grand total[1]	4,003	89	295	793	81	5,261	304

[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 1984

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price[1]
January	$92.10	$98.30	$90.30	$93.56
February	90.50	103.25	91.00	94.91
March	87.50	100.50	85.75	91.25
April	85.50	100.50	84.50	90.16
May	85.50	99.75	82.00	89.08
June	80.50	94.50	80.50	85.16
July	77.50	88.10	80.50	82.03
August	78.50	87.25	81.00	82.25
September	81.50	92.00	81.50	85.00
October	80.90	87.70	80.10	82.90
November	84.75	81.50	74.50	80.25
December	83.60	83.40	76.10	81.03
Average 1984	84.02	93.06	82.31	86.46
Average 1983[r]	75.03	77.46	68.64	73.71

[r]Revised.
[1]Composite price, Chicago, Pittsburgh, and Philadelphia. American Metal Market, Mar. 4, 1985.

Table 10.—U.S. exports[1] of iron and steel scrap, by country

(Thousand short tons and thousand dollars)

Country	1980		1981		1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	790	57,507	737	52,463	307	21,006	539	39,717	779	59,521
Greece	545	57,484	271	25,452	208	16,517	112	8,215	125	11,236
Italy	892	101,865	34	2,407	12	2,972	65	4,395	306	27,038
Japan	2,838	308,784	1,191	117,724	1,530	145,083	2,600	218,337	2,680	264,857
Korea, Republic of	1,736	192,745	1,241	114,736	1,522	115,515	1,476	111,051	1,833	160,892
Mexico	1,134	137,273	896	102,329	380	33,822	419	36,017	484	47,663
Spain	1,163	114,837	434	34,570	868	61,616	356	22,734	608	55,228
Taiwan	990	125,716	374	59,874	352	57,213	499	75,638	405	54,515
Turkey	318	31,363	364	31,814	639	48,286	700	50,851	807	69,579
Other	762	98,367	874	97,274	987	108,273	754	69,767	1,471	167,451
Total[2]	11,168	1,225,941	6,415	638,644	6,804	610,302	7,520	636,723	9,498	917,981

[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	1980		1981		1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	2,907	297,666	1,606	141,205	1,883	138,973	1,895	139,935	2,512	215,482
No. 2 heavy melting scrap	1,067	102,137	618	51,630	626	44,032	720	50,081	879	70,906
No. 1 bundles	119	11,542	41	3,476	115	8,619	206	16,486	77	8,258
No. 2 bundles	314	24,852	273	18,993	181	11,310	220	13,727	286	18,836
Stainless steel scrap	125	78,034	63	40,307	131	74,052	80	44,671	164	96,426
Shredded steel scrap	3,323	345,946	1,923	179,626	2,023	160,169	2,029	154,753	2,775	251,976
Borings, shovelings, turnings	769	50,381	486	24,757	577	28,923	532	28,277	800	49,664
Other steel scrap[1]	1,762	240,886	903	127,937	878	112,130	1,532	164,101	1,416	155,685
Iron scrap	783	74,497	501	50,714	389	32,096	306	24,692	590	50,748
Total[2]	11,168	1,225,941	6,415	638,644	6,804	610,302	7,520	636,723	9,498	917,981
Ships, boats, other vessels (for scrapping)	169	18,340	52	3,643	69	4,440	198	9,623	283	9,503
Rerolling material	86	12,768	57	10,831	53	7,969	34	4,194	58	10,918
Total exports[2]	11,423	1,257,049	6,524	653,118	6,925	622,711	7,752	650,540	9,840	938,402
Imports for consumption:										
Iron and steel scrap	582	61,192	556	62,126	[r]468	[r]37,572	641	48,219	572	46,946

[r]Revised.
[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	1980		1981		1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Korea, Republic of	4	538	--	--	--	--	5	462	--	--
Mexico	65	10,848	55	10,267	33	5,290	28	3,579	57	8,248
Pakistan	2	185	--	--	--	--	--	--	--	--
Other	14	1,197	2	564	20	2,679	1	153	1	2,670
Total	[1]86	12,768	57	10,831	53	7,969	34	4,194	58	10,918

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

Table 13.—U.S. imports for consumption of iron and steel scrap,[1] by country

Country	1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	116	$253	55	$175
Belgium-Luxembourg	422	11	63	49
Canada	589,645	41,754	532,241	41,866
Germany, Federal Republic of	2,027	94	2,141	131
Japan	1,346	2,634	3,157	419
Mexico	32,590	2,061	20,990	2,866
Netherlands	(2)	(2)	1	(2)
Panama	--	--	4,235	123
Sweden	251	101	750	104
United Kingdom	2,236	396	2,261	261
Other	12,113	913	6,115	952
Total[3]	640,745	48,219	572,010	46,946

[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)

Continent, country group, and country	1979	1980	1981	1982	1983
North America:					
Canada[2 3 4 5]	9,145	9,395	8,233	6,261	6,965
United States[2 5 6]	98,901	83,710	85,097	56,386	61,782
Latin America:[7]					
Argentina	1,621	[r]1,321	1,338	1,569	1,570
Brazil	6,497	7,130	6,052	5,625	6,137
Chile	204	209	[r][e]210	146	209
Colombia	261	211	[e]205	324	369
Mexico	[r]3,223	[r]3,425	3,618	3,332	2,383
Peru	230	[r]224	[r][e]180	120	186
Uruguay	[r]21	24	[e]20	34	56
Venezuela	1,052	1,068	[e]1,090	1,027	457
Central America, not further detailed	[8]128	[8]54	[e]50	[e]50	[e]50
Europe:					
European Economic Community:					
Belgium[2]	4,467	4,065	4,133	4,566	[e]4,685
Denmark[8]	[r]999	894	758	690	644
France	8,941	8,748	8,040	7,076	7,197
Germany, Federal Republic of[5]	23,993	22,401	21,632	[r]19,339	19,692
Greece[e]	330	310	300	300	275
Ireland[9]	93	3	41	76	174
Italy	17,928	[9]19,825	17,799	16,944	15,861
Luxembourg	1,968	1,738	1,458	1,450	1,508
Netherlands	2,166	2,025	1,961	1,594	1,607
United Kingdom	16,761	10,248	11,424	11,535	[10]10,858
European Free Trade Association:					
Austria	2,013	1,910	1,910	1,807	[3]1,797
Finland	819	848	807	758	[11]780
Norway	607	526	[r]559	537	[e]550
Portugal	542	564	480	[r][e]410	[e]575
Sweden[2 3]	3,045	[5]2,835	2,924	3,145	[e][3]3,395
Switzerland	[r][e]940	992	[9]948	[9]915	[e]915

See footnotes at end of table.

Table 14.—Iron and steel scrap consumption in selected countries[1] —Continued

(Thousand short tons)

Continent, country group, and country	1979	1980	1981	1982	1983
Europe —Continued					
Council for Mutual Economic Assistance:					
Bulgaria[e]	805	860	830	830	820
Czechoslovakia[2 3 5]	8,438	8,884	8,244	8,186	8,665
German Democratic Republic	5,545	5,833	5,816	5,649	5,682
Hungary[2 3 5]	2,595	2,528	2,425	2,446	2,445
Poland	11,597	11,817	9,598	[r]9,104	9,917
Romania[e]	4,190	4,300	4,250	[r]4,260	4,270
U.S.S.R.[e]	53,020	56,690	56,900	56,500	58,700
Other:					
Spain	7,961	[r]9,974	9,933	10,042	10,795
Yugoslavia	2,272	2,287	2,324	2,245	2,434
Africa: South Africa, Republic of[2 12]	3,062	3,974	3,333	[e]3,060	2,600
Asia:					
China[e]	8,700	9,400	9,000	9,400	10,100
India[e]	4,400	4,080	4,100	4,200	4,050
Japan[5]	50,292	48,291	44,616	42,832	44,269
Korea, Republic of[e]	1,800	2,200	2,700	3,300	3,350
Taiwan[e 13]	[r]1,100	1,200	1,100	1,400	1,700
Turkey	[e]1,500	[e]1,900	[9]1,764	[e]1,900	[e]2,300
Oceania:					
Australia	[9]2,639	[e]2,470	[e]2,480	[e]2,070	[e]1,820
New Zealand	[9]160	[e]160	[e]155	[e]160	[e]150
Total	[r]376,971	[r]361,551	[r]350,835	[r]313,600	324,744

[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 1983, v. 11, New York, 1984, 38 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 by 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, 1983, Santiago, 1984, 160 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 1979, Paris, 1980, 40 pp.; 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; The Iron and Steel Industry in 1983, Paris, 1985, 52 pp.

[10]Includes 8,543,000 tons reported for use in production of pig iron and crude steel, and an estimated 2,315,000 tons used by iron foundries.

[11]Excludes consumption, if any, in the production of pig iron.

[12]Iron and Steel Statistics Bureau (United Kingdom). International Steel Statistics, Republic of South Africa, 1981, p. 4.

[13]Excludes a substantial tonnage derived from shipbreaking (possibly of the order of several million short 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	1979	1980	1981	1982	1983
North America:					
Canada	1,139	865	632	r627	965
United States[2] [3]	11,124	11,254	6,472	6,857	7,554
Latin America:					
Mexico[2]	1	4	2	22	e25
Europe:					
European Economic Community:					
Belgium-Luxembourg	606	592	637	549	752
Denmark	100	110	204	r130	193
France	3,887	3,651	3,510	3,397	3,557
Germany, Federal Republic of	3,305	3,392	3,756	3,160	3,282
Greece	(4)	(4)	1	1	1
Ireland	79	93	80	65	23
Italy	14	9	25	19	20
Netherlands	1,259	1,316	1,380	1,300	1,678
United Kingdom	1,475	3,092	3,712	3,387	4,182
European Free Trade Association:					
Austria	17	14	14	10	14
Finland	3	(4)	(4)	(4)	(4)
Norway	46	42	35	35	40
Portugal	6	6	6	10	11
Sweden	19	15	15	20	23
Switzerland	110	71	141	116	164
Council for Mutual Economic Assistance:					
Bulgaria	143	171	87	63	42
Czechoslovakia[5]	137	109	113	95	e100
German Democratic Republic[5]	57	54	21	20	e20
Hungary	41	34	35	58	55
Poland[5]	12	16	r80	258	161
Romania[5]	1	(4)	(4)	(4)	(4)
U.S.S.R.[2]	2,190	2,756	2,681	2,859	3,715
Other:					
Iceland	5	3	3	4	8
Spain	(4)	1	r21	1	1
Yugoslavia	52	50	[2]65	70	78
Africa:					
Morocco[2]	98	38	r56	57	e60
South Africa, Republic of[5]	1	7	2	4	e4
Asia:					
China[5]	(4)	11	r161	108	e100
Hong Kong[2]	412	302	371	r327	353
India[2]	12	2	22	r e20	e20
Indonesia[2]	--	1	--	(4)	1
Japan	166	175	206	193	128
Korea, Republic of[2]	14	10	28	155	314
Malaysia[2]	15	12	13	7	e10
Philippines	3	2	2	2	1
Singapore[2]	2	6	2	9	132
Taiwan[2]	79	14	141	443	308
Thailand[2]	--	1	2	9	2
Oceania:					
Australia[2]	63	e600	708	1,249	e1,000
New Zealand[2]	5	49	3	3	3
Total	26,698	28,950	r25,445	r25,719	29,100

eEstimated. rRevised.

[1]Unless otherwise specified, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe 1983, v. 11, New York, 1984, 38 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	1979	1980	1981	1982	1983
North America:					
Canada	1,156	1,119	924	[r]505	[2]734
United States[2]	761	582	556	468	641
Latin America:					
Argentina[2]	7	2	2	2	[e]2
Brazil[2]	([3])	24	8	8	([3])
Chile	([3])	([3])	5	[e]10	[e]10
Colombia[2]	25	14	33	30	51
Cuba	[4]80	[4]95	[e]100	[e]100	[e]100
Mexico[2]	393	257	235	96	[e]100
Peru[2]	--	36	40	18	[e]20
Venezuela[2]	50	36	55	[e]50	[e]50
Europe:					
European Economic Community:					
Belgium-Luxembourg	1,069	947	1,054	978	[2]1,152
Denmark	313	239	198	[r]97	74
France	465	503	383	304	338
Germany, Federal Republic of	1,769	1,658	1,473	1,421	1,423
Greece	254	263	317	478	[2]574
Ireland	6	9	4	2	77
Italy	7,596	8,168	6,107	6,141	4,901
Netherlands	136	170	262	244	401
United Kingdom	49	28	23	41	12
European Free Trade Association:					
Austria	149	158	187	420	241
Finland	98	117	68	56	41
Norway	8	58	26	4	17
Portugal	161	164	94	[r]138	121
Sweden	143	84	272	583	496
Switzerland	197	151	125	118	162
Council for Mutual Economic Assistance:					
Bulgaria	[4]1	([3] [4])	--	--	--
Czechoslovakia[4]	47	62	[r]278	81	[e]100
German Democratic Republic	780	1,001	764	502	[e]500
Hungary	7	4	159	15	31
Poland	7	250	58	6	6
Romania	11	62	--	--	--
U.S.S.R.	[5]22	[6]23	[6]24	[6]27	[e]30
Other:					
Spain	3,805	4,835	4,479	[r]5,249	5,227
Yugoslavia	292	437	[2]528	560	812
Africa:					
Egypt[2]	18	41	15	14	[e]15
Morocco	([3])	([3])	[2]2	[2]3	[e]3
South Africa, Republic of[2]	9	31	14	[r]31	8
Asia:					
China[4]	6	2	([3])	3	[e]3
Hong Kong[2]	116	103	104	71	30
India	160	124	573	[r] [e]500	[e]500
Indonesia	33	43	69	250	2,281
Japan	3,688	3,291	1,974	2,232	4,306
Korea, Republic of[2]	1,742	2,130	2,546	1,994	2,090
Malaysia	7	5	60	28	[e]30
Pakistan	139	368	[2]534	[2]173	[2]132
Philippines[2]	105	10	10	28	([3])
Singapore[2]	120	190	86	103	104
Taiwan[2]	839	1,358	971	718	811
Thailand[2]	678	373	460	429	707
Turkey	399	381	579	825	1,184
Oceania:					
Australia[2]	1	1	1	[e]1	[e]1
New Zealand[2]	1	69	5	6	3
Total	[r]27,918	[r]30,076	[r]26,844	[r]26,161	30,652

[e]Estimated. [r]Revised.

[1]Unless otherwise specified, source is United Nations Economic Commission for Europe. Annual Bulletin of Steel Statistics for Europe 1983, v. 11, New York, 1984, 38 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]Officially reported, but may be an incomplete figure.

[6]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, $Al_2O_3 \bullet SiO_2$. 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 no record in recent years exists of significant utilization of either dumortierite or topaz for this purpose in the United States.

Although published statistics were incomplete, the United States, the Republic of South Africa, and India appeared to be the leading world producers of kyanite-group minerals. The U.S.S.R. and perhaps a few other industrialized nations were also presumed to produce significant quantities of these materials.

U.S. kyanite output in 1984 was estimated to be slightly higher than that of 1983. Major end uses of kyanite and mullite were in refractories for the ferrous and nonferrous metals industries. These industries showed some increase in output in the first half of 1984 compared with that of 1983.

Export and import data since 1977 for kyanite and mullite-containing materials are no longer collected as a separate category by the Bureau of the Census.

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. One company stopped responding in the late 1970's and the other, with two mines, last reported in 1981. 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 1984, 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. C-E Minerals Inc. operated the Graves Mountain Mine in Lincoln County, GA. In late 1984, C-E Minerals sold its kyanite operation to its management staff. The name of the new company is Pasco Mining Inc.

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 1984 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 at Americus, GA, and Harbison-Walker Refractories Co. at Eufaula, AL. Electric-furnace-fused mullite was produced by The Carborundum Co. at Niagara Falls, NY.

Table 1.—U.S. production of synthetic mullite

Year	Quantity (short tons)	Value (thousands)
1980	40,540	$8,012
1981	42,000	9,050
1982	27,000	5,950
1983[e]	23,000	4,700
1984[e]	27,000	5,300

[e]Estimated.

CONSUMPTION AND USES

Kyanite and related materials were consumed mostly in the manufacture of high-alumina or mullite-class refractories and 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 1984, 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.

The December 1984 issue of Industrial Minerals (London) quoted kyanite-group prices approximately equivalent to the following:[2]

	Per short ton
Andalusite, Transvaal, 52% to 54% Al_2O_3, bulk, c.i.f. main European port	$79
Andalusite, Transvaal, 60% Al_2O_3, c.i.f. main European port	102
Sillimanite, South African, 70% Al_2O_3, bags, c.i.f. main European port	215
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
U.S. kyanite, f.o.b. plant, carlots:	
Raw	70-137
Calcined	123-172

FOREIGN TRADE

An estimated one-third of U.S. production of kyanite and mullite-containing materials was exported, primarily to the Federal Republic of Germany. According to a non-Government source, 6,000 tons of andalusite was imported in 1984 from the Republic of South Africa.

WORLD REVIEW

Australia.—A journal article described the mining operation of Australian Industrial Minerals N.L. (AIM), located near Williamstown, 36 miles northeast of Adelaide, the capital of South Australia. Refractory clay, filler clay, sillimanite, and mica were produced from two open pit mining operations. Output of sillimanite, approximately 650 to 750 tons per year, was being sent to Nonporite Ltd. in Melbourne for calcining and resale for use in high-temperature refractories such as porcelain insulators for spark plugs. AIM was developing a market for sillimanite in Japan.[3]

A deposit of topaz and quartz in silexite, an igneous rock, was under investigation at Torrington in New South Wales. Early work had established indicated and inferred reserves of 6.6 million tons of silexite containing 1.3 million tons of topaz. However, reserves had evidently been extended since. Calcination of topaz at 2,280° F to 2,550° F yields mullite and fluorine-rich gases, mainly silicon tetrafluoride. The latter can be converted to fluosilicic acid or sodium hexafluoride, which are starting compounds for manufacturing fluorine chemicals. Topaz concentrates were test calcined and yielded a clean, white mullite product containing over 70% alumina. Two groups apparently interested in the deposit were Pacific Copper Ltd. and Kingsway Resources.[4]

Canada.—Topaz was expected to be a byproduct from a proposed Rio Algom Ltd. tin mine 34 miles northeast of Yarmouth, Nova Scotia, near the village of East Kemptville. Topaz would be separated electrostatically from a cassiterite concentrate.[5]

China.—Andalusite was discovered in Liaoning Province, with reserves estimated to be over 55 million tons. The deposit is close to the surface at some points, and open pit working was considered feasible.[6]

A large-scale sillimanite mine with total reserves of 40 million tons was verified in Jixi City, Heilongjiang Province.[7]

India.—In addition to reserves of about 140,000 tons of lump kyanite at Hindustan Copper Ltd.'s Lapso Buru mining operation in Bihar State, very large tonnages of lower grade material exist in India. Initial beneficiation test work on lower grade material by the Indian Bureau of Mines at their laboratories in Nagpur, Maharashtra State, yielded favorable results. Beneficiation of a sample of raw kyanite ore containing approximately 35% kyanite, 50% quartz, 10% mica, and 5% other minerals yielded a product containing about 95% kyanite, 1% quartz, 1% mica, and 3% other minerals. The product was considered to be acceptable for refractory use.[8]

Japan.—Imports of kyanite, andalusite, and sillimanite in 1983 totaled 19,500 tons; countries of origin were the Republic of South Africa, 13,400 tons; the United States, 5,300 tons; and India, 700 tons.[9]

United Kingdom.—In 1983, imports of kyanite-group minerals totaled 39,300 tons; principal countries of origin and tonnages were France, 18,700 tons; the Republic of South Africa, 13,400 tons; and the United States, 4,500 tons.[10]

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[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$1.25.

[3]Industrial Minerals (London). A Profile of the Williamstown Kaolin-Sillimanite-Mica Deposits. No. 196, Jan. 1984, pp. 37-40.

[4]Coope, B. M. Developments in Australia's Industrial Minerals. Ind. Miner. (London), No. 206, Nov. 1984, p. 69.

[5]Moyle, J. E. Development and Construction Begins at East Kemptville, North America's Only Primary Tin Mine. Min. Eng., v. 36, No. 4, Apr. 1984, p. 336.

[6]Industrial Minerals (London). Company News & Mineral Notes. No. 205, Oct. 1984, p. 71.

[7]———. No. 207, Dec. 1984, p. 67.

[8]Mining Magazine (London). Beneficiation of Lapso Buru Kyanite. V. 151, No. 4, Oct. 1984, p. 289.

[9]Industrial Minerals (London). Japanese Imports and Exports of Industrial Minerals, 1983. No. 203, Aug. 1984, p. 52.

[10]———. United Kingdom Industrial Mineral Statistics. No. 199, Apr. 1984, p. 73.

Table 2.—Kyanite: World production, by country[1]

(Short tons)

Country[2] and commodity	1980	1981	1982	1983[p]	1984[e]
Australia: Sillimanite[3]	729	365	863	[r] [e]225	225
Brazil: Kyanite[4]	4,707	1,753	466	[r] [e]1,100	1,100
China: Unspecified[e]	2,800	2,800	2,800	2,800	2,800
France: Kyanite-andalusite[e]	33,100	33,100	33,100	33,100	33,100
India:					
Andalusite	--	161	591	2,836	3,000
Kyanite	51,282	42,200	37,425	42,226	41,890
Sillimanite	14,315	11,303	14,403	8,739	9,925
Korea, Republic of: Andalusite	90	99	90	319	220
South Africa, Republic of:					
Andalusite	216,622	199,818	171,655	128,503	155,425
Sillimanite	17,851	17,090	11,089	898	1,545
Spain: Andalusite	7,133	6,780	5,627	4,945	4,960
United States:					
Kyanite	W	W	W	W	W
Synthetic mullite	40,540	42,000	27,000	[e]23,000	27,000
Zimbabwe	789	959	2,433	[e]2,540	2,540

[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. 17, 1985.

[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]Series reflects output of marketable products; crude production (as reported in previous editions of this chapter) was as follows, in short tons: 1980—24,505 (revised); 1981—24,302 (revised); 1982—24,302; 1983—20,000 (revised, estimated); and 1984—20,000 (estimated).

Lead

By William D. Woodbury[1]

Domestic mine output of recoverable lead declined by about 127,000 metric tons in 1984, and was the lowest production since 1967. Primary refinery output was also the lowest since 1967 and was about 119,000 tons less than that of 1983. The low production levels in 1984 were attributed to strikes of 8-1/2 months and 7 months at mines in Missouri of the Nation's two fully integrated primary lead producers. The plants affected by the strike in Missouri operated intermittently, often using only supervisory and other salaried personnel. Secondary refinery production in the United States, however, increased significantly during the year after 4 consecutive years of decline. Net imports of refined metal for consumption were over 150,000 tons for the second straight year. Total domestic reported consumption, especially by the lead-acid storage battery sector, increased significantly and reached the highest level since 1979.

Table 1.—Salient lead statistics

(Metric tons unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production:					
Domestic ores, recoverable lead content	550,366	445,535	512,516	r449,216	321,897
Value thousands	$515,189	$358,821	$288,579	r$214,708	$181,305
Primary lead (refined):					
From domestic ores and base bullion	508,163	440,238	459,865	459,328	330,168
From foreign ores and base bullion	39,427	55,085	52,295	55,227	65,409
Antimonial lead (primary lead content)	851	3,008	4,622	W	W
Secondary lead (lead content)	675,578	641,105	571,276	503,501	582,753
Exports (lead content):					
Lead ore and concentrates	27,615	33,043	29,104	20,119	11,858
Lead materials excluding scrap	164,458	23,320	55,629	r24,351	16,563
Imports, general:					
Lead in ore and matte	44,095	58,545	35,807	47,516	68,870
Lead in base bullion	296	449	19	53	43
Lead in pigs, bars, reclaimed scrap	88,995	107,185	99,587	[1]179,485	167,868
Stocks, Dec. 31 (lead content):					
At primary smelters and refineries	125,994	140,207	125,537	106,661	135,079
At consumers and secondary smelters	126,214	123,216	97,209	100,771	97,072
Consumption of metal, primary and secondary	1,070,303	1,167,101	1,075,408	1,148,487	1,207,033
Price: Common lead, average, cents per pound[2]	42.46	36.53	25.54	21.68	25.55
World:					
Production:					
Mine thousand metric tons	r3,469.7	r3,369.7	3,441.8	p3,366.2	e3,190.4
Refinery[3] do	r3,169.4	r3,126.6	3,169.6	p3,231.2	e3,153.0
Secondary refinery do	r2,260.5	r2,211.6	2,059.1	p2,022.9	e2,135.5
Price: London Metal Exchange, pure lead, cash average, cents per pound	41.21	33.30	24.66	19.27	20.12

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.

In addition to the supply disruptions in the United States, there were strikes and floods in Australia; disputes between smelter-refinery operators in Europe and Morocco and the concentrate producers in Morocco; and floods, landslides, and guerilla activities hampering shipments in Peru. Therefore, world primary refined lead production declined. Total refined lead production was about 120,000 tons less than the estimated total world consumption, which was over 150,000 tons greater than that estimated for 1983. The temporary disruptions of production caused intermittent shortage periods throughout the world of high-quality 99.99% refined lead, the standard generally in demand by battery manufacturers. Those temporary supply squeezes allowed the U.S. and London Metal Exchange (LME) prices to recover in June, July, and August, the start of the buying season by the battery manufacturers, to the highest levels since 1982. The average U.S. producer price for 1984 was about 4 cents per pound greater than that of 1983, and about the same as that of 1982, at 25.5 cents per pound. On the LME, the price averaged 1 cent per pound greater than that of 1983, and averaged 5.4 cents per pound less than in the United States, which permitted considerable importation of refined lead metal into the United States.

In the United States, major Government agency and legislative actions affected the lead industry with respect to effluent limitations from producer and consumer plants, in-plant maximum permissible exposure limits for workers, solid and hazardous waste disposal, and new limits for lead in gasoline were proposed to become effective in 1985. In 1984, a prototype 25-ton-capacity, battery-powered tractor was tested and evaluated under actual specialized working conditions, with encouraging results. Also, a newly developed lead-foil and plastic-laminate underground power cable system was installed in the United States.

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 and consumer surveys. Of the 348 plants to which a consumer survey request was sent, 95% responded, representing 99% of the total lead consumption shown in tables 1, 12, 13, 14, and 15. Of the 67 plants to which a secondary smelter production survey request was sent, 93% responded, representing 97% of the total refinery production of secondary lead recovered from scrap shown in tables 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.—In March, the Environmental Protection Agency (EPA) published final effluent limitations under the Clean Water Act of 1977, as amended, that included lead and battery manufacturing plants. The limits were based on each type of plant production or consumption of metal and the best available technology (BAT), which generally represented the best existing performance in a specific industry. The standards became effective on July 1, 1984. For those existing plants indirectly discharging through, or interfering with, publicly owned water treatment plants, BAT pretreatment standards must be complied with by March 1987. In 1983, an economically achievable standard of zero discharge of process waste water, based on 100% recycling, was established for lead oxide manufacturers.

All primary and secondary lead smelter-refineries and lead-acid-battery manufacturing plants were required to submit final compliance plans for the Occupational Safety and Health Administration's (OSHA) in-plant maximum permissible exposure limit (PEL) standard of 50 micrograms of lead per cubic meter of air by August 1, 1984. The operational deadline was June 29, 1986, for secondary and battery plants, and June 29, 1991, for primary smelter-refineries. The interim operational PEL standard in effect for all plants until these dates was 100 micrograms of lead per cubic meter of air. Variable combinations of administrative controls and worker self-protection, with engineering controls, could be employed in the interim and final plans, but each plan was to be negotiated on a plant-by-plant basis with the Government, and where applicable, with the union. Variable combinations were permitted instead of full compliance solely by the engineering-controlled average limits (ECAL) originally mandated, because ECAL were determined by OSHA to be uneconomical in most cases and technologically infeasible to retrofit in some cases.

On November 8, 1984, Public law 98-616, the Hazardous and Solid Waste Amendments Act, was enacted amending the Solid Waste Disposal Act of 1965 (SWDA) previous amendments, the Resource Conservation and Recovery Act of 1976, and the SWDA amendments of 1980. Under Public Law 98-616, lead mine, concentrator, and smelter-refinery effluents, including those associated with any solid or sludge, would be classified as hazardous if the concentration of lead or its compounds were 500 parts per million or greater, and/or the pH was less than or equal to 2.0. The EPA Administrator, however, in the case of all mine and other special wastes, was authorized to modify the minimum technological disposal and monitoring requirements in the case of landfills or surface impoundments receiving such solid wastes, as long as protection of human health and the environment were ensured. The general provisions of the law also apply to all secondary plants and lead product plants, including battery manufacturers and breakers.

The EPA announced in early August that it was considering a reduction in the permissible amount of lead in gasoline to 0.1 gram per gallon effective January 1, 1988, nearly a 90% reduction from the 1.1-gram-per-gallon standard in effect since November 1, 1982. The effective date was subsequently moved up to January 1, 1986. An interim limit of 0.5 gram was set for July 1, 1985, and a total ban was being considered at the end of 1984 for January 1, 1988. According to EPA, the change was needed because of significantly more leaded gas being consumed than anticipated, apparently owing to considerable unlawful consumer use of leaded gasoline in vehicles requiring unleaded gasoline.

On July 25, 1984, the U.S. Department of Commerce's International Trade Administration (ITA) directed the U.S. Customs Service to immediately start collecting a cash deposit of 5.22% on imports of litharge, red lead, and lead stabilizers from Mexico as a countervailing duty based on a finding of unfair subsidization of those products by the Government of Mexico. This was in addition to the 3.39% ad valorem penalty imposed on December 6, 1982. The ITA also finally decided on a 9.26% retroactive penalty on those same products imported from Mexico between September 21, 1982, and December 5, 1982. On October 30, 1984, an omnibus trade bill was signed into law, which included a provision reducing the tariff on unwrought lead from 3.5% ad valorem to 3.0% ad valorem, but not less than 1.0625 cents per pound. The provision was retroactive to July 1, 1983, on which date a similar law expired. The new provision expires on December 30, 1988.

Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), which was scheduled to expire in September 1985, lead oxide producers are taxed at a rate of $4.56 per ton ($4.14 per short ton). Several Superfund reauthorization bills introduced in Congress in 1984 proposed that all lead be added to the list of potentially hazardous materials to be taxed, but no legislation was enacted. Proposed revenue schemes included waste-end taxes, corporate taxes on hazardous waste generation, direct taxes on metal feedstocks (either flat rate or geared to a specified percentage of the selling price), and various broad-based value-added systems.

During 1984, the National Defense Stockpile remained at 545,000 tons, about 55% of the current authorized goal.

DOMESTIC PRODUCTION

MINE PRODUCTION

The production of U.S. lead mines in terms of recoverable lead content was the lowest since 1967, 2 years before the Missouri Viburnum Trend operations came fully on-stream. The decline in 1984 was the result of prolonged strikes at the Nation's two Missouri-based, integrated primary producers' facilities. Seven Missouri lead mines accounted for over 86% of total domestic production, and together with the lead-producing mines in Colorado, Idaho, Montana, and New York accounted for 99.8% of the total U.S. mine output. Some byproduct lead was also recovered from mining in six other States during the year.

According to AMAX Inc.'s annual report, the Buick Mine in Iron County, MO, equally owned by AMAX Lead Co. of Missouri, the operator, and Homestake Mining Co., continued to be the Nation's largest single lead-producing unit, milling 1.36 million tons of ore at an average grade of 8.1% lead. Production was down nearly 30% from that of 1983 owing to a strike by the United Steelworkers of America from June 1 to December 29, 1984, during which time the mine was operated at reduced capacity using supervisory personnel and workers brought in from other AMAX operations. The average lead content of the ore hoisted for the year was 0.2% higher than that of 1983. The lead content of the concentrates produced was 106,230 tons. Estimated reserves of the mine at yearend were 32.75 million tons of ore at an average grade of 5.6% lead, down 0.1% in grade and 1.65 million tons from yearend 1983.

The second largest producing lead mine was the Magmont Mine, jointly owned by Cominco American Incorporated and Dresser Industries Inc. The Magmont Mine is also in Iron County, MO. According to Cominco Ltd.'s annual report, 1.01 million tons of ore was milled at an average grade of 7.1% lead. Lead concentrate production decreased slightly to 90,350 tons from that of 1983, and the average grade also decreased, from 77.4% to 77.0%, reflecting the 0.1% overall drop in the grade of the ore hoisted. In August, the mine attained its highest monthly production of total concentrates ever—14,300 tons. A new annual record was also set for total concentrate production, owing to significantly higher zinc grades and improved mining equipment efficiencies in the new Magmont West area, which was opened in late 1983. Total measured and indicated reserves at Magmont increased over 25% to 7.17 million tons in 1984, but the average lead grade dropped from 8.0% to 6.5%. 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.

St. Joe Lead Co., the largest integrated producer of lead in the United States, about 34% of domestic lead mine production in 1984, operated three mine and mill complexes involving five mines in southeastern Missouri. According to St. Joe's parent corporation, Fluor Corp., in its annual Securities and Exchange (SEC) Form 10-K covering Fluor's fiscal year ending October 31, 1984, the five mines produced 122,700 tons of lead in concentrates. The Fletcher Mine in Reynolds County, MO, was the Nation's third largest producing lead mine during the year. An additional 2,145 tons was produced at St. Joe's zinc mines in New York. St Joe's total production was down considerably from its 1983 fiscal year owing to a strike from April 1 to December 12, 1984, at the company's five Missouri mines. Curtailed production levels were attained by the use of salaried personnel and nonunion labor. The three mills treated 2.67 million tons of ore grading 4.76% lead, a tonnage decrease of 36% from that of fiscal year 1983. St. Joe's total estimated mill capacity was 20,000 tons of ore per day, and its mine capacity was estimated by the Bureau of Mines to be about 40% of that estimated for the U.S. primary lead industry. St. Joe had proven domestic reserves in Missouri of 57.3 million tons of ore grading about 5% lead at its fiscal yearend.

Hecla Mining Co. reported in its annual report that its Lucky Friday unit in Shoshone County, ID, produced at capacity throughout the year and milled a record high 233,432 tons of silver ore that contained 28,428 tons of lead, also a new record. The record highs were attributed primarily to the first full year of production from the 6,200-foot-deep shaft, but during the year the unit's efficiency was also improved by the completion of a new pumping system and cooling plant, turbine generator, and new ball mill. An exploration program began in the first quarter to explore recently acquired properties surrounding Lucky Friday, including a long-term lease on Allied Silver-Lead Co.'s property acquired during the year. Ore reserves at Lucky Friday at yearend were 569,260 tons, up 21% over that of 1983, and were estimated by Hecla to contain 17.5 troy ounces of silver per ton and 13.2% lead, up 1% over that at yearend 1983. Hecla operated the Sherman Mine, or Sherman Tunnel, on a 60% equity basis for Leadville Corp. in Lake County, CO, but sold its 60% share back to Leadville on December 14, after ceasing operations in September for economic reasons. For 9 months in 1984, the mine had produced over 500,000 troy ounces of silver and 280 tons of byproduct lead.

Preliminary underground development at Asarco's large new West Fork Mine in southeast Missouri continued and was expected to be completed in the first quarter of 1985, with probable initial production phasing in late in the year. When in full operation, West Fork was reported to be capable of processing 3,450 tons of ore per day and producing 46,000 tons per year of lead in concentrates, according to Asarco. The reserves were estimated at 13.6 million tons, grading 5.5% lead and 1.2% zinc in the company's 1984 annual report. Output at the Leadville Mine in Colorado, formerly known as the Resurrection Mine, which Asarco operated under a 50%-owned joint venture, totaled 6,100 tons of lead in concentrates.

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 134,500 tons of refined lead, down 35% from that of 1983 owing to the strike at its captive mines, according to St. Joe's parent, Fluor Corp., in its annual SEC 10-K Report. The plant was shut down from May 18 to mid-September for lack of feedstocks. Sintering operations were restarted in mid-September, and smelting and refining operations were resumed at the beginning of October at about one-half capacity. The second blast furnace was not restarted until after the December 9 mine strike settlement. According to AMAX's SEC 10-K Report, the AMAX-Homestake smelter-refinery at Boss, MO, produced 104,650 tons of refined lead from Buick Mine concentrates, down 19% from the record high set in 1983. The decline was attributed to a strike during the second half of the year. The plant continued to operate under salaried technical and administrative personnel at 33% to 75% of capacity, but was closed completely from November 10 to yearend to replenish feedstocks.

Asarco reported that its three smelters, one each at East Helena, MT, El Paso, TX, and Glover, MO, produced 184,700 tons of lead bullion. That was only 3,300 tons less than that of 1983 despite two lengthy shutdown periods at the Glover facility, owing to a temporary shortage of feedstocks from March 4 to May 7, and a strike from October 1 to mid-December. In the latter instance, the refinery was operated by salaried and supervisory personnel at about one-half capacity, processing stockpiled bullion. The El Paso and East Helena smelters, which processed purchased and custom toll concentrates from both foreign and domestic sources, shipped their bullion to Asarco's Omaha, NE, refinery where 101,240 tons of lead metal for domestic consumption was produced, 11,240 tons more than that of 1983. Refinery production at Glover was down about 19% from that of 1983 to 74,200 tons or about three-quarters of capacity, but the company's total refined lead production for domestic consumption was down only 5,700 tons from that of 1983. The feedstocks to the Glover smelter-refinery came primarily from Cominco-Dresser's Magmont Mine at Boss, MO, supplemented by some foreign concentrates. The overall toll and purchased feed to El Paso and East Helena came primarily from Peru, Australia, and Canada, in order of significance. Feed purchased for domestic consumption, however, was mostly from Peru, where Asarco had direct interests or long-term relationships, and the El Mochito Mine in Honduras, operated by Rosario Resources Corp., a wholly owned subsidiary of AMAX.

Secondary.—Permanent closure was announced for two secondary smelter-refineries with a combined capacity of 62,000 tons per year, and one plant with a capacity of 68,000 tons per year closed indefinitely in January owing to bankruptcy. Three other plants that closed indefinitely in 1983, totaling an additional 69,000 tons of capacity, were not expected to reopen. Although the capacity of the secondary lead industry was about 1.1 million tons at the beginning of the year, it was less than 900,000 tons at yearend, the lowest level since the early 1970's. During the year, about 70 companies produced some form of secondary lead, but 26 of those companies, operating 37 plants with capacities greater than 5,000 tons per year and ranging to 65,000 tons per year, produced about 99% of the reported secondary lead total. In July, Bergsoe Metal Corp. sold its Seattle, WA, secondary smelter, refinery, and lead products complex to Seafab Metal Corp., which permanently closed the smelter and refinery. This closure reduced the secondary lead production capacity in the Pacific Northwest by over 50%. In April, Federated Metals Corp., a wholly owned subsidiary of Asarco, sold its secondary lead solder plant in San Francisco, CA, to Frys Metals Inc.; and in May, RSR Corp., the Nation's largest secondary lead producer, sold its 65,000-ton-per-year smelter-refinery at Dallas, TX, to Murmur Corp. under a divestiture ordered by the Federal Trade Commission. The plant in Texas did not come back on-stream during the year, however, owing to environmental cleanup and legal problems. The plant had been shut down by RSR since the end of February.

CONSUMPTION AND USES

The increase in reported domestic consumption of lead was the result of increased usage in virtually every end use except gasoline additives, radiation shielding, and lead-based solder. The increase in the use of lead oxides in glass and ceramic products was attributed primarily to the growth market of television tubes, especially video display terminals for computers and word processors, which represent about 75% of the use of lead in the glass and ceramic sector. The first lead-foil and plastic-laminate underground power cable was installed in the United States by U.S. and Japanese companies in a joint venture. Cross-linked polyethylene insulated cable, which had been increasingly used to replace lead for land cables, are proving to be relatively short lived, and lead was expected to regain a significant share of this end use category.

According to Battery Council International, shipments of replacement automotive batteries, the largest single end use of lead, increased 5.8% to 59.33 million units, and shipments of original equipment automotive batteries increased almost 18% to 12.77 million units. These increases, together with over a 23% increase in the consumption of lead and lead oxides for the manufacture of industrial and traction batteries, resulted in the total battery sector in the United States increasing its consumption of lead by over 7%. The Bureau of Mines estimated consumption of lead for industrial and traction batteries at 102,500 tons. The total use of lead in each automotive battery was estimated by the Bureau of Mines to have declined about 0.5 pound per unit from 1983 to an estimated 20.6 pounds per unit. However, markedly increased new car sales (especially larger ones), an 18% increase in lead-acid storage battery exports to just under 2.6 million units, and the high incidence of consumer replacements more than offset the loss in the average lead weight per unit. The use of lead for storage batteries in the United States reached a record high 72% of the total lead consumed for all products.

STOCKS

Refined soft lead stocks at domestic primary refineries decreased almost 20% because of the supply disruptions at domestic mines, which resulted in curtailed operations at the three Missouri smelter-refineries in addition to the strike at Asarco's Glover facility. However, concentrate feedstocks on hand at yearend were nearly twice those at yearend 1983, owing to about a one-third increase in concentrate imports as the smelters replenished depleted feedstocks in anticipation of more prolonged strikes than actually occurred. Bullion stocks remained about level, and stocks at U.S. secondary producers and consumers declined slightly.

Stocks of lead and antimonial lead metal in the market economy countries reporting to the International Lead and Zinc Study Group (ILZSG) were approximately 430,000 tons at yearend, about 8% of current total world annual demand, and 110,000 tons less than that at yearend 1983.[2] The net decline of over 20% was mostly the result of 131,000 tons being withdrawn from LME warehouses during 1984. At yearend, LME lead metal stocks were 41,000 tons, the lowest yearend level since 1979.

PRICES

The U.S. producer price quotations for lead opened 1984 in a range of 24 to 26 cents per pound, according to Metals Week, but at the end of the first week in January the quote increased to 24 to 28 cents. These quotations held through the first week of March, but then narrowed to 25 to 28 cents and remained at that level through mid-June. Most sales, however, were discounted around the low quotation as seasonal demand from the battery manufacturers tapered off. In mid-June, the quoted producer prices moved upward to 28 to 30 cents per pound in anticipation of possible strike-caused shortages during the impending battery manufacturers' buying season. The quoted range continued to rise gradually, reaching 30 to 34 cents during the first week of August, then declined gradually throughout the rest of the year, closing in the range of 20 to 23 cents per pound, 3 to 4 cents lower than at the start of the year. The weighted average U.S. producer transactions price of 21.9 cents per pound during December was the lowest monthly price since September 1983 (21.7 cents), and that of 30.5 cents per pound in July 1984 was the highest since December 1981 (31.07 cents). The average producer transactions price reached 8.2 cents per pound above the LME average cash price during July 1984, a record-high spread since July 1979, from which time U.S. prices have stayed consistently above the LME. However, the spread dropped to only 0.5 cent per pound by yearend, compared with 7.1 cents in January. The average spread for the year of 5.4 cents per pound made importation attractive, even though most domestic sales were near the low end of the range. The total cost of shipping, duty, handling, and inland freight to U.S. destinations of imported pig lead was estimated to average 5 to 6 cents per pound, with ocean freight, duty, and insurance accounting for 3 to 3.5 cents.

The quoted 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 technique, freight considerations, quality requirements, and other factors. The average total premiums for 100-pound units in carload lots, f.o.b. plant, exclusive of container, were 13.1 cents per pound above the average pig lead for litharge, and 15 cents above for red lead, according to shipment values reported to the Bureau of Mines.

FOREIGN TRADE

Owing to the mine strikes in Missouri, exports of lead in concentrates decreased 41% from the 1983 level, which had been the lowest level since lead concentrates were classified separately from mixed ores in 1978. Nearly all of the exports of concentrates in 1984 went to Canada, which in turn supplied nearly 60% of the refined pig lead imported by the United States. Exports of pig metal and wrought lead products were the lowest since 1976. Taiwan was the major market for U.S. scrap exports in 1984. The lead content of exported scrap, which was recorded by gross weight, was estimated to be 60%. The United States had net imports for consumption of lead in all forms, including scrap and drosses or other residues, of 142,600 tons compared with 125,800 tons in 1983. Peru, a traditional supplier of concentrates to domestic producers, supplied about two-thirds of that category, but receipts from the other traditional supplier, Honduras, were significantly below normal for the second straight year. About one-quarter of U.S. imports of refined pig lead came from Mexico, but those from Australia, in recent years the third leading source, declined by about one-third owing to lengthy strikes. Canada, Mexico, and Peru accounted for nearly 90% of contained lead in all forms imported by the United States. Canada was the recipient of over one-third of the U.S. exports of lead in all forms.

The 22% increase in total imports of lead chemicals and compounds was primarily attributed to about a one-third increase in the importation of chrome yellow used for highway markings and a one-third increase in lead salts compared with that of 1983. Mexico accounted for most of the U.S. imports of litharge and red lead, while Canada supplied 37% of all other categories, including over 70% of the chrome yellow. The Federal Republic of Germany and the Netherlands supplied 42% of all the other categories. Peru accounted for most of the lead arsenate imported; China, most of the lead nitrate; and the Federal Republic of Germany, about 60% of the lead acetate. Canada, Mexico, and Peru supplied 83% of the total U.S. imports of lead chemicals and oxides.

Table 2.—U.S. import duties for lead materials, January 1, 1984

(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	2.8% 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 Omnibus Trade Act.

WORLD REVIEW

According to ILZSG statistics, consumption of refined soft lead and antimonial lead in the market economy nations was over 3.9 million tons, compared with about 3.8 million tons in both 1983 and 1982 and about 3.9 million tons in 1981.[3] Estimated total world consumption of lead in all forms during 1984 increased significantly to 5.41 million tons from 5.25 million tons in 1983, compared with 5.23 and 5.34 million tons in 1982 and 1981, respectively. Estimated 1984 total world refinery production, which excluded remelt scrap, increased marginally compared with that of 1983, but world primary metal and mine production both decreased significantly, a result of the major supply disruptions in Australia, Morocco, Peru, and the United States. World secondary lead production, however, increased by over 100,000 tons, mostly in the United States, and was over 40% of the world's total refinery output.

ILZSG, at its 29th annual session in Geneva, Switzerland, in October 1984, forecast lead consumption during 1985 to remain stable in the fully industrialized countries but to strengthen in some of the developing countries. Rises in both mine and metal production were anticipated, assuming increased output in the United States and other countries in which it had been interrupted in 1984. Net metal exports to the centrally planned economy countries were about 100,000 tons during 1984 and were expected to remain at that level in 1985.

Australia.—Production at Broken Hill Associated Smelters Pty. Ltd.'s (BHAS) Port Pirie complex, Australia's only primary refinery, was about the same as that of 1983 despite planned increases. Production was less than planned because of strikes at BHAS's parent Australia Mining and Smelting Ltd.'s (AM&S) two mines at Broken Hill, New South Wales, and North Broken Hill Ltd.'s North Mine. These three mines represented over 40% of Australia's estimated lead mine capacity. The strikes began in late March and lasted 7 weeks, until mid-May. During that period, there were also strikes at Aberfoyle Ltd.'s Que River Mine, and EZ Industries Ltd.'s Read Rosebery Mine, in Tasmania. However, production at Mount Isa in Queensland was slightly more than the previous record high 1983 total, and also increased at AM&S's CSA Mine and EZ's Elura Mine, in New South Wales. Overall, lead mine production was down only 7% and exceeded that of the United States for the second consecutive year.

Output of secondary refined lead from the Port Pirie complex was considerably reduced owing to the mine strikes idling the plant. The Government approved a 1982 plan for BHAS to acquire a 50% interest in Simsmetal Pty. Ltd.'s 19,000-ton-per-year secondary smelters at Sydney and Melbourne. The joint venture reportedly should enable those two plants to achieve a production level more in line with their current capacities, and the diversion of secondary materials away from Port Pirie should allow for an increase in primary feed processing at that location. BHAS also acquired an interest through investment in Thai Ping Industrial Co. Ltd.'s 25,000-ton-per-year secondary plant at Tauliau, Kaohsiung, Taiwan, during 1984. Consideration was being given to expanding that facility to 40,000 tons per year when regional marketing conditions improve.

Exports of lead concentrates increased, largely because of increased production at EZ's west coast Tasmania mines, Read Rosebery and Hercules. Over 90% of Australia's mine production, however, was processed to either bullion or refined lead. Exports of lead bullion increased by 26%, but exports of refined lead decreased by 18% compared with that of 1983. With over 147,000 tons of refined lead exported, however, Australia continued to be the world's leader in that category.

Although production increased at EZ's new Elura Mine in New South Wales, which opened in early 1983, it only operated at about 75% of capacity during the first quarter of 1984 because of both labor and technical difficulties, but was close to design capacity for the rest of the year. Deep diamond drilling of the main ore body at the Woodlawn joint venture near Tarago, New South Wales, continued in order to determine the feasibility of underground development. Open pit mining at the Woodlawn operation was expected to end in 1987. Woodlawn was owned one-third each by AM&S, St. Joe International Explorations Ltd., and Phelps Dodge Corp., but Phelps Dodge sold out to AM&S in October 1984.

Development of the lower levels continued at the CSA Mine north of Cobar, New South Wales, to raise the capacity to about 800,000 tons per year of ore in 1985. A consortium continued with exploration of the Woodcutters base metal deposit near Darwin, Northern Territory, for design of an open pit mine and treatment plant of about 140,000 tons per year of lead concentrates that was expected to come on-stream in mid-1985. Aberfoyle, 47% owned by Cominco of Canada, continued surface drilling at Hellyer, 2 miles north of its Que River Mine in Tasmania, and indicated 16.3 million tons of ore grading 18.2% combined lead and zinc and 3.9 troy ounces of silver per ton. Underground exploration was expected to start in 1985.

Mount Isa Mines Holdings Ltd. (MIM), in which Asarco had a 44% interest, reportedly reduced its work force in 1984 by 16% at its Mount Isa, Townsville, and Brisbane facilities in Queensland while maintaining planned production levels. MIM's properties represented about 35% of Australia's estimated lead mine production capacity and 39% of smelter capacity. MIM has no domestic refining capability and sells or exports the bullion produced. MIM's future outlook was augmented considerably by new mineral discoveries. At the Hilton Mine, 12.5 miles north of Mount Isa, MIM was preparing a major silver-lead-zinc ore body for trial mining in 1986. Continued exploration in the Hilton Mine area disclosed the existence of two additional, but apparently separate blocks, which have been named Hilton North and Hilton South. Ten mineralized zones were delineated at Hilton North, which reportedly at least doubled MIM's reserves in the general area. Exploration was to continue at Hilton South in 1985.

Canada.—Production at the copper-lead-zinc MacLean Mine at Buchans, Newfoundland, operated by Asarco and owned by Abitibi-Price Inc., 51%, and Asarco, 49%, ceased permanently at the end of September 1984 because of depletion of reserves. The mine originally opened in 1927 and in recent years had produced an average of about 7,000 tons of lead and 13,000 tons of zinc per year. At Brunswick Mining and Smelting Corp. Ltd.'s No. 12 Mine in New Brunswick, planned 5-year major modifications were begun. Capacity to produce at the mine was about 90,000 tons of lead and 260,000 tons of zinc per year. Heath Steele Mines Ltd., a wholly owned subsidiary of Noranda Mines Ltd. and its 25% partner Asarco, indefinitely closed its underground Little River Mine near Newcastle, New Brunswick, on December 21. The mine had been on a care-and-maintenance basis since April 1983, but during 1984 some production was obtained from a new open pit on the property, which was to continue to be developed during 1985.

An inclined exploration ramp was begun late in 1984 at a promising silver-zinc-lead discovery on the Yukon Territory and British Columbia border. Called the Midway property, it was owned jointly by Regional Resources Ltd., 51%, and Canamax Resources Inc. and Procan Exploration Co., 49%, and was estimated to contain 5 million tons of ore grading 18% combined lead and zinc. With the shutdown of Cyprus Anvil Mining Corp.'s Anvil Mine at Faro, Yukon Territory, in June 1982, lead production in the Yukon has come only from United Keno Hill Mines Ltd.'s Elsa Mine, an open pit-underground silver mine dating back to 1919. However, Cyprus Anvil continued a 2-year stripping program at Faro begun in June 1983 with financial assistance from the Federal and Yukon Territorial governments, but on October 28, 1984, the company locked out the approximately 200 mine and mill workers. The contract between management and the United Steelworkers had expired on September 30, and was not renegotiated. According to the company, work was not to resume until management agrees to a long-term labor contract and obtains lower electricity and transportation rates from the Government, and until lead and zinc market prices improve.

Cominco announced plans to modernize and expand its lead smelter, the largest in Canada, at Trail, British Columbia. The conventional sinter-blast furnace with a capacity of 120,000 tons per year would be replaced in two stages with state-of-the-art Kivcet furnaces with a total capacity of 160,000 tons per year. The new autogenous, direct-smelting process, a Soviet design, would reportedly improve the competitiveness of Trail's lead and zinc operations significantly. The company was seeking Federal assistance of $60 million. Significant gains in productivity were achieved at Cominco's 69%-owned Pine Point Mines Ltd. on the south shore of Great Slave Lake, Northwest Territories, by a changeover to larger shovels and trucks at the open pit operation. All of the lead concentrate produced there in 1984 was sold to Mitsubishi Cominco Smelting Co. Ltd. in Japan, which was 45% owned by Cominco. On September 20, Cominco announced that it was reducing its ownership of Pine Point Mines to 51% in January 1985.

At Cominco's Sullivan Mine at Kimberley, British Columbia, a mine mechanization project was essentially complete by yearend with only final ramping to lower levels to be completed. In its 76th year of operation by Cominco, the mine achieved record-high ore production of 2.47 million tons through the use of new mobile, rubber-tired mining equipment. The Sullivan Mine was the principal supplier of zinc and lead concentrates to Cominco's Trail metallurgical complex. At the company's Polaris Mine on Little Cornwallis Island, Northwest Territories, the world's most northerly metal mine, a continuous diamond drilling program increased the total measured and indicated ore reserves at that site by 3.1 million tons, or 18%, and a new production area was opened up in the "South Keel Zone."

To accelerate the development and application of new mining methods in Canada, a cost-sharing research and development corporation, HDRK Mining Research Ltd., was set up by four major Canadian mining companies: Inco Ltd., Falconbridge Ltd., Kidd Creek Mines Ltd., and Noranda Mines.

Greece.—At Laurium, in Attica, the primary lead smelter-refinery formerly owned by Compagnie Francaise des Mines du Laurium S.A.F., and which was nationalized and shut down early in 1982, was reopened in February 1984 after undergoing modernization. The new rated capacity of 20,000 tons of lead per year was 10,000 tons per year less than the old plant, and the plant was operated by the Government's Hellenic Mining and Metallurgical Co. of Laurium S.A.

Honduras.—AMAX's wholly owned subsidiary, Rosario Resources, continued with investigations and planning for development work in 1985 at the El Mochito Mine in Santa Bárbara Department to raise its lead mine capacity by an additional 9,000 tons per year to 30,000 tons per year of lead in concentrates. A new, high-speed, trackless mining system became operational in 1984 as well as an increase in mill capacity to 2,800 tons of ore per day. By 1988, the mine and mill capacity was expected to reach about 900,000 tons of ore per year.

Iran.—A new secondary lead smelter-refinery at Sorb Abad, near Tehran, with a capacity of 15,000 tons per year, reportedly became operational in 1984.

Mexico.—Development of two new underground mines, and a large-scale expansion at another, were expected to add an additional 19,000 tons per year to Mexico's lead mine production capacity during 1985. An additional 2,000 tons per year of capacity was brought on-stream at another underground mine at Sombrerete, Zacatecas, in 1984. Mexico's lead mine capacity at yearend was estimated to be about 208,000 tons per year.

Morocco.—The 65,000-ton-per-year lead smelter-refinery at Oued el Heimer was shut down from January 1 until late February because of a dispute over treatment terms with its prime feed source, the Touissit Mine, at Bujda. The shutdown created a temporary shortage of high-grade refined lead in Europe, principally Greece and Italy, and the Moroccan Government had to arbitrate the dispute. Exports of Moroccan concentrates to Europe, mainly from the Djebel Aouam Mine in Meknes and the Zaida Mine at Khénifra, were suspended from mid-November 1983 through mid-February 1984 owing to a similar dispute with European smelters. The latter problem was reportedly created by the 20% depreciation of the Moroccan dirham against the U.S. dollar.

Peru.—The opening of a new primary smelter and refinery with a capacity of 12,000 tons per year at Sayan, owned by Fundición de Concentrados S.A., was delayed by about 1 year to secure additional financing, but was expected to open in late 1985.

From February 22, 1984, through early April, a force majeure was in effect on refined lead shipments from Empresa Minera del Centro del Perú's (Centromin) 90,000-ton-per-year La Oroya smelter-refinery because of severe rainstorms and landslides, which blocked rail and road links. Force majeure was reinstituted in July reportedly because of a 1-week strike and the destruction of a major rail bridge between La Oroya and the port of Callas by guerillas. The guerillas also reportedly attacked an ore train carrying feed and blew up three road bridges on the highway from the mining area of Ayacucho.

Cía. Minera Milpo S.A. of Peru, Mitsubishi Metal Co., and Mitsubishi Corp. of Japan announced intentions to develop the San Hilarion zinc-lead-silver deposit. Milpo was to own and pay 65% of the costs. Lead output was estimated to eventually reach 20,000 tons per year. Centromin was expected to add 9,000 tons per year of additional mine capacity by 1986 through expansion at two of its mines begun in 1984. Gran Bretaña SMRL doubled the capacity of its Contonga Mine to 4,000 tons per year of lead. Peru's lead mine capacity at yearend was estimated to be about 205,000 tons per year.

Spain.—Two new zinc-lead mines under consideration and a third existing mine undergoing expansion were expected to add an additional 17,000 tons per year of capacity by 1986 or 1987. An expansion of a new mine by 2,000 tons per year to 5,000 tons per year was completed in 1984 at Sortiel, near Huelva, and a new replacement secondary smelter-refinery with a capacity of 18,000 tons per year was opened late in the year at San Esteban de Gormaz, Soria. Total estimated lead mine capacity at yearend was about 92,500 tons per year.

Yugoslavia.—Two mine projects, totaling 8,000 tons per year additional lead capacity, were completed; one was a new open pit, and the other, an underground expansion. Investigation continued at another new mine with an estimated eventual lead capacity of about 19,000 tons per year. That mine, when producing, will become part of the RMPK Zletovo-Sasa enterprise of Makedonska Kamenica, near Delcevo, in Macedonia. Total estimated lead mine capacity at the end of 1984 was about 130,000 tons per year, the largest in Europe outside of the U.S.S.R.

TECHNOLOGY

The Lead Industries Association Inc. (LIA) introduced a prototype heavy-duty, multipurpose, lead-acid-battery-powered yard tractor for handling trailers and shipping containers at a major industrial marine terminal in New Jersey. The market potential for dockside applications was the estimated 40,000 to 60,000 diesel-powered tractors presently performing this function at container terminals and warehouse yards throughout North America. The demonstration prototype vehicle was designed to function identically to the diesel-powered ones in service, and have identical external dimensions. Powered by two 1,400-ampere-per-hour lead-acid batteries, the unloaded tractor reportedly could attain a speed of 22 miles per hour, and with a 25-ton load go up a 2% grade at 14 miles per hour. The final drive is by twin 40-horsepower electric motors. Preliminary data indicated that a 70% savings in fuel costs was attained, based on electricity costs of 8 cents per kilowatt hour, and diesel fuel costs of 99 cents per gallon. The tractor contained about 4 tons of lead in its nearly 6 tons of batteries. Other performance features were elimination of exhaust fumes, no heat buildup, and quiet operation.[4]

Throughout the year, LIA's electromotive programs also focused on expanding existing markets such as forklift trucks, underground mining equipment, and airport ground support equipment (GSE) such as pushout tractors and baggage tugs. In the latter case, since 1981, approximately 20 major U.S. air carriers have converted at least part of their GSE fleets from gasoline and diesel power to battery units. The largest user of these, Eastern Airlines, reportedly realized reductions of almost 90% in operating costs and about 70% in maintenance costs, using battery-powered jumbo aircraft pushout tractors. According to LIA surveys, at the end of 1982, battery power had penetrated the market about 10%, and by 1984, about 14%. The major airlines consulted estimated that by the end of the century up to 90% of their applicable GSE could be battery powered, including conveyor belt loaders, cabin service vehicles, and miscellaneous maintenance vehicles. In addition, research was begun by LIA to profile the potential market for battery-powered GSE among the Nation's several thousand fixed-base operators, freight carriers, military installations, and smaller regional airlines.[5]

Performance testing and environmental monitoring of LIA's lead-in-asphalt pavement demonstrations in Ontario, Canada, and New Jersey continued during the year. Sampling at regular intervals indicated that the lead-stabilized asphalts at each site were standing up considerably better than the control pavements that did not contain lead, and there was no indication of lead migrating out of the organo-compounds. Also, a 1-mile demonstration strip was constructed in a Missouri highway in cooperation with St. Joe.[6] Research on assessing the effects of organo-lead antioxidant compounds upon the weathering durability of roofing asphalts was also performed during the year by Manville Service Corp. sponsored by the International Lead-Zinc Research Organization.[7] Less spectacular initial results were achieved with lead diamyldithiocarbamate than were evident with the pavement tests, but it was generally believed that significant life extensions could be eventually achieved with further research.

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, the 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. 25, No. 8, Aug. 1985, pp. 16-18.
[3]Work cited in footnote 2.
[4]Lead Industries Association Inc. 1984 Annual Report. Pp. 6-11.
[5]Work cited in footnote 4.
[6]Work cited in footnote 4.
[7]Suhaka, S. C., and R. C. Hines. Lead Compounds as Stabilizers for Roofing Asphalts. Paper in Proceedings of Lead Industries Association Inc. 56th Annual Meeting. Denver, CO, Apr. 2-4, 1984, pp. 17-22.

Table 3.—Mine production of recoverable lead in the United States, by State

(Metric tons)

State	1980	1981	1982	1983	1984
Alaska	31	W	W	W	--
Arizona	162	993	359	r155	W
California	W	W	W	W	W
Colorado	10,272	11,431	W	W	W
Idaho	38,607	38,397	W	r25,893	W
Illinois	W	W	W	W	W
Missouri	497,170	389,721	474,460	409,280	278,329
Montana	295	194	661	1,163	W
Nevada	26	W	W	14	W
New Mexico	--	W	W	258	--
New York	876	968	1,065	1,299	W
Oregon	--	W	--	W	--
Tennessee	--	--	--	--	W
Utah	W	1,662	W	--	W
Virginia	1,563	1,607	--	--	--
Washington	W	--	W	--	--
Total	550,366	445,535	512,516	r449,216	321,897

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 4.—Mine production of recoverable lead in the United States, by month

(Metric tons)

Month	1983r	1984
January	44,873	41,900
February	39,579	42,735
March	37,480	46,338
April	36,726	20,923
May	35,876	24,076
June	28,356	12,251
July	35,345	24,176
August	43,236	23,531
September	37,357	18,619
October	37,119	22,409
November	38,326	19,528
December	34,943	25,411
Total	449,216	321,897

rRevised.

Table 5.—Production of lead and zinc, in terms of of recoverable metal, in the United States in 1984, 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	W	W	--	--	--	--	--	--	--
California	--	--	--	--	--	--	--	--	--
Colorado	--	--	--	--	--	--	W	W	W
Idaho	W	W	--	--	--	--	--	--	--
Illinois	--	--	--	--	--	--	--	--	--
Kentucky	--	--	--	W	--	W	--	--	--
Missouri	4,748,910	278,329	45,458	--	--	--	--	--	--
Montana	--	--	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--
New Jersey	--	--	--	W	--	W	--	--	--
New York	--	--	--	W	W	W	--	--	--
Tennessee	--	--	--	W	W	W	--	--	--
Utah	--	--	--	W	W	W	--	--	--
Total	4,748,960	278,407	45,458	5,186,887	1,991	185,827	([1])	([1])	([1])
Percent of total lead or zinc	XX	86	18	XX	1	74	XX	([1])	([1])

State	Copper-lead, copper-zinc, copper-lead-zinc ores: Gross weight (dry basis)	Lead	Zinc	All other sources[2]: Gross weight (dry basis)	Lead	Zinc	Total: Gross weight (dry basis)	Lead	Zinc
Arizona	--	--	--	W	W	--	W	W	--
California	--	--	--	W	W	--	W	W	--
Colorado	--	--	--	W	W	W	W	W	W
Idaho	--	--	--	W	W	W	W	W	W
Illinois	--	--	--	([3])	W	W	([3])	W	W
Kentucky	--	--	--	--	--	--	W	--	W
Missouri	--	--	--	--	--	--	4,478,910	278,329	45,458
Montana	--	--	--	W	W	--	W	W	--
Nevada	--	--	--	W	W	--	W	W	--
New Jersey	--	--	--	--	--	--	W	--	W
New York	--	--	--	--	--	--	W	W	W
Tennessee	W	--	W	--	--	--	[4]6,071,125	W	[4]116,526
Utah	--	--	--	--	--	--	W	W	W
Total	([1])	--	([1])	27,233,011	41,499	21,484	37,168,858	321,897	[5]252,768
Percent of total lead or zinc	XX	--	([1])	XX	13	8	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 zinc recovered from copper-zinc ore in Tennessee in order to avoid disclosing company proprietary data. Also includes lead and zinc recovered from copper, gold, silver, and fluorspar ores and from mill tailings and miscellaneous cleanups.

[3]Excludes tonnages of fluorspar from which lead and zinc were recovered as byproducts.

[4]Includes items in Tennessee withheld to avoid disclosing company proprietary data.

[5]Zinc recovered from classes of ore does not add to total shown because of independent rounding.

Table 6.—Twenty-five leading lead-producing mines in the United States in 1984, 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	Fletcher	Reynolds, MO	St. Joe Lead Co.	Do.
4	Viburnum No. 29	Washington, MO	do	Do.
5	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Silver ore.
6	Viburnum No. 28	Iron, MO	St. Joe Lead Co.	Lead ore.
7	Viburnum No. 35	do	do	Do.
8	Brushy Creek	Reynolds, MO	do	Do.
9	Leadville unit	Lake, CO	ASARCO Incorporated	Lead-zinc ore.
10	Sunnyside	San Juan, CO	Standard Metals Corp	Gold ore.
11	Balmat	St. Lawrence, NY	St. Joe Lead Co.	Zinc ore.
12	Black Pine	Granite, MT	Black Pine Mining Co.	Silver ore.
13	Bulldog Mountain	Mineral, CO	Homestake Mining Co	Do.
14	Clayton	Custer, ID	Clayton Silver Mines	Do.
15	Troy unit	Lincoln, MT	ASARCO Incorporated	Do.
16	Rosiclare	Hardin and Pope, IL	Ozark-Mahoning Co.	Fluorspar.
17	Sherman Tunnel (Leadville unit).	Lake, CO	Hecla Mining Co.	Lead ore.
18	Bachelor	Ouray, CO	Camp Bird Colorado Inc	Silver ore.
19	Ray	Pinal, AZ	Kennecott	Copper ore.
20	Pierrepont	St. Lawrence, NY	St. Joe Resources Co	Zinc ore.
21	Star unit	Shoshone, ID	CSC Mining Co.	Lead ore.
22	Tiger	Pinal, AZ	McFarland & Hullinger	Gold-silver tailings.
23	Red Cloud	La Paz, AZ	Red Cloud Mining Ltd	Silver ore.
24	Comet	Beaverhead, MT	Concorde Mines Ltd.	Gold-silver ore.
25	Franklin	Clear Creek, CO	Consolidated Mines Inc.	Gold ore.

Table 7.—Refined lead produced at primary refineries in the United States, by source material

(Metric tons unless otherwise specified)

Source material	1980	1981	1982	1983	1984
Refined lead:					
From primary sources:					
Domestic ores and base bullion	508,163	440,238	459,865	459,328	330,168
Foreign ores and base bullion	39,427	55,085	52,295	55,227	65,409
Total	547,590	495,323	512,160	514,555	395,577
From secondary sources	2,117	1,745	657	648	1,023
Grand total	549,707	497,068	512,817	515,203	396,600
Calculated value of primary refined lead[1] thousands	$512,590	$398,908	$288,377	$245,938	$222,821

[1]Value based on average quoted price and excludes value of refined lead produced from scrap at primary refineries.

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1984, 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
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	596,790	--	609,434	609,434	29,767
Mixed common babbitt	130	1,956	--	1,801	1,801	285
Solder and tinny lead	997	17,105	--	15,993	15,993	2,109
Type metals	591	4,181	--	4,270	4,270	502
Drosses and residues	5,706	66,017	63,917	--	63,917	7,806
Total	55,240	749,154	63,917	695,688	759,605	44,789

[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 in 1984

(Metric tons)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	227,681	--	--	--	227,681
Remelt lead	15,502	--	--	--	15,502
Total	243,183	--	--	--	243,183
Refined pig tin	--	1,097	--	--	1,097
Remelt tin	--	10	--	--	10
Total	--	1,107	--	--	1,107
Lead and tin alloys:					
Antimonial lead	297,430	894	11,153	685	310,162
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	324,393	4,863	11,851	696	341,803
Tin content of chemical products	--	301	--	--	301
Grand total	567,576	6,271	11,851	696	586,394

[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)

	1980	1981	1982	1983	1984
As metal:					
At primary plants	2,117	1,745	657	648	1,023
At other plants	313,061	280,409	239,819	188,954	242,160
Total	315,178	282,154	240,476	189,602	243,183
In antimonial lead:					
At primary plants	3	46	34	--	--
At other plants	306,683	304,330	284,333	271,638	297,430
Total	306,686	304,376	284,367	271,638	297,430
In other alloys	53,714	54,575	46,433	42,261	42,140
Grand total:					
Quantity	675,578	641,105	571,276	503,501	582,753
Value[1] thousands	$632,397	$516,313	$321,663	$240,655	$328,253

[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)

	1983	1984
KIND OF SCRAP		
New scrap:		
Lead-base	48,534	44,342
Copper-base	2,981	3,278
Tin-base	8	5
Total	51,523	47,625
Old scrap:		
Battery-lead plates	371,540	443,119
All other lead-base	69,469	79,945
Copper-base	10,969	12,064
Tin-base	--	--
Total	451,978	535,128
Grand total	503,501	582,753
FORM OF RECOVERY		
As soft lead:		
At primary plants	648	1,023
At other plants	188,954	242,160
Total	189,602	243,183
In antimonial lead	271,638	297,430
In other lead alloys	27,178	26,793
In copper-base alloys	15,075	15,342
In tin-base alloys	8	5
Total	313,899	339,570
Grand total	503,501	582,753

Table 12.—U.S. consumption of lead, by product

(Metric tons)

SIC code	Product	1983	1984
	Metal products:		
3482	Ammunition: Shot and bullets	43,697	47,828
	Bearing metals:		
35	Machinery except electrical	1,283	894
36	Electrical and electronic equipment	141	254
371	Motor vehicles and equipment	2,808	2,898
37	Other transportation equipment	1,612	631
	Total bearing metals	5,844	4,677
3351	Brass and bronze: Billets and ingots	10,980	6,954
36	Cable covering: Power and communication	10,505	12,270
15	Calking lead: Building construction	3,572	3,966
	Casting metals:		
36	Electrical machinery and equipment	1,277	1,649
371	Motor vehicles and equipment	690	762
37	Other transportation and equipment	5,638	7,913
3443	Nuclear radiation shielding	8,640	5,480
	Total casting metals	16,245	15,804
	Pipes, traps, other extruded products:		
15	Building construction	12,771	11,371
3443	Storage tanks, process vessels, etc	245	2,287
	Total pipes, traps, other extruded products	13,016	13,658
	Sheet lead:		
15	Building construction	10,939	13,377
3443	Storage tanks, process vessels, etc	130	160
3693	Medical radiation shielding	3,176	1,128
	Total sheet lead	14,245	14,665

Table 12.—U.S. consumption of lead, by product —Continued

(Metric tons)

SIC code	Product	1983	1984
	Solder:		
15	Building construction	7,554	6,543
341	Metal cans and shipping containers	5,141	3,275
367	Electronic components and accessories	5,674	5,361
36	Other electrical machinery and equipment	2,433	2,226
371	Motor vehicles and equipment	7,688	7,036
	Total solder	28,490	24,441
	Storage batteries:		
3691	Storage battery grids, post, etc	382,336	426,300
3691	Storage battery oxides	424,563	439,242
	Total storage batteries	806,899	865,542
371	Terne metal: Motor vehicles and equipment	5,057	6,074
27	Type metal: Printing and allied industries	2,540	2,162
34	Other metal products[1]	7,869	8,284
	Total metal products	968,959	1,026,325
	Other oxides:		
285	Paints	15,441	17,360
32	Glass and ceramic products	39,671	46,102
28	Other pigments and chemicals	13,582	13,346
	Total other oxides	68,694	76,808
2911	Gasoline additives	89,118	78,933
	Miscellaneous uses	21,716	24,967
	Grand total	1,148,487	1,207,033

[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	1983	1984
January	91,521	124,906
February	73,950	99,484
March	83,139	103,905
April	85,852	93,737
May	83,778	90,636
June	96,251	101,693
July	79,266	84,107
August	102,620	103,202
September	115,663	102,068
October	112,266	111,290
November	102,747	96,948
December	121,434	95,057
Total[2]	1,148,487	1,207,033

[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 1984, by State[1]

(Metric tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	51,867	37,064	7,460	314	96,705
Colorado	965	327	44	--	1,336
Connecticut	5,744	7,749	--	481	13,974
District of Columbia	13	--	--	--	13
Florida	15,500	9,192	2,894	--	27,586
Georgia	25,291	7,043	5,215	--	37,549
Illinois	27,256	34,391	3,510	897	66,054
Indiana	217,176	31,816	10,862	872	260,726
Kansas	11,651	6,900	4,449	--	23,000
Kentucky	12,190	9,838	2,364	--	24,392
Maryland	80	712	--	--	792
Massachusetts	1,163	143	73	62	1,441
Michigan	13,629	11,492	84	--	25,205
Missouri	11,019	12,586	--	--	23,605
Nebraska	4	5	559	837	1,405
New Jersey	56,030	215	2,596	204	59,045
New York	11,766	5,623	2,677	23	20,089
Ohio	17,321	12,205	4,544	239	34,309
Pennsylvania	98,689	44,915	18,852	1,537	163,993
Rhode Island	2,179	41	11	--	2,231
Tennessee	1,018	1,745	1,214	162	4,139
Virginia and West Virginia	676	359	702	--	1,737
Washington	12,223	631	103	--	12,957
Wisconsin	1,058	3,086	27	78	4,249
Alabama and Mississippi	7,476	3,796	2,072	2,354	15,698
Arkansas and Oklahoma	1,955	288	14	--	2,257
Hawaii and Oregon	6,040	8,663	501	--	15,204
Iowa and Minnesota	13,918	18,175	4,881	--	36,974
Louisiana and Texas	109,470	21,821	3,835	--	135,126
Montana and Idaho	69	--	--	--	69
New Hampshire, Maine, Vermont, Delaware	12,867	14,619	--	18	27,504
North Carolina and South Carolina	38,379	24,396	3,650	--	66,425
Utah, Nevada, Arizona	--	--	1,244	--	1,244
Total	784,682	329,836	84,437	8,078	1,207,033

[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 1984, 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	79,166	54,056	23,676	3,884	160,783
Storage batteries	530,835	277,305	57,402	--	865,542
Other oxides	76,808	--	--	--	76,808
Gasoline additives	78,933	--	--	--	78,933
Miscellaneous	21,494	1,067	2,406	--	24,967
Total[2]	787,236	332,428	83,484	3,884	1,207,033

[1]Data may not add to totals shown because of independent rounding.
[2]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	1983			1984		
	Production (metric tons)	Shipments		Production (metric tons)	Shipments	
		Metric tons	Value[2]		Metric tons	Value[2]
White lead, dry	1,051	r1,077	$1,407,994	1,205	1,225	$1,534,515
Red lead	15,042	r14,897	11,829,368	11,629	11,236	10,046,120
Litharge	r59,920	r56,540	r43,200,436	60,139	56,898	48,468,634
Leady oxide	r446,909	--	--	462,329	--	--

rRevised.
[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	
	1983	1984
White lead	841	964
Red lead	13,688	10,582
Litharge	r55,726	55,929
Leady oxide	r424,563	439,213
Total	r494,818	506,688

rRevised.
[1]Excludes basic lead sulfate; withheld to avoid disclosing company proprietary data.

Table 18.—Distribution of red lead shipments in the United States, by industry

(Metric tons)

Industry	1980	1981	1982	1983	1984
Paints	3,241	3,172	2,395	r2,533	2,384
Ceramics	2,597	2,307	W	W	W
Storage batteries	6,068	7,573	W	W	W
Other	995	2,025	11,274	r12,364	8,852
Total	12,901	15,077	13,669	r14,897	11,236

rRevised. W 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	1980	1981	1982	1983	1984
Ceramics	36,560	34,732	30,980	r36,782	37,960
Chrome pigments	3,015	4,247	6,591	r5,973	4,367
Oil refining	170	227	W	W	W
Paints	3,362	3,765	3,052	3,256	3,635
Rubber	943	1,107	787	933	1,016
Other	784	3,063	10,267	r9,596	9,920
Total	44,834	47,141	51,677	r56,540	56,898

rRevised. 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	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
White lead	332	$300	442	$524
Red lead	843	461	923	553
Litharge	11,528	5,149	12,726	6,314
Chrome yellow	1,754	3,275	2,322	4,223
Other lead pigments	215	1,059	342	1,189
Other lead compounds	995	1,200	2,326	2,219
Total	15,667	11,444	19,081	15,022

Table 21.—Stocks of lead at primary smelters and refineries in the United States, December 31

(Metric tons)

Stocks	1980	1981	1982	1983	1984
Refined pig lead	54,728	78,836	73,455	58,267	47,696
Lead in antimonial lead	122	666	W	W	W
Lead-base bullion	5,398	4,872	4,252	5,557	5,837
Lead in ore and matte	65,746	55,833	47,830	42,837	81,546
Total	125,994	140,207	125,537	106,661	135,079

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
1980	72,601	44,820	7,851	942	126,214
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	53,797	37,015	5,326	934	97,072

Table 23.—Average monthly and annual quoted prices of lead[1]

(Cents per pound)

Month	1983 U.S. producer	1983 London Metal Exchange	1984 U.S. producer	1984 London Metal Exchange
January	22.03	21.54	25.12	18.01
February	21.12	20.61	24.07	18.33
March	20.71	20.09	25.03	20.82
April	21.17	20.74	26.43	21.83
May	20.22	19.63	25.37	20.54
June	19.41	18.49	28.16	21.95
July	19.32	18.27	30.51	22.37
August	19.46	18.04	28.24	21.18
September	21.69	18.34	24.18	18.20
October	25.38	19.00	22.33	18.67
November	25.15	18.34	25.25	19.96
December	24.46	18.23	21.89	18.83
Average	21.68	19.27	25.55	20.12

[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	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Ore and concentrates (lead content):				
Brazil	896	$202	--	--
Canada	16,298	5,382	11,675	$4,627
Haiti	--	--	54	40
Mexico	119	36	43	13
Spain	2,699	1,810	--	--
United Kingdom	--	--	66	56
Other	107	72	20	24
Total	20,119	7,502	11,858	4,760
Drosses and residues including flue dust (lead content):				
Belgium-Luxembourg	948	150	2,458	622
Brazil	878	288	4,353	1,080
Canada	839	703	274	562
Denmark	241	479	473	496
Germany, Federal Republic of	284	156	273	162
Netherlands	41	94	3	5
United Kingdom	631	1,167	1,268	2,421
Other	40	43	16	4
Total	3,902	3,080	9,118	5,352
Unwrought lead and lead alloys (lead content):				
Australia	16	34	4	4
Belgium-Luxembourg	4,581	3,487	113	1,832
Brazil	292	64	(1)	5
Canada	2,537	1,576	2,817	2,181
Chile	--	--	174	178
China	--	--	8	288
Dominican Republic	75	71	56	42
Egypt	194	351	105	302
Finland	--	--	39	36
France	8	12	3	11
Germany, Federal Republic of	42	44	104	80
Ghana	92	78	100	66
Greece	552	147	--	--
Haiti	46	47	36	27
Honduras	10	10	3	4
Japan	64	259	148	184
Korea, Republic of	137	127	95	169
Mexico	252	342	584	766
Netherlands	8,227	3,414	66	850
Netherlands Antilles	18	12	--	--
Peru	3	5	15	17
Philippines	62	43	121	128
Saudi Arabia	79	401	16	33
Singapore	42	54	58	65
Taiwan	33	98	90	75
Thailand	13	9	12	15
Trinidad and Tobago	32	28	--	--
United Kingdom	130	137	108	115
Venezuela	34	136	7	39
Other	r113	r318	78	157
Total	17,684	11,304	4,960	7,669
Wrought lead and lead alloys (lead content):				
Australia	11	32	--	2
Belgium-Luxembourg	(1)	5	91	138
Canada	1,005	1,087	495	516
Denmark	--	--	17	25
Ecuador	25	42	4	8
France	4	17	15	34
Germany, Federal Republic of	32	297	11	19
Honduras	10	26	11	23
Hong Kong	--	--	33	50
India	2	6	--	--
Israel	5	7	--	--
Italy	70	128	--	1
Japan	68	359	16	193
Korea, Republic of	--	--	25	95
Mexico	1,059	4,253	1,273	5,190
Netherlands	17	23	4	6
Panama	6	10	14	33
Philippines	13	27	10	30
Saudi Arabia	86	280	30	84
Singapore	11	60	33	62

See footnotes at end of table.

Table 24.—U.S. exports of lead, by country —Continued

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Wrought lead and lead alloys (lead content) —Continued				
Spain	43	$148	(1)	$1
Taiwan	11	48	98	319
United Kingdom	180	584	185	393
Venezuela	28	25	86	121
Other	79	322	34	202
Total	2,765	7,786	2,485	7,545
Scrap (gross weight):				
Argentina	131	39	--	--
Belgium-Luxembourg	347	400	345	388
Brazil	4,844	1,153	5,861	1,192
Canada	15,708	3,472	6,117	2,190
Colombia	2,899	324	5,649	548
Denmark	235	329	430	516
Ecuador	101	95	59	58
Germany, Federal Republic of	1,517	622	904	480
Hong Kong	--	--	156	77
India	34	19	298	167
Italy	376	57	--	--
Japan	265	77	336	166
Korea, Republic of	4,277	972	1,550	331
Mexico	886	275	2,873	823
Netherlands	492	526	262	293
Philippines	255	48	1,000	239
Spain	1,992	395	513	73
Taiwan	14,193	2,901	13,530	2,803
Thailand	520	94	--	--
Trinidad	1,045	103	3,541	520
United Kingdom	785	1,217	659	400
Venezuela	--	--	992	300
Other	16	21	22	11
Total	50,918	13,139	45,097	11,575
Grand total	r95,388	r42,811	73,518	36,901

rRevised.
1Less than 1/2 unit.

Table 25.—U.S. exports of lead

Year	Blocks, pigs, anodes, etc.: Unwrought: Quantity (metric tons)	Unwrought: Value (thousands)	Unwrought alloys: Quantity (metric tons)	Unwrought alloys: Value (thousands)	Wrought lead and lead alloys: Sheets, plates, rods, other forms: Quantity (metric tons)	Sheets, plates, rods, other forms: Value (thousands)	Foil, powder, flakes: Quantity (metric tons)	Foil, powder, flakes: Value (thousands)	Scrap (gross weight): Quantity (metric tons)	Scrap: Value (thousands)	Drosses, etc.: Quantity (metric tons)	Drosses, etc.: Value (thousands)
1982	47,250	$35,917	3,739	$3,032	4,078	$9,056	562	$813	51,752	$17,254	21,202	$9,450
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

Table 26.—U.S. imports[1] of lead, by country

(Lead content)

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Ore, matte, flue dust, residues, n.s.p.f.:						
Australia	7,694	$2,875	10,002	$2,865	17,024	$5,689
Bolivia	--	--	--	--	816	390
Canada	4,780	2,259	6,143	1,234	14,127	5,242
Chile	--	--	--	--	904	189
Honduras	8,677	4,850	8,663	3,945	5,370	2,889
Italy	--	--	--	--	5,103	1,664
Mexico	--	--	4	1	2,803	1,630
Peru	14,549	5,481	22,702	7,041	22,718	8,671
Other	r107	r33	2	1	5	2
Total	35,807	15,498	47,516	15,087	68,870	26,366
Base bullion:						
Canada	19	25	28	12	19	10
France	--	--	--	--	18	8
Mexico	--	--	25	10	6	37
Other	(2)	3	(2)	1	(2)	2
Total	19	28	53	23	43	57
Pigs and bars:						
Australia	7,256	3,786	10,883	3,825	10,884	5,187
Belgium-Luxembourg	146	783	322	2,273	231	282
Canada	49,834	27,701	72,655	31,578	94,893	50,103
Denmark	449	351	--	--	11	4
Germany, Federal Republic of	927	5,836	1,022	7,020	1,528	4,205
Italy	--	--	113	79	418	316
Mexico	23,473	12,422	34,861	14,071	39,502	19,158
Netherlands	--	--	11	84	116	92
Peru	8,296	3,816	10,096	3,526	9,205	4,349
South Africa, Republic of	--	--	--	--	496	275
Spain	--	--	--	--	3,184	1,635
United Kingdom	748	1,902	716	898	974	943
Other	60	125	r53	r92	123	58
Total	91,189	56,722	130,732	63,446	161,565	86,607
Reclaimed scrap, etc.:						
Australia	3,992	1,301	2,272	347	1,302	359
Bahamas	37	8	90	6	--	--
Canada	3,481	1,205	2,718	861	2,311	1,099
Mexico	852	398	1,551	371	2,638	864
United Kingdom	--	--	93	20	48	23
Other	r36	r12	r29	r106	3	13
Total	8,398	2,924	6,753	1,711	(3)6,303	2,358
Pigs and bars:						
London Metal Exchange (return of U.S. brands)[4]	--	--	42,000	16,945	--	--
Grand total	135,413	75,172	227,054	97,212	236,781	115,388

rRevised.

[1]Data are "general imports"; that is, they include lead imported for immediate consumption plus material entering the country under bond.

[2]Less than 1/2 unit.

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

[4]Bureau of Mines estimate.

Table 27.—U.S. imports for consumption of lead, by country

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Ore, matte, flue dust, residues, n.s.p.f. (lead content):						
Canada	29	$10	483	$112	1,843	$477
Honduras	8,677	4,850	1,522	674	4,121	2,201
Italy	--	--	--	--	1,569	467
Mexico	--	--	4	1	2,654	1,550
Peru	10,131	3,891	17,742	4,924	19,695	7,226
Other	r108	r33	2	1	5	2
Total[1]	18,945	8,784	19,753	5,712	29,888	11,923
Base bullion (lead content):						
Canada	19	25	28	12	19	10
France	--	--	--	--	18	8
Mexico	--	--	25	10	6	37
Other	(2)	3	(2)	1	(2)	2
Total	19	28	53	23	43	57
Pigs and bars (lead content):						
Australia	10,882	5,674	14,508	4,604	9,978	4,364
Belgium-Luxembourg	146	783	322	2,273	231	282
Canada	49,834	27,701	72,655	31,578	94,815	50,062
Denmark	449	351	--	--	11	4
Germany, Federal Republic of	927	5,836	1,022	7,020	1,528	4,205
India	--	--	--	--	907	447
Italy	--	--	113	79	419	316
Mexico	23,513	12,444	34,861	14,071	39,502	19,158
Netherlands	--	--	11	84	116	92
Peru	8,296	3,816	10,096	3,526	9,205	4,349
South Africa, Republic of	--	--	--	--	496	275
Spain	--	--	--	--	3,184	1,635
United Kingdom	748	1,903	716	898	974	943
Other	60	125	r53	r92	121	58
Total[1]	94,855	58,633	134,357	64,225	161,489	86,189
Reclaimed scrap, etc. (lead content):						
Australia	428	132	6	6	27	30
Bahamas	37	8	90	6	--	--
Canada	3,481	1,205	2,443	831	2,311	1,099
Guatemala	--	--	14	6	--	--
Mexico	852	398	1,551	371	2,638	864
United Kingdom	--	--	93	20	48	23
Other	r36	r12	15	100	3	13
Total[1]	4,834	1,755	4,212	1,340	5,026	2,029
Sheets, pipe, shot, other forms:						
Belgium-Luxembourg	27	25	16	32	90	107
Canada	313	335	228	238	471	837
Germany, Federal Republic of	40	111	216	1,189	315	1,693
Italy	24	52	--	--	(2)	2
Mexico	45	73	10	64	669	853
United Kingdom	3	12	3	14	51	128
Other	r15	r86	r23	r95	72	424
Total[1]	467	694	496	1,632	1,667	4,044
Pigs and bars (lead content):						
London Metal Exchange (return of U.S. brands)[3]	--	--	42,000	16,945	--	--
Grand total[1]	119,120	69,894	200,871	89,877	198,108	104,241

rRevised.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.
[3]Bureau of Mines estimate.

Table 28.—U.S. imports for consumption of lead

(Thousand metric tons and thousand dollars)

Year	Ore (lead content) Quantity	Ore (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
1980	30	23,927	(1)	509	81	87,629	(1)	888
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

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
1980	2	2,144	1	761	1	620	116,478
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

[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.

Table 29.—U.S. imports for consumption of miscellaneous products containing lead[1]

Year	Gross weight (metric tons)	Lead content (metric tons)	Value (thousands)
1981	1,090	520	$7,813
1982	1,423	639	10,596
1983	2,312	1,131	13,720
1984	2,671	1,363	17,299

[1]Babbitt metal, solder, white metal, and other lead-containing combinations.

Table 30.—Lead: World mine production, by country, of lead in concentrates[1]

(Thousand metric tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Algeria	1.8	5.1	4.9	[e]6.0	6.0
Argentina	32.6	32.7	30.1	31.3	34.0
Australia	397.5	388.1	455.3	480.6	446.0
Austria	4.3	4.3	4.1	4.3	4.2
Bolivia	17.7	16.8	12.4	11.8	8.4
Brazil	[r]21.8	[r]21.7	19.4	18.8	19.0
Bulgaria[e]	[r]116.0	[r]116.0	[r]95.0	[r]95.0	95.0
Burma	14.2	16.1	16.1	23.1	[3]21.9
Canada	296.6	332.0	341.2	251.5	[3]259.4
Chile	.3	.2	1.4	1.5	2.0
China[e]	160.0	160.0	160.0	160.0	160.0
Colombia	[r].3	[r].3	.4	.3	.3
Congo (Brazzaville)	[r]3.6	7.7	4.1	[r e]6.0	2.0
Czechoslovakia	3.3	3.4	3.1	3.2	3.2
Ecuador	.2	.2	[e].2	[e].2	.2
Finland	1.1	1.9	1.9	1.1	2.1
France	28.4	17.2	5.9	1.5	[3]1.6
Germany, Federal Republic of	23.1	21.6	23.5	23.5	[3]21.0
Greece[e]	[3]20.5	21.0	[r]19.0	[r]20.0	20.0
Greenland	[r]30.1	27.4	26.3	22.0	[3]18.5
Guatemala[e]	.1	--	--	--	--
Honduras	13.3	12.6	15.1	19.3	[3]20.5
Hungary[e]	1.1	[r].5	[r].6	[r].7	.7
India	12.7	15.3	[e]16.6	[e]25.7	23.0
Iran[e]	12.0	20.0	25.0	[3]26.0	28.0
Ireland	59.0	[r]30.5	39.0	33.6	34.0
Italy	22.9	21.6	16.2	23.6	[3]21.7

See footnotes at end of table.

Table 30.—Lead: World mine production, by country, of lead in concentrates[1] —Continued

(Thousand metric tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Japan	44.7	46.9	45.9	46.9	[3]48.7
Korea, North[e]	125.0	[r]110.0	95.0	[r]75.0	75.0
Korea, Republic of	11.4	[r]13.4	12.2	12.2	10.0
Mexico[4]	[r]147.2	[r]148.9	170.2	184.3	195.0
Morocco	114.8	116.0	103.6	98.0	[3]100.7
Namibia	50.2	46.9	32.9	38.5	[3]33.4
Nigeria[e]	.4	.2	.3	.3	.3
Norway	[r]2.5	[r]3.0	3.7	4.1	5.3
Peru	189.1	192.7	175.8	205.1	196.0
Philippines	1.8	1.1	--	--	--
Poland	60.0	50.4	57.5	59.2	61.0
Romania[e]	[r]25.0	[r]25.0	[r]27.0	[r]30.0	30.0
South Africa, Republic of	86.1	98.9	90.3	80.2	[3]94.8
Spain	87.1	80.2	73.3	82.0	85.0
Sweden	72.2	84.1	86.8	[r e]83.0	80.0
Thailand	10.6	17.3	18.6	21.0	[3]16.7
Tunisia	8.3	5.7	5.0	4.6	4.5
Turkey	6.7	8.0	6.4	[e]6.3	6.0
U.S.S.R.[e]	420.0	425.0	430.0	435.0	440.0
United Kingdom	3.6	7.0	4.0	[e]4.0	4.0
United States	[r]573.1	[r]459.0	530.3	465.6	[3]333.2
Yugoslavia	121.5	118.6	[e]115.0	[r e]114.4	100.0
Zambia	[e]13.9	17.2	21.2	25.9	[3]18.1
Total	[r]3,469.7	[r]3,369.7	3,441.8	3,366.2	3,190.4

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 18, 1985.
[2]In addition to the countries listed, Egypt and Uganda may produce lead, but available information is inadequate to make reliable estimates of output levels.
[3]Reported figure.
[4]Production series modified according to reported data on mine output per municipality and State.

Table 31.—Lead: World smelter production, by country[1]

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Argentina:					
Primary (refined)	23.2	19.0	17.0	16.0	19.0
Secondary (refined)	18.5	15.6	14.6	15.0	17.0
Total	41.7	34.6	31.6	31.0	[2]36.0
Australia:					
Primary:					
Bullion for export	160.2	[r]162.6	181.6	189.2	[2]184.0
Refined	200.5	207.7	218.8	196.3	[2]196.2
Secondary (refined)[e]	[r]33.2	31.5	28.3	28.0	21.5
Total	[r]393.9	[r]401.8	428.7	413.5	401.7
Austria:					
Primary (refined)	5.4	3.3	3.4	4.2	4.2
Secondary (refined)	11.5	12.8	14.5	12.9	13.0
Total	16.9	16.1	17.9	17.1	17.2
Belgium:					
Primary[e 3]	53.9	60.2	52.9	[r]54.5	55.0
Secondary[4]	30.0	28.0	28.0	30.0	32.0
Total	83.9	88.2	80.9	84.5	87.0
Brazil:					
Primary (refined)	44.5	34.7	21.9	20.6	[2]26.0
Secondary (refined)	40.4	[r]31.0	27.4	28.9	30.0
Total	84.9	[r]65.7	49.3	49.5	56.0

See footnotes at end of table.

Table 31.—Lead: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Bulgaria:[e]					
Primary	115.0	115.0	[r]114.0	[r]112.0	112.0
Secondary[4]	4.0	4.0	4.0	4.0	4.0
Total	119.0	119.0	[r]118.0	[r]116.0	116.0
Burma: Primary[e]	6.0	4.1	7.8	[2]7.6	7.0
Canada:					
Primary (refined)	162.5	168.5	174.3	178.1	173.0
Secondary (refined)	72.1	69.7	64.6	63.9	79.0
Total	234.6	238.2	238.9	242.0	252.0
China:[e]					
Primary (refined)	145.0	150.0	155.0	[r]165.0	165.0
Secondary (refined)	30.0	25.0	20.0	[r]30.0	30.0
Total	175.0	175.0	175.0	[r]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	2.5
Czechoslovakia: Secondary (refined)	20.0	21.0	21.0	21.0	21.0
Denmark: Secondary (refined)	24.5	[r]24.0	15.9	10.0	10.0
Finland: Secondary (refined)	3.2	4.5	4.4	[e]4.0	4.0
France:					
Primary (refined)	126.8	128.6	122.7	114.9	121.9
Secondary	35.7	38.9	40.7	[e]37.6	33.5
Total	162.5	167.5	163.4	152.5	155.4
German Democratic Republic: Secondary (refined)[e 4]	42.0	48.0	50.0	[r]40.0	45.0
Germany, Federal Republic of:					
Primary	111.9	107.5	110.7	116.2	102.3
Secondary	189.5	254.8	239.7	236.3	254.9
Total	301.4	362.3	350.4	352.5	357.2
Greece:					
Primary (refined)	15.6	21.0	3.2	([5])	15.0
Secondary (refined)	4.0	4.0	([5])	([5])	--
Total	19.6	25.0	3.2	([5])	15.0
Guatemala: Secondary (refined)	.1	.1	.1	.1	.1
Hungary: Secondary (refined)[e]	.1	.1	.1	.1	.1
India:					
Primary (refined)	14.9	14.3	[e]14.4	15.0	15.0
Secondary (refined)	10.7	11.1	[e]8.8	6.6	7.0
Total	25.6	25.4	[e]23.2	21.6	22.0
Ireland: Secondary (refined)[e]	7.0	10.0	10.0	10.0	10.0
Italy:					
Primary (refined)	42.1	35.6	36.4	37.0	37.6
Secondary (refined)	91.6	97.4	97.3	[e]90.0	90.0
Total	133.7	133.0	133.7	127.0	127.6
Jamaica: Secondary (refined)[e]	2.0	1.0	1.0	1.0	1.0
Japan:					
Primary	185.8	190.7	192.8	[r e]215.0	241.0
Secondary (refined)	129.8	141.6	119.1	118.3	131.9
Total	315.6	332.3	311.9	[r e]333.3	372.9
Korea, North: Primary (refined)[e]	65.0	65.0	60.0	60.0	60.0
Korea, Republic of:					
Primary (refined)[e]	8.6	7.2	9.5	10.5	10.3
Secondary (refined)[e]	1.8	7.5	6.6	7.3	10.0
Total	10.4	14.7	16.1	17.8	20.3
Malaysia: Secondary (refined)[e]	5.2	3.5	[2]3.0	[r]4.0	3.6
Mexico:					
Primary	145.0	156.7	145.4	166.8	170.0
Secondary (refined)[e]	44.0	38.0	34.0	35.0	35.0
Total	189.0	194.7	179.4	201.8	205.0

See footnotes at end of table.

Table 31.—Lead: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Morocco:					
Primary (refined)	40.3	50.1	56.5	[r] [e]57.1	48.5
Secondary (refined)[e]	2.1	2.1	2.0	2.0	2.0
Total	42.4	52.2	58.5	[r] [e]59.1	50.5
Namibia: Primary (refined)	42.7	41.7	40.6	35.4	[2]28.9
Netherlands:					
Primary[e]	6.0	2.5	2.5	2.5	2.5
Secondary	[r]19.8	[r]19.7	27.3	23.3	34.0
Total	[r]25.8	[r]22.2	29.8	25.8	36.5
New Zealand: Secondary (refined)[e]	7.0	7.0	[r]6.0	[r]6.0	6.0
Nigeria: Secondary (refined)[e]	2.0	2.0	2.0	2.0	2.0
Norway: Secondary (refined)	.4	--	--	--	--
Pakistan: Secondary (refined)[e]	1.0	1.0	1.0	1.0	1.0
Peru:					
Primary (refined)	79.9	79.2	77.0	67.7	[2]70.3
Secondary (refined)[e]	5.0	5.0	5.0	5.0	5.0
Total	84.9	84.2	82.0	72.7	75.3
Philippines: Secondary (refined)	4.8	4.0	6.0	6.0	6.0
Poland:					
Primary (refined)[e]	58.0	47.0	55.0	56.5	58.4
Secondary (refined)[e] [4]	24.0	22.0	23.8	24.5	25.0
Total	82.0	69.0	78.8	81.0	83.4
Portugal: Secondary (refined)	5.6	5.3	4.0	([5])	--
Romania:					
Primary (refined)[e]	[r] [2]40.9	[r] [2]40.6	[r]40.5	[r]40.0	39.0
Secondary (refined)[e]	[r]4.0	[r]5.0	[r]5.2	[r]9.3	10.0
Total	[r]44.9	[r]45.6	45.7	49.3	49.0
South Africa, Republic of: Secondary	35.4	26.9	30.4	23.6	[2]21.9
Spain:					
Primary (refined)[3]	83.3	83.1	99.5	107.8	110.0
Secondary (refined)	37.4	34.1	32.1	36.9	38.0
Total	120.7	117.2	131.6	144.7	148.0
Sweden:					
Primary (refined)	[r]27.0	[r]14.8	29.6	35.2	35.0
Secondary (refined)	22.0	22.0	19.9	19.0	20.0
Total	[r]49.0	[r]36.8	49.5	54.2	55.0
Switzerland: Secondary (refined)[e]	7.0	7.2	7.0	6.0	6.0
Taiwan: Secondary (refined)[e]	16.8	30.0	35.0	[r]38.0	38.0
Thailand: Secondary (refined)	1.7	[r].5	.9	3.2	[2]6.2
Trinidad and Tobago: Secondary (refined)[e]	2.0	2.0	2.0	2.0	2.0
Tunisia:					
Primary (refined)	19.2	17.5	15.3	10.4	10.0
Secondary (refined)[e]	.6	.5	.5	[r].5	.5
Total	19.8	18.0	15.8	10.9	10.5
Turkey:					
Primary (refined)	[r]3.0	[r]3.0	3.0	4.0	4.0
Secondary (refined)	([5])	([5])	([5])	([5])	--
Total	[r]3.0	[r]3.0	3.0	4.0	4.0
U.S.S.R.:[e]					
Primary (refined)	475.0	480.0	485.0	490.0	495.0
Secondary (refined)	225.0	235.0	245.0	255.0	260.0
Total	700.0	715.0	730.0	745.0	755.0
United Kingdom:					
Primary[6]	30.0	26.5	34.1	40.7	40.7
Secondary (refined)	211.4	198.0	179.2	185.3	191.0
Total	241.4	224.5	213.3	226.0	231.7

See footnotes at end of table.

Table 31.—Lead: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983^p	1984^e
United States:					
Primary (refined)	548.4	498.3	516.8	514.6	[2]396.6
Secondary (refined)	675.6	641.1	571.3	503.5	[2]582.8
Total	1,224.0	1,139.4	1,088.1	1,018.1	[2]979.4
Venezuela: Secondary (refined)^e	10.0	10.0	10.0	10.0	10.0
Yugoslavia:					
Primary	85.0	74.0	74.0	^e75.0	70.0
Secondary	39.7	46.5	35.0	^e35.0	30.0
Total	124.7	120.5	109.0	^e110.0	100.0
Zambia: Primary (refined)	10.0	9.9	14.6	14.6	[2]8.8
Grand total	^r5,397.3	^r5,375.4	5,295.0	5,267.0	5,318.7
Of which:					
Primary	^r3,180.6	^r3,119.9	3,185.8	3,230.4	3,132.2
Secondary	^r2,216.7	^r2,255.5	2,109.2	2,036.6	2,186.5

^eEstimated. ^pPreliminary. ^rRevised.

[1]Table includes data available through June 18, 1985. Figures presented represent, to the extent possible, production of crude (or unrefined) lead, including bullion and impure lead derived from scrap. The figures for secondary crude lead for a number of countries are undoubtedly high, but insufficient information is available to separate impure secondary lead from lead merely re-refined. Countries for which this is the case have been footnoted. (See footnote 4.) For those countries from which crude 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 crude for 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 re-refined, and as such probably should not be included here, but a substantial part of the total presumably was recovered from sufficiently impure materials 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	1980	1981	1982	1983^p	1984^e
Argentina:					
Primary	23.2	19.0	17.0	16.0	19.0
Secondary	18.5	15.6	14.6	14.0	17.0
Total	41.7	34.6	31.6	30.0	36.0
Australia:					
Primary	200.5	207.7	218.8	196.3	[2]196.2
Secondary	^r32.2	31.5	28.3	27.1	21.5
Total	^r232.7	239.2	247.1	223.4	217.7
Austria:					
Primary	5.4	3.3	3.4	4.2	4.2
Secondary	11.5	12.8	14.5	12.9	13.0
Total	16.9	16.1	17.9	17.1	17.2
Belgium:					
Primary	75.9	73.9	66.0	96.3	96.4
Secondary	52.0	36.0	33.7	37.8	38.6
Total	127.9	109.9	99.7	134.1	135.0
Brazil:					
Primary	44.5	34.7	21.9	21.0	[2]26.0
Secondary	40.4	^r31.0	27.4	29.0	30.0
Total	84.9	^r65.7	49.3	50.0	56.0

See footnotes at end of table.

Table 32.—Lead: World refinery production, by country[1] —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Bulgaria:[e]					
Primary	[r]101.2	[r]101.2	[r]100.3	[r]98.6	98.6
Secondary	[r]17.8	[r]17.8	[r]17.7	[r]17.4	17.4
Total	[r]119.0	[r]119.0	[r]118.0	[r]116.0	116.0
Burma:					
Primary[e]	5.8	3.9	7.6	7.4	6.8
Secondary[e]	.2	.2	.2	.2	.2
Total	6.0	4.1	7.8	7.6	7.0
Canada:					
Primary	162.5	168.5	174.3	178.1	173.0
Secondary	72.1	69.7	64.6	63.9	79.0
Total	234.6	238.2	238.9	242.0	252.0
China:[e]					
Primary	145.0	150.0	155.0	[r]165.0	165.0
Secondary	30.0	25.0	20.0	[r]30.0	30.0
Total	175.0	175.0	175.0	[r]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	2.5
Czechoslovakia: Secondary	20.0	21.0	21.0	21.0	21.0
Denmark: Secondary	24.5	[r]24.0	15.9	10.0	10.0
Finland: Secondary	3.2	4.5	4.4	4.0	4.0
France:					
Primary	126.8	128.6	122.7	115.0	121.9
Secondary	92.0	99.4	85.9	99.4	85.4
Total	218.8	228.0	208.6	214.4	207.3
German Democratic Republic: Secondary[e]	42.0	48.0	50.0	[r]40.0	45.0
Germany, Federal Republic of:					
Primary	191.1	189.5	201.6	212.5	216.2
Secondary	159.2	158.8	148.9	135.5	141.0
Total	350.3	348.3	350.5	348.0	357.2
Greece:					
Primary	15.6	21.0	3.2	(3)	15.0
Secondary	4.0	4.0	(3)	(3)	--
Total	19.6	25.0	3.2	(3)	15.0
Hungary: Secondary	.1	.1	.1	.1	.1
India:					
Primary	[r]14.8	14.3	14.4	23.0	15.0
Secondary	10.7	11.1	8.8	6.6	7.0
Total	[r]25.5	25.4	23.2	29.6	22.0
Ireland: Secondary[e]	7.0	10.0	10.0	10.0	10.0
Italy:					
Primary	42.1	35.6	36.4	36.9	37.5
Secondary	91.6	97.4	97.3	89.4	90.0
Total	133.7	133.0	133.7	126.3	127.5
Jamaica: Secondary[e]	2.0	1.0	1.0	1.0	1.0
Japan:					
Primary	175.2	175.4	183.1	203.3	233.8
Secondary	129.8	141.6	119.1	118.3	131.9
Total	305.0	317.0	302.2	321.6	365.7
Korea, North:[e]					
Primary	60.0	60.0	55.0	55.0	55.0
Secondary	5.0	5.0	5.0	5.0	5.0
Total	65.0	65.0	60.0	60.0	60.0

See footnotes at end of table.

Table 32.—Lead: World refinery production, by country[1] —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Korea, Republic of:					
Primary[e]	8.6	7.2	9.5	10.5	10.3
Secondary[e]	1.8	7.5	6.6	7.3	10.0
Total	10.4	14.7	16.1	17.8	20.3
Malaysia: Secondary[e]	5.2	3.5	[2]3.0	[r]4.0	[2]3.6
Mexico:					
Primary	140.3	[r]150.6	137.2	162.5	160.0
Secondary[e]	44.0	38.0	34.0	[r]31.0	35.0
Total	184.3	[r]188.6	171.2	193.5	195.0
Morocco:					
Primary	40.3	50.1	56.5	54.2	46.1
Secondary[e]	2.1	2.1	2.0	2.0	2.0
Total[e]	42.4	52.2	58.5	[r]56.2	48.1
Namibia: Primary	42.7	41.7	40.6	35.4	[2]28.9
Netherlands:					
Primary	[r]12.4	[r]14.2	5.6	2.3	1.0
Secondary	[r]19.8	[r]19.7	27.3	23.3	34.0
Total	[r]32.2	[r]33.9	32.9	25.6	35.0
New Zealand: Secondary[e]	7.0	7.0	[r]6.0	[r]6.0	6.0
Nigeria: Secondary[e]	2.0	2.0	2.0	2.0	2.0
Norway: Secondary	.4	--	--	--	--
Pakistan: Secondary[e]	1.0	1.0	1.0	1.0	1.0
Peru:					
Primary	79.9	79.2	77.0	67.7	70.3
Secondary[e]	5.0	5.0	5.0	5.0	5.0
Total[e]	84.9	84.2	82.0	72.7	75.3
Philippines: Secondary	4.8	4.0	6.0	6.0	6.0
Poland:					
Primary[e]	[r]57.4	[r]48.3	[r]55.2	[r]56.7	58.4
Secondary[e]	[r]24.6	[r]20.7	[r]23.6	[r]24.3	25.0
Total	82.0	69.0	78.8	81.0	83.4
Portugal:					
Primary	--	(3)	--	--	--
Secondary	5.6	5.3	4.0	6.0	6.0
Total	5.6	[r]5.3	4.0	6.0	6.0
Romania:[e]					
Primary	[2]40.9	[2]40.6	[r]40.5	[r]40.0	39.0
Secondary	[r]4.0	[r]5.0	[r]5.2	[r]9.2	10.0
Total	[r]44.9	[r]45.6	[2]45.7	[2]49.2	49.0
South Africa, Republic of: Secondary	35.4	26.9	30.4	23.6	24.1
Spain:					
Primary	83.3	83.1	99.5	107.8	110.0
Secondary	37.4	34.1	32.1	36.9	38.0
Total	120.7	117.2	131.6	144.7	148.0
Sweden:					
Primary	20.3	7.0	29.6	20.0	20.0
Secondary	22.0	22.0	19.9	19.0	20.0
Total	42.3	29.0	49.5	39.0	40.0
Switzerland: Secondary[e]	7.0	7.2	7.0	6.0	6.0
Taiwan: Secondary[e]	16.8	30.0	35.0	[r]38.0	38.0
Thailand: Secondary	1.7	[r].5	.9	3.1	[2]6.1
Trinidad and Tobago: Secondary[e]	2.0	2.0	2.0	2.0	2.0
Tunisia:					
Primary	19.2	17.5	15.3	10.4	10.0
Secondary[e]	.6	.5	.5	.4	.5
Total[e]	19.8	18.0	15.8	10.8	10.5

See footnotes at end of table.

Table 32.—Lead: World refinery production, by country[1] —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Turkey:					
Primary	[r]3.0	[r]3.0	3.0	4.0	4.0
Secondary	([3])	([3])	([3])	([3])	--
Total	[r]3.0	[r]3.0	3.0	4.0	4.0
U.S.S.R.:[e]					
Primary	475.0	480.0	485.0	490.0	495.0
Secondary	225.0	235.0	245.0	255.0	260.0
Total	700.0	715.0	730.0	745.0	755.0
United Kingdom:					
Primary	113.4	135.4	131.0	136.9	140.0
Secondary	211.4	198.0	175.2	185.2	191.0
Total	324.8	333.4	306.2	322.1	331.0
United States:					
Primary	548.4	498.3	516.8	514.6	[2]396.6
Secondary	675.6	641.1	571.3	503.5	[2]582.8
Total	1,224.0	1,139.4	1,088.1	1,018.1	[2]979.4
Venezuela: Secondary[e]	10.0	10.0	10.0	10.0	10.0
Yugoslavia:					
Primary	84.7	73.9	72.0	[r e]75.0	75.0
Secondary	17.0	12.5	10.2	[r e]35.0	7.8
Total	101.7	86.4	82.2	110.0	[2]82.8
Zambia: Primary	10.0	9.9	14.6	14.6	[2]8.8
Grand total	5,429.9	[r]5,338.2	5,228.7	5,245.1	5,288.5
Of which:					
Primary	[r]3,169.4	[r]3,126.6	3,169.6	3,231.2	3,153.0
Secondary	[r]2,260.5	[r]2,211.6	2,059.1	2,022.9	2,135.5

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 18, 1985. 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 J. W. Pressler[1]

Lime output, including that for Puerto Rico, was 16.0 million short tons, an increase of 7% compared with that of 1983. Total value increased 7% to $816 million.

Output of agricultural lime increased 30%, refractory lime increased 17%, construction lime increased 15%, and chemical and industrial lime increased 6%.

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 144 operations to which the annual survey request was sent, all responded, representing 100% of total production shown in tables 1 and 2.

Table 1.—Salient U.S. lime statistics[1]

(Thousand short tons unless otherwise specified)

	1980	1981	1982	1983	1984
Number of plants	153	150	147	139	132
Sold or used by producers:					
Quicklime	15,972	16,142	11,701	12,383	13,134
Hydrated lime	2,544	2,279	2,037	2,066	2,302
Dead-burned dolomite	494	435	337	418	487
Total	19,010	18,856	14,075	14,867	[2]15,922
Value[3] thousands	$842,922	$884,197	$696,207	$757,611	$811,183
Average value per ton	$44.34	$46.89	$49.46	$50.96	$50.95
Lime sold	13,809	14,271	10,856	12,083	13,064
Lime used	5,201	4,585	3,219	2,784	2,858
Exports[4]	42	28	23	28	25
Imports for consumption[4]	480	504	348	283	247

[1]Excludes regenerated lime. Excludes Puerto Rico.
[2]Data do not add to total shown because of independent rounding.
[3]Selling value, f.o.b. plant, excluding cost of containers.
[4]Bureau of the Census.

DOMESTIC PRODUCTION

Lime sold or used by producers increased 7% to 16.0 million tons. Commercial sales increased 8% to 13.1 million tons. Captive lime used by producers increased 3% to 2.9 million tons, but was 61% below the record-high year of 1971.

Production of quicklime increased 6% to 13.6 million tons. Production of hydrated lime increased 11% to 2.3 million tons. Production of dead-burned dolomite increased 17%, but was 80% below the 1956 record-high level of 2.4 million tons.

Six States—Ohio, Pennsylvania, Missouri, Kentucky, Alabama, and Texas—produced over 1 million tons each and accounted for 56% of total lime output. Production increased 19% in Alabama, 9% in Kentucky, 8% in Texas and Missouri, and 7% in Pennsylvania, but decreased 2% in Ohio.

Table 2.—Lime sold or used by producers in the United States, by State[1]

State	1983 Plants	1983 Hydrated (thousand short tons)	1983 Quicklime (thousand short tons)	1983 Total[2] (thousand short tons)	1983 Value (thousand dollars)	1984 Plants	1984 Hydrated (thousand short tons)	1984 Quicklime (thousand short tons)	1984 Total[2] (thousand short tons)	1984 Value (thousand dollars)
Alabama	5	125	856	981	41,149	5	146	1,018	1,163	50,560
Arizona	3	--	340	340	16,700	3	--	359	359	17,304
Arkansas, Louisiana, Oklahoma	5	119	213	332	19,751	4	112	213	325	17,635
California	11	W	W	358	22,994	11	W	W	406	26,827
Colorado, Nevada, Wyoming	11	W	W	242	14,287	11	W	W	230	16,674
Connecticut	1	--	5	5	400	1	--	W	W	W
Florida	3	W	W	W	13,881	3	W	W	171	9,379
Hawaii, Oregon, Washington	5	27	277	306	20,115	5	27	329	355	23,539
Idaho	3	--	85	85	7,686	3	--	87	87	5,616
Illinois, Indiana, Missouri	8	391	2,582	2,974	144,049	8	416	2,879	3,295	155,853
Iowa, Kansas, Nebraska, South Dakota	7	W	W	208	10,165	7	W	W	227	12,207
Kentucky, New York, Tennessee, West Virginia	6	79	2,141	2,220	105,753	6	97	2,281	2,379	113,313
Maryland	1	4	3	7	383	1	4	3	7	419
Massachusetts	2	16	140	156	10,671	2	16	155	171	12,426
Michigan	9	W	W	503	23,142	9	W	W	622	30,092
Minnesota	4	--	W	W	W	4	W	W	W	W
Montana	3	--	86	86	W	3	--	89	89	5,097
New Mexico	1	--	17	17	W	--	--	--	--	--
North Dakota	3	--	57	57	6,798	3	--	59	60	5,912
Ohio	14	W	W	1,906	84,928	11	W	W	1,859	87,951
Pennsylvania	10	308	1,199	1,507	81,682	10	402	1,218	1,620	90,182
Puerto Rico	1	35	--	35	3,885	1	35	--	35	4,531
Texas	9	485	582	1,067	60,193	8	555	602	1,157	61,214
Utah	4	W	W	315	16,771	4	W	W	297	16,471
Virginia	6	103	454	557	24,637	5	97	465	562	24,799
Wisconsin	5	97	222	319	17,624	5	105	266	373	19,892
Other[3]	(4)	311	3,542	322	13,852	(4)	324	3,596	110	7,819
Total[2]	140	2,100	12,801	14,902	761,496	133	2,336	13,620	15,956	815,714

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.

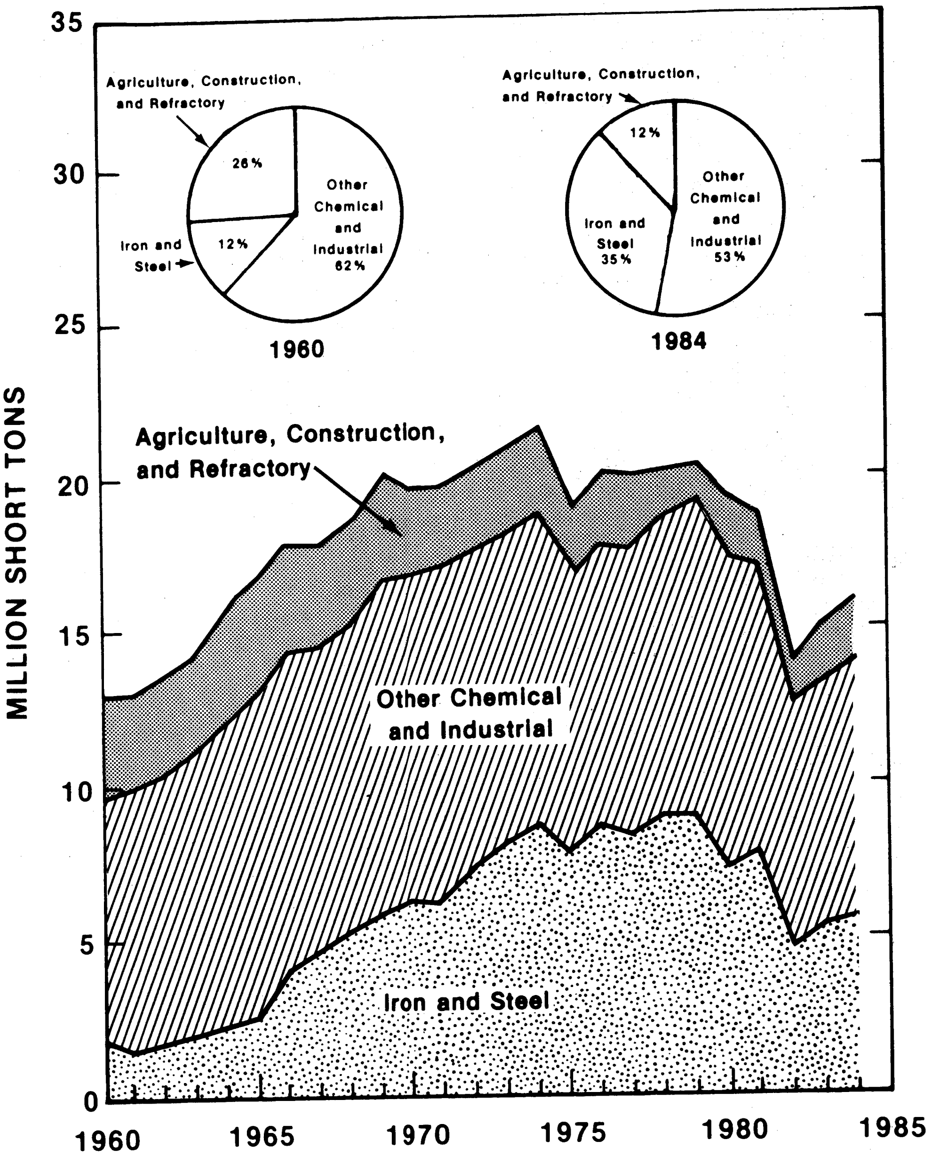

Figure 1.—Trends in major uses of lime.

Leading producing companies were Marblehead Lime Co. with two plants in Illinois, two in Michigan, and one each in Indiana, Pennsylvania, and Utah; Dravo Lime Co. with one plant each in Alabama, Kentucky, Louisiana, and Texas; Mississippi Lime Co. in Missouri; Martin Marietta Corp., Chemical Div., with two plants in Ohio; Allied Chemical Corp. in New York; Black River Lime Co. in Kentucky; Genstar Lime Co. with two plants in California, two in Nevada, and one each in Arizona and Utah; Rangaire Corp. with one plant each in Arkansas, Pennsylvania, Texas, and Virginia; Bethlehem Steel Corp. with two plants in Pennsylvania; and Allied Products Co. with two plants in Alabama. These 10 companies, operating 30 plants, accounted for 52% of the total lime production.

The six largest lime plants, each producing more than 400,000 tons, accounted for 29% of the total lime output. In 1984, 23 plants produced from 200,000 to 400,000 tons each and accounted for 36% of the total.

Leading individual plants were Mississippi Lime's Ste. Genevieve plant in Missouri, Dravo Lime's Maysville plant in Kentucky, Martin Marietta Chemical Div.'s Woodville No. 1 plant in Ohio, Black River Lime's Carntown plant in Kentucky, and Marblehead Lime's Buffington plant in Indiana.

A total of 352 lime kilns were operated during 1984. A total of 11 sugar companies operated 35 plants with 54 shaft kilns and 1 rotary kiln, and produced 617,000 tons of lime valued at $41.9 million. The balance of the lime industry, not including the paper and pulp and the calcium carbide industries, operated 297 kilns during the year: 113 vertical kilns, 144 rotary kilns, 20 pot kilns, 13 Calcimatic traveling-hearth kilns, 4 fluidized-bed kilns, and 3 Maerz-Warwick vertical kilns.

Hydrators for production of hydrated lime, including those used by the sugar industry, totaled 137; 120 were of the continuous type, and 17 were of the batch type.

The number of lime plants in the United States and Puerto Rico decreased by 7 to 133, and the average production per plant, excluding the sugar industry average of 17,600 tons per year, was 156,500 tons per year.

New Plants, Expansions, and Changes.—Construction was initiated by Florida Crushed Stone Co. in early 1984 for a 350,000-ton-per-year lime plant near Brooksville, Hernando County, FL. The lime plant was part of a $100 million project, which also consisted of a 600,000-ton-per-year cement plant and a 125-megawatt cogeneration powerplant.[2]

Kaiser Aluminum & Chemical Corp. sold its Natividad dolomitic lime and refractory dead-burned dolomite plant and facilities in Monterey County, CA, to National Refractories & Mineral Corp. at yearend. Pfizer Inc. permanently closed its Canaan dolomitic lime plant in Litchfield County, CT, in the first quarter of 1984. Chino Mines Co. permanently closed its rotary lime kiln in Grant County, NM, in November. National Gypsum Co. sold its Kimballton lime plant, consisting of an underground limestone mine, three rotary kilns, and one continuous hydrator, to USG Industries Inc. in February.

Seven less plants reported production compared with that of 1983. This was attributed to permanent closures of Aluminum Co. of America's (Alcoa) Bauxite plant in Arkansas; Cuyahoga Lime Co.'s Cleveland plant, Pfizer's Gibsonburg plant, and C-E Basic Inc.'s Maple Grove plant, all in Ohio; Alcoa's Point Comfort plant in Texas; and Genstar Stone Products Co.'s Stephens City plant in Virginia. Mathis Mining & Exploration Co.'s plant in Grant County, NM, was closed in September 1983 and was dormant in 1984.

Reflecting continued depressed markets for lime, particularly in the iron and steel and copper industries, several plants remained dormant. Amstar Corp.'s plant in Chandler, AZ, remained idle. Kennecott-Ray Mines Div.'s plant in San Manuel, AZ, and Phelps Dodge Corp.'s plant in Morenci, AZ, were dormant. S. I. Lime Co.'s Morgan City, LA, two rotary lime kilns, originally shut down in July 1982, remained dormant in 1983-84, and the company operated only two continuous hydrators on quicklime shipped from Kentucky. Armco Inc.'s Azbe vertical lime kiln in Houston, TX, had been shut down in late 1982 and remained dormant during 1983-84. Greer Lime Co.'s Saltville, VA, plant had ceased operations July 1982, and has remained dormant during 1983-84. Riverton Corp.'s Martinsburg, WV, plant, which had been closed in July 1982, remained dormant in 1983-84.

As reported by the National Lime Association, direct fuel sources for the commercial lime industry through 1984 were coal, 78%; natural gas, 14%; petroleum coke, 6%; and oil, 2%. Changing fuel consumption patterns in the industry caused a 39% reduction in the use of natural gas and a 28% increase in the use of coal and coke compared with that of 1980. A 1983 energy survey of the major lime producers indicated an average consumption of 6.7 million British thermal units per ton of quicklime production at a cost of about $13.50 per ton.

Table 3.—Lime sold or used by producers in the United States,[1] by size of plant

Size of plant	1983 Plants	1983 Quantity (thousand short tons)	1983 Percent of total	1984 Plants	1984 Quantity (thousand short tons)	1984 Percent of total
Less than 10,000 tons	23	133	1	20	115	1
10,000 to 25,000 tons	29	501	3	25	423	3
25,000 to 50,000 tons	18	667	5	18	663	4
50,000 to 100,000 tons	24	1,861	12	22	1,723	11
100,000 to 200,000 tons	27	4,131	28	19	2,769	17
200,000 to 400,000 tons	13	3,383	23	23	5,668	36
More than 400,000 tons	6	4,226	28	6	4,595	29
Total	140	14,902	100	133	15,956	[2]100

[1]Excludes regenerated lime. Includes Puerto Rico.
[2]Data 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, Michigan, and Texas, each of which consumed more than 1 million tons. These five States accounted for 46% of the total lime consumed. In 1984, 24 plants in 13 States produced dolomitic quicklime or dead-burned dolomite, and represented about 18% of the lime industry.

Lime consumption in the steel industry increased 3% to 5.6 million tons, and equaled 34% of all lime consumed in the United States. Increased housing and building starts caused increases in the sales and use of mason's and finishing lime, 8% and 48%, respectively. Environmental uses of lime continued to increase. Lime consumption in flue gas desulfurization processes and effluent water cleanup increased 19%.

Leading quicklime-consuming States were Pennsylvania, Indiana, Ohio, and Michigan, each of which consumed more than 1 million tons. These four States accounted for 42% of the total quicklime consumed.

Leading hydrate-consuming States were Texas, Pennsylvania, Ohio, Louisiana, and Illinois, each of which consumed more than 100,000 tons, These five States accounted for 49% of the total hydrate consumed.

Lime sold or used by producers was for chemical and industrial uses, 88%; construction, 9%; and refractories and agriculture, 3%. Captive lime used by producers declined to 18% of the total. Captive lime was used mainly in the production of basic oxygen furnace (BOF) steel, 28%; alkalies, 22%; and sugar, 20%.

Leading individual uses for lime were for BOF steel, water purification, sulfur removal from stack gases, paper and pulp, and electric steel, which together accounted for 57% of the total consumption.

Of the main chemical and industrial uses, lime for BOF's was produced principally in Indiana and Illinois combined, 30%; Ohio, 22%; and Pennsylvania, 12%. Lime for water purification was produced mainly in Missouri, 31%; Alabama, 13%; and Texas, 10%. Lime for sulfur removal from stack gases was produced principally in the Eastern United States. Lime used for paper and pulp, excluding regenerated lime, was produced mainly in Alabama, 33%; Virginia, 16%; Tennessee, 15%; and Wisconsin, 11%. Lime for electric steel was produced principally in Pennsylvania, 24%; Alabama, 15%; and Texas, 11%.

Mason's lime was produced at 21 plants in 14 States, including Puerto Rico. Leading States were Wisconsin, 21%, with four plants; Virginia, 20%, with three plants; Texas, 14%, with three plants; and Pennsylvania, 13%, with three plants. Finishing lime was produced in 12 plants in 9 States; the leading State was California with three plants.

The use of lime in agriculture increased 30% from its long-term decline, to about 79,000 tons. Compared with its high of 252,000 tons per year in 1956, it has become of small significance. Conversely, 21 million tons of less-reactive pulverized limestone was used for agricultural purposes in 1983.

Table 4.—Destination of shipments of lime sold or used by producers in the United States, by State[1]

(Thousand short tons)

State	1983			1984		
	Quicklime	Hydrated lime	Total[2]	Quicklime	Hydrated lime	Total[2]
Alabama	367	57	424	370	54	424
Alaska	W	W	8	(3)	2	2
Arizona	210	25	235	244	32	275
Arkansas	98	36	134	78	28	106
California	436	72	508	399	84	483
Colorado	81	20	101	95	14	110
Connecticut	33	13	46	34	10	43
Delaware	40	5	45	37	5	42
District of Columbia	W	W	13	13	34	47
Florida	333	18	351	373	65	438
Georgia	215	74	289	213	61	274
Hawaii	1	5	6	4	2	6
Idaho	95	3	97	101	3	104
Illinois	560	103	664	552	112	664
Indiana	1,512	41	1,553	1,520	41	1,562
Iowa	62	17	79	73	18	91
Kansas	64	15	79	65	16	81
Kentucky	457	22	479	471	19	490
Louisiana	166	100	265	238	127	365
Maine	11	1	13	15	1	16
Maryland	262	18	280	241	20	261
Massachusetts	65	12	77	67	14	80
Michigan	993	29	1,022	1,165	32	1,197
Minnesota	181	16	198	190	19	209
Mississippi	96	32	129	117	28	146
Missouri	148	35	183	148	40	188
Montana	62	10	72	62	11	73
Nebraska	51	6	57	66	5	71
Nevada	50	6	56	72	8	80
New Hampshire	W	W	3	3	1	3
New Jersey	106	40	147	126	61	186
New Mexico	62	19	81	25	28	53
New York	607	40	647	631	45	676
North Carolina	170	23	193	192	24	216
North Dakota	81	8	88	103	11	114
Ohio	1,470	110	1,580	1,483	135	1,618
Oklahoma	88	15	103	91	12	104
Oregon	87	8	95	128	15	143
Pennsylvania	1,469	195	1,664	1,601	234	1,835
Rhode Island	5	2	7	5	2	6
South Carolina	88	15	103	109	14	123
South Dakota	61	16	77	12	9	21
Tennessee	122	53	174	188	77	265
Texas	586	515	1,101	624	548	1,172
Utah	240	11	251	270	11	281
Vermont	W	W	W	(3)	1	1
Virginia	110	74	183	95	55	150
Washington	222	16	238	262	14	276
West Virginia	386	29	415	490	26	516
Wisconsin	109	45	154	93	48	141
Wyoming	51	18	69	43	15	58
Other[4]	13	36	25	1	24	25
Total[2]	12,782	2,079	14,861	13,598	2,314	15,912
Exports:						
Canada	16	7	23	18	7	25
Mexico	(3)	--	(3)	--	--	--
Other countries	3	14	17	4	15	19
Total	19	21	40	22	22	44
Grand total[2]	12,801	2,100	14,902	13,620	2,336	15,956

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]Less than 1/2 unit.
[4]Includes Puerto Rico, possessions, and States indicated by symbol W.

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

(Thousand short tons and thousand dollars)

Use	1983				1984			
	Sold	Used	Total[2]	Value	Sold	Used	Total[2]	Value
Agriculture	61	--	61	3,246	79	--	79	4,848
Construction:								
Road stabilization	592	--	592	33,384	608	--	608	33,499
Soil stabilization	215	--	215	12,660	243	--	243	13,625
Finishing lime	160	--	160	13,243	236	--	236	20,424
Mason's lime	W	W	218	14,166	W	W	235	14,894
Other[3]	17	--	17	1,216	56	--	56	3,299
Total[2]	W	W	1,201	74,668	W	W	1,379	85,741
Chemical and industrial:								
Steel, BOF	3,461	832	4,293	193,552	3,593	797	4,390	202,015
Water purification	W	W	1,488	76,932	W	W	1,401	71,978
Sulfur removal from stack gases	1,019	--	1,019	50,817	1,213	--	1,213	56,371
Paper and pulp	W	W	916	44,619	W	W	1,135	53,811
Steel, electric	W	W	808	38,937	W	W	929	44,167
Sewage treatment	W	W	578	31,847	W	W	669	36,901
Alkalies	W	W	560	26,852	W	W	647	31,657
Sugar refining	43	523	566	38,320	44	573	617	41,869
Magnesia from seawater or brine	W	W	557	27,084	W	W	564	27,586
Copper ore concentration	W	W	390	19,529	W	W	367	18,288
Acid water, mine or plant	W	W	268	14,365	W	W	270	14,507
Steel, open-hearth	W	W	292	13,265	W	W	256	11,043
Calcium carbide	W	W	209	9,416	W	W	226	9,736
Magnesium metal	W	W	171	10,707	W	W	192	12,141
Aluminum and bauxite	W	W	203	11,423	156	--	156	8,261
Precipitated calcium carbonate	W	W	128	9,046	W	W	131	9,118
Glass	156	--	156	6,947	128	--	128	6,172
Ore concentration, other	80	--	80	3,963	71	--	71	3,606
Oil and grease	52	--	52	3,166	50	--	50	3,049
Petrochemicals	W	--	W	W	W	--	W	W
Food products, animal or human	35	--	35	2,255	39	--	39	2,265
Citric acid	--	20	20	1,337	37	--	37	866
Tanning	20	--	20	1,246	30	--	30	1,668
Petroleum refining	26	--	26	1,308	29	--	29	1,452
Fertilizer	5	--	5	456	23	--	23	1,190
Oil well drilling	30	--	30	2,113	16	--	16	1,092
Calcium silicate	W	--	W	W	11	--	11	599
Metallurgy, other	11	--	11	492	11	--	11	505
Gelatin	5	--	5	311	5	--	5	320
Brick, sand-lime	4	--	4	220	4	([4])	5	274
Paint	2	--	2	161	2	--	2	163
Other[5]	5,569	1,328	329	18,442	5,789	1,389	391	23,063
Total[2]	10,518	2,703	13,221	659,128	11,252	2,759	14,011	695,733
Refractory dolomite	W	W	418	24,454	W	W	487	29,391
Grand total[2]	12,118	2,784	14,902	761,496	13,099	2,858	15,956	815,714

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]Includes asphalt antistripping.

[4]Less than 1/2 unit.

[5]Includes briquetting, brokers, chrome, coke and gas (1983), commercial hydrators, desiccants, explosives, ferroalloys, fiberglass, glue, insecticides, ladle desulfurizing, manganese, other uses, pelletizing, pharmaceuticals, rubber, silica brick, soap, starfish control, wire drawing, and uses indicated by symbol W in "Chemical and industrial" lime only.

PRICES

The average value of lime sold or used by producers in 1984 remained virtually the same at $51.12 per ton, an increase of 132% over the 1974 price. Values ranged from $49.65 for chemical and industrial lime to $60.40 for refractory dolomite, $61.03 for lime used in agriculture, and $62.19 for construction lime.

Values for quicklime sold ranged from $45.92 for chemical lime to $50.92 for construction lime, $51.07 for lime used in agriculture, and $61.14 for refractory dead-burned dolomite, and averaged $46.72, a slight decrease.

Values for hydrated lime sold ranged from $64.98 for chemical lime to $66.36 for construction lime and $70.39 for lime used in agriculture, and averaged $65.69, a slight decrease.

FOREIGN TRADE

Exports of lime decreased 12% to 24,700 tons, 64% below the 1968 record high. Of the total exports, Canada received 82%; Mexico, 5%; and Guyana, 3%. The remaining 10% went to 28 countries.

Imports, principally from Canada, 71%, and Mexico, 29%, were 247,500 tons, a decrease of 12%. Import reliance, expressed as a percentage of apparent consumption, shipments minus net imports, was 1%.

Table 6.—U.S. exports of lime

	Quantity (short tons)	Value (thousands)
1981	28,429	$3,996
1982	22,541	3,199
1983	28,154	4,815
1984	24,714	6,805

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)
1981	65,717	$3,471	438,623	$18,092	504,340	$21,563
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	247,484	13,391

WORLD REVIEW

Austria.—Commercial sales of lime were 720,000 tons in 1983 with a value of $40 million, a 9% increase in value compared with that of 1982. This increase was caused by a shift to higher grade products. Principal end uses were iron and steel, 50%; construction, 45%; and agriculture, 5%. Principal fuel was heavy oil or natural gas, with very little coal utilization because of specification limitations of carbon and ash residue.[3]

Bahrain.—A gas-fired rotary lime kiln and hydrating plant was installed by the Arab Iron & Steel Co. with a capacity of 400 tons per day. Used in a 4-million-ton-per-year iron ore pelletizing plant, the hydrated lime was added at a rate of 2% to the finely ground iron ore concentrate as a binder prior to pelletization.[4]

Belgium.—Production of lime in 1983 was 2.3 million tons, a slight increase compared with that of 1982. End uses were iron and steel, 34%; chemicals, 4%; construction, 3%; others, including agriculture, 5%; and exports, 54%.[5]

Denmark.—Commercial sales of lime in 1983 were 120,000 tons, of which 13% was hydrated lime. Principal end uses included iron and steel, 25%; building materials, 21%; masonry lime and mortar, 19%; sewage treatment, 10%; other, 13%; and exports, 13%.[6]

Finland.—Commercial sales of lime in 1983 were 253,000 tons. End uses included pulp and paper, 32%; sand-lime brick, 19%; water treatment, 18%; iron and steel, 15%; nonferrous metallurgy, 11%; and other, 5%.[7]

France.—Lime production fell for the fifth consecutive year to 3.3 million tons in 1983, a 24% decrease since 1979. The iron and steel industry was principally responsible for this trend, as its consumption of lime had fallen by 32% in the last 5 years, but still represented almost 55% of total consumption. Major end uses in 1983 were iron and steel, 46%; construction, 12%; agriculture, 8%; nonferrous metallurgy and chemicals, 7% each; other, 11%; and exports, 9%.[8]

Germany, Federal Republic of.—Almost

7.2 million tons of lime was produced in the Federal Republic of Germany in 1984. In 1983, major end uses were iron and steel, 32%; sand-lime brick, 15%; construction, 19%; environmental, 9%; agriculture, 7%; and exports, 6%. Quicklime sales were only slightly improved in 1984. Structural changes in the West German lime industry included increased conversions from oil and gas to powdered brown coal; mergers with large companies in the crushed stone and sand and gravel industries, including prefabricated dry mortar plants; and diversified sales, including both calcined and uncalcined products.[9]

Italy.—Production of lime in Italy was 6.7 million tons in 1983. End uses were construction, including hydraulic lime, 48%; iron and steel, 16%; chemicals, 15%; environmental, 10%; other industrial, 8%; and agriculture, 3%.[10]

Japan.—Production of lime in Japan was 11.2 million tons in 1983, 18% of which was hydrated lime. End uses consisted of iron and steel, 56%; chemicals, 24%; environmental, 7%; construction and building materials, 6%; agriculture, 4%; and other, 3%. Demand for burnt lime in 1983 declined by 5% from that of 1982, mainly owing to the drop of 7% in shipments to the steel industry and 4% to the chemical industry. In steelmaking, the BOF operators are shifting to a new method, which resulted in average consumption of burnt lime per ton of crude steel decreasing from 83 pounds in 1983 to 79 pounds in 1984.[11]

Netherlands.—Sales of lime in the Netherlands was 700,000 in 1983. Principal end uses consisted of industrial, including iron and steel, 47%; sand-lime brick and other construction materials, 37%; mortar and plaster, 14%; agriculture, 1%; and exports, 1%.[12]

South Africa, Republic of.—Sales of lime for 1983 totaled 2.2 million tons, 14% below the 1982 level. The reduction was due to the depressed conditions in the steel and nonferrous metal industries. Utilization of lime plant capacity was about 60%, and the larger producers placed their older less-efficient kilns on standby. Principal end uses were nonferrous metal industry, 41%; iron and steel, 26%; calcium carbide, 13%; construction, 8%; and other, 12%.[13]

Spain.—Commercial sales of lime in Spain in 1983 were 560,000 tons. End uses consisted of iron and steel, 51%; paper and pulp, 22%; construction, 19%; environmental, 6%; and other, 2%.[14]

Sweden.—Commercial sales of lime in Sweden in 1983 were 406,000 tons. End-use patterns consisted of iron and steel, 46%; cellulose, 19%; water treatment, 9%; chemicals, 6%; and other, 20%.[15]

Zambia.—The Ndola Lime Co. has initiated construction of a $15 million, 1,000-ton-per-day vertical lime kiln. The new kiln, which will treble present quicklime production, will produce lime for the tailings leach plant at the Nchanga Div.[16]

Table 8.—Quicklime and hydrated lime, including dead-burned dolomite: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Algeria[e]	45	45	45	45	45
Australia[3]	[r]937	[r]964	1,045	1,047	1,100
Austria	1,108	1,140	1,132	1,257	1,270
Belgium	[r]2,748	[r]2,372	1,683	1,951	[4]1,786
Brazil[e]	5,300	5,500	5,500	5,500	5,500
Bulgaria	[r]2,037	1,938	1,958	1,801	1,870
Burundi	(5)	(5)	(5)	(5)	(5)
Canada	2,815	2,816	2,422	2,460	2,510
Chile	858	714	711	797	770
Colombia[e]	1,430	1,430	1,430	1,430	1,430
Costa Rica[e]	8	8	[r]10	[r]11	11
Cuba	161	154	160	[e]160	165
Cyprus	15	12	11	9	9
Czechoslovakia	3,327	3,565	3,404	3,417	[4]3,436
Denmark	187	215	109	119	[4]141
Dominican Republic[e]	[4]44	44	44	44	44
Egypt	97	101	[e]105	103	107
Fiji Islands	2	[r]5	4	[e]3	3
Finland	432	422	396	379	390
France	3,979	3,710	3,300	3,247	3,300
German Democratic Republic	3,749	3,793	3,869	3,812	3,900
Germany, Federal Republic of	9,453	8,726	7,604	7,574	7,900

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]	1980	1981	1982	1983[p]	1984[e]
Guatemala	39	27	[e]27	[e]27	26
Hungary	769	834	931	906	[4]895
India[e]	440	440	440	440	440
Iran[e]	550	550	600	700	700
Ireland	35	51	51	[e]50	[e]50
Israel	[e]137	88	[e]55	45	55
Italy	2,606	2,543	2,389	2,228	2,300
Jamaica	175	146	126	134	130
Japan	10,307	8,848	8,573	8,197	[4]8,547
Jordan	[e]4	22	66	294	300
Kenya	29	[e]30	24	38	39
Korea, Republic of[e]	[4]232	220	220	220	220
Kuwait	20	24	11	[r e]5	17
Lebanon	132	67	[e]55	[r e]22	11
Libya	254	259	248	287	287
Malawi	--	--	2	3	3
Malta	[r]7	7	8	6	6
Martinique[e]	--	[4]6	6	6	6
Mauritius[e]	8	8	8	8	8
Mexico	4,795	4,960	[e]4,400	[e]4,000	4,400
Mongolia[e]	55	55	65	70	72
Mozambique[e]	11	11	11	11	11
Nepal	11	[e]11	[e]11	[e]11	[4]8
New Zealand[e]	190	190	190	180	165
Nicaragua[e]	44	33	[r]6	[4]5	3
Norway[e]	145	145	145	145	145
Paraguay	[r]54	63	59	81	[4]94
Peru	([5])	37	[e]40	[e]40	40
Philippines	96	94	73	56	65
Poland	5,324	4,607	4,476	4,640	4,600
Portugal	298	287	276	[e]250	220
Romania	4,203	4,125	4,180	3,994	4,100
Saudi Arabia[e]	165	190	220	[r]10	11
South Africa, Republic of (sales)	2,407	2,380	2,232	2,085	[4]2,325
Spain	1,047	1,158	[e]1,200	[e]1,100	1,100
Sweden	820	708	640	661	660
Switzerland	71	63	51	[e]50	45
Taiwan	219	158	120	145	[4]130
Tanzania[e]	7	7	[r]7	[4]3	3
Tunisia	583	514	[r e]550	640	660
Turkey	1,100	1,000	1,000	1,100	1,100
Uganda[e]	17	17	17	17	17
U.S.S.R	[r]31,306	[r]31,306	31,636	32,518	33,100
United Arab Emirates[e]	[4]49	45	45	50	50
United Kingdom	[4]3,285	3,310	3,310	3,310	3,400
United States including Puerto Rico (sold or used by producers)	19,037	18,890	14,112	14,902	[4]15,956
Uruguay	22	[e]55	15	11	11
Venezuela	NA	2	2	[e]2	2
Yugoslavia	2,628	2,826	2,657	[r e]2,750	2,200
Zaire	125	136	114	[e]115	120
Zambia	201	221	204	213	[4]256
Total	[r]132,791	[r]129,448	120,846	121,947	124,796

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 18, 1985.
[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]Reported figure.
[5]Less than 1/2 unit.

TECHNOLOGY

Lime sold for sulfur removal in flue gas desulfurization (FGD) systems of coal-burning powerplants in the United States was 1.2 million tons. It is estimated that almost 2.0 million tons of pulverized limestone was used for the same purpose. Linear regression analysis of 1975-84 lime data indicated a growth rate of over 40%. A similar analysis of pulverized limestone for 1976-84, a principal competitor for this use, indicated a growth rate of about 10%. A mathematical model, using a variable of legislative acid rain passage and effective implementation, indicated that additional demand in 1992 could be about 9 million tons for lime or about 21 million tons for limestone, but that the use of FGD alone will probably not achieve the required lowering in sulfur dioxide emissions. Alternative methods might include mandatory scrubbing requirements, financial subsidies, and direct financial aid.[17]

Pressure injection grouting of lime slurry has been utilized for more than 20 years in civil engineering applications. Recently, the addition of fly ash to the slurry has made it economically possible to grout nonreactive natural and fill areas, for stabilizing landfills to support construction of buildings and parking lots, and for repair and renovation of existing buildings and parking lots. The ready availability of an inexpensive supply of fly ash and the development of new equipment and procedures indicated favorable economics. The method utilized hydraulically pushed grout probes rather than predrilled grout holes, and is usually faster and cheaper than the older stationary grout pipe methods.[18]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Bagli, C. V. $100 Million Plant Will Rise From Floor of Limestone Mine. Hernando Tribune (Brookville). Jan. 23, 1985.

[3]International Lime Association (Paris, France). Situation of the Austrian Lime Industry in 1983. Report to the International Lime Association. Aug. 23, 1984, 1 pp.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

[4]Skillings' Mining Review. Aisco Starting Up New Iron Ore Pellet Plant in Bahrain To Supply Direct Reduction Facilities Throughout World. V. 74, No. 2, Jan. 12, 1985, pp. 26-31.

[5]Wouters, E. State of the Belgian Lime, Limestone and Dolomite Sectors. 1983 Report to the International Lime Association. Paris, France, Aug. 23, 1984, 4 pp.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

[6]International Lime Association (Paris, France). Sales of Burnt Products of Lime and Dolomite in 1983. Report to the International Lime Association. Aug. 23, 1984, 2 pp.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

[7]Work cited in footnote 6.

[8]International Lime Association (Paris, France). Situation in the French Lime Industry. Report to the International Lime Association. Sept. 21, 1984, 2 pp.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

[9]———. Situation in the German Lime Industry—Autumn 1984. Report to the International Lime Association. Dec. 9, 1984, 3 pp.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

[10]Work cited in footnote 6.

[11]International Lime Association (Paris, France). Present Situation and Outlook of Lime Industry in Japan. Report to the International Lime Association. Dec. 1984, 3 pp.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

[12]Work cited in footnote 6.

[13]International Lime Association (Paris, France). Report on the South African Lime Industry for 1983. Steering Committee Meeting (Tokyo, Japan, Sept. 5, 1984), Internat. Lime Assoc., 1984, 2 pp.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

[14]———. Sales of Burnt Products of Spanish Limestone and Dolomite in 1983. Report to the International Lime Association. Dec. 1984, 1 p.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

[15]Work cited in footnote 6.

[16]Industrial Minerals (London). Company News & Mineral Notes. No. 210, Mar. 1985, p. 79.

[17]Bhagwat, S. B. The Lime and Limestone Market for Sulfur Removal: Potential for 1992. IL Dep. Energy and Nat. Res., IL Miner. Note 90, 1985, 13 pp.

[18]Blacklock, J. R., R. C. Joshi, and P. J. Wright. Pressure Injection Grouting of Landfills. Reprinted from Public Works, May 1984, 3 pp.; available from J. W. Pressler, Bureau of Mines, Washington, DC.

Lithium

By John E. Ferrell[1]

As the world's largest producer and consumer of lithium minerals and chemicals, the United States remained self-sufficient in this commodity and was the world's largest exporter. The two U.S. producers reported increased lithium sales, reflecting increased demand for lithium products.[2] U.S. exports, imports, and apparent consumption increased for 1984. With the opening of a new plant in Chile and an increase in capacity at a plant in Australia, the estimated rest-of-world production increased by about 27%. Major consumers of lithium were the aluminum, ceramics and glass, grease, and synthetic rubber industries. These markets were closely aligned with the construction and automotive industries. Consumption of lithium in aluminum-lithium alloys and lithium primary and rechargeable batteries was small but increasing.

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)

	1980	1981	1982	1983	1984
United States:					
Production[1]	W	W	W	W	W
Producers' stock changes[1]	W	W	W	W	W
Imports[2]	90	150	30	35	90
Shipments of Government stockpile surplus[3]	--	--	2	1	1
Supply[1 4]	r6,400	r6,900	5,000	r6,000	6,600
Supply[e 5]	5,500	5,800	4,300	4,800	6,100
Exports[e 6]	2,500	2,600	2,300	2,600	2,900
Consumption:					
Apparent	W	W	W	W	W
Estimated	3,000	3,200	2,000	2,200	3,200
Rest of world: Production[e 1]	r2,800	r2,800	r2,600	r2,600	3,300

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data.
1Mineral concentrate and carbonate.
2Compounds, concentrate, ores, and metal.
3Lithium hydroxide monohydrate.
4Production plus inventory decrease.
5Based primarily on monitoring at the carbonate stage and assuming a 15% lithium loss during conversion of concentrate to chemicals.
6Compounds.

Legislation and Government Programs.—The General Services Administration (GSA) reported two sales of lithium hydroxide monohydrate ($LiOH \cdot H_2O$) from excess stocks in the National Defense Stockpile. The sales totaled 8 short tons of material depleted of lithium 6: 4 tons at a price of $1.43 and 4 tons at $1.58 per pound. GSA reported stocks were 15,885 pounds of virgin material and 39,971 tons of depleted material that may contain 8 to 9 parts per million of mercury. This material was excess from a nuclear weapons program.

DOMESTIC PRODUCTION

Two companies continued to produce lithium products in the United States. Foote Mineral Co., 87.5% owned by Newmont Mining Corp., produced lithium ore from pegmatite dikes in North Carolina and lithium compounds from subsurface brines in Nevada. Lithium Corp. of America (Lithco), owned by Gulf Resources & Chemical Corp., produced lithium from pegmatite dikes in North Carolina.[3]

Foote Mineral reported total domestic production of 13,126 tons of lithium carbonate (Li_2CO_3) equivalent, or 2,468 tons of contained lithium, an increase of about 11% from 1983 production. Foote Mineral reported production of 6,998 tons of Li_2CO_3 equivalent, or 1,316 tons of contained lithium, from the Nevada plant and 6,127 tons of Li_2CO_3 equivalent, or 1,152 tons of contained lithium, from the North Carolina plant.[4] This was the first year that Foote Mineral reported a higher Li_2CO_3 production level at the company's Nevada plant than at its North Carolina plant. Foote Mineral's annual rated plant capacity remained at 17,000 tons of Li_2CO_3 equivalent. Downstream lithium chemicals were produced in Frazer, PA; Sunbright, VA; and New Johnsville, TN. During the year, Foote Mineral upgraded its lithium chloride (LiCl) production facility at Frazer.

Lithco reported production of 16,162 tons of Li_2CO_3 equivalent, or 3,038 tons of contained lithium, a 13% increase from that of 1983. Contributions to earnings from lithium operations rose more than 23%. Lithco's enhanced financial performance was made possible chiefly by decreased operating costs associated with increased production. Lithco reported that 49% of the company's sales was to foreign customers.[5] The rated annual mill capacity of Lithco's North Carolina plant was 18,000 tons of Li_2CO_3 equivalent. Lithco offered a full line of lithium chemicals, metal, and related products from its facility near Bessemer City, NC.

CONSUMPTION AND USES

Because of their unique chemical and physical properties, lithium chemicals and metal were used for a wide variety of purposes. Li_2CO_3 was also used as the feedstock material for most of the other lithium compounds. The addition of Li_2CO_3 to the cryolite bath in aluminum potlines was the largest end use for lithium. Li_2CO_3, after conversion to lithium fluoride, decreases the melting point of the bath, thereby allowing a lower operating pot temperature, as well as increasing the electrical conductivity of the bath. These changes allow the potline operator more flexibility to either increase production, reduce power consumption, or increase current efficiency.[6]

Lithium consumption in the glass and ceramics industries was second only to that in the aluminum industry. As an additive in glass and ceramics, lithium reduces melting temperatures, reduces the thermal expansion coefficient, and replaces toxic compounds. The largest single ceramic use was in the manufacture of thermal-shock-resistant cookware, of which low-iron spodumene concentrate, a source of lithia and alumina, was a major component. Lithium minerals such as spodumene were also used in the manufacture of black-and-white television picture tubes and foam glass insulation. Lithium in the form of lithia (Li_2O), usually obtained from lithium carbonate, was used as a flux for various types of glazes. For example, in chinaware glazes, the addition of 0.5% Li_2O usually improves the fluidity of the glass, thereby producing greater uniformity and a higher gloss.[7] Li_2O was also used in the production of photochromic lenses, ceramic cooking countertops, and sealed-beam headlights.

The third major use of lithium was in the manufacture of multipurpose greases. Lithium-based greases have a high dropping point, sometimes called the melting point, at 390° F, and offer very good water resistance. Therefore, they work well under a wide range of temperatures and were used extensively in military, industrial, automotive, aircraft, and marine applications.

Complex lithium greases, which were consumed in smaller quantities, contain more lithium than the multipurpose lithium greases. They also have greater water resistance and a dropping point above 400° F. These properties give the complex lithium greases a very long service life under severe temperature and atmospheric conditions such as those encountered by bearings in oven rollers, dryer rollers, induced draught fans, rotary steam joints, and lubricated-for-life bearings.

Aluminum-lithium alloys for the aerospace industry were available in limited sizes and quantities for testing purposes. These alloys contained 2% to 3% lithium and compared with conventional aluminum alloys, offered lower density, higher elastic modulus, and excellent corrosion resistance. Aluminum Co. of America (Alcoa), British Alcan Aluminium Ltd. (United Kingdom), and Pechiney (France) were each developing production facilities in their countries for ingot casting of these alloys.

Primary lithium batteries were finding niches in the battery marketplace where their intrinsic properties of low density, working well under extreme temperatures, and long shelf life made them attractive and cost effective. Some of the battery applications included computer memory backup, heart pacemakers, watches, cameras, and calculators. Growth in the use of lithium batteries had been bolstered by their military applications. Lithium-thionyl chloride batteries were added to the silos of the U.S. Air Force's Minuteman Intercontinental Ballistic Missile Program and were expected to be used as a backup power supply for the new Peacekeeper missile system. A U.S. Army representative reported that the Army ordered 590,000 lithium batteries in fiscal year 1984 compared with only 7,031 in fiscal year 1977.[8]

Moli Energy Ltd., Ontario, Canada, introduced a rechargeable lithium-molybdenum disulfide battery in AA and C sizes. These cells, with their excellent charge retention characteristics, had potential to compete in the marketplace with other rechargeable systems such as nickel-cadmium batteries.

Lithium bromide and LiCl, because of their great affinity for water, were used in industrial absorption-type air conditioning and dehumidification systems. Anhydrous LiCl was also used as the 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 Li_2CO_3 prescribed for treatment of manic-depressive mental disorder, lithium hydride as a source of hydrogen for emergency balloons, lithium acetate dihydrate as an ester interchange catalyst in polyester production, and lithium metal as a gas scavenger in copper and copper alloy melts.

PRICES

Most lithium material prices increased moderately during the year, although many of these increases were made near yearend.

Table 2.—Domestic yearend producers' prices of lithium and lithium compounds

(Dollars per pound)

	1983	1984
Lithium bromide, 54% brine: 2,268-pound lots, delivered in drums	3.79	4.06
Lithium carbonate, technical: Truckload lots, delivered	1.48	1.54
Lithium chloride, anhydrous, technical: Truckload lots, delivered	3.15	3.32
Lithium fluoride	4.72	4.90
Lithium hydroxide monohydrate: Truckload lots, delivered	1.93	1.93
Lithium metal ingot, battery-grade: 1,000-pound lots, f.o.b	[r]31.00	32.50
Lithium metal ingot, standard-grade: 1,000-pound lots, f.o.b	21.70	22.70
Lithium sulfate, anhydrous	[r]2.64	3.09
N-butyllithium in n-hexane (15%): 3,000-pound lots, delivered	13.39	14.75

[r]Revised.

FOREIGN TRADE

U.S. exports of lithium hydroxide increased 43%, and exports of other lithium compounds increased 27%; however, Li_2CO_3 exports remained at about 1983 levels. The small increase in Li_2CO_3 exports, compared with that of the other two export categories, was probably due to the influx of Chilean Li_2CO_3 onto the world market. The Federal Republic of Germany and Japan were the leading importers of U.S.-produced Li_2CO_3; Japan and the Federal Republic of Germany, of lithium hydroxide; and the United

Kingdom, of other lithium compounds. A major foreign consumer of other lithium compounds was Lithco's British subsidiary, which produced lithium specialty products and lithium metal.

Following the opening of its Li_2CO_3 plant at midyear, Chile became the leading exporter of lithium compounds to the United States, and U.S. imports increased significantly. Imports of lithium compounds from China, the leading U.S. supplier in 1983, declined sharply in 1984. Part of this decline may be attributed to Lithco's announcement that it had terminated distribution of Chinese $LiOH \cdot H_2O$.[9] Total imports of spodumene concentrate from Australia increased, although the tonnage was small.

Table 3.—U.S. exports of lithium chemicals, by compound and country

Compound and country	1983 Gross weight (pounds)	1983 Value	1984 Gross weight (pounds)	1984 Value
Lithium carbonate:				
Argentina	262,587	$377,817	57,200	$85,730
Brazil	686,852	1,113,583	83,039	114,949
Canada	1,890,333	2,889,872	1,238,183	1,941,641
Germany, Federal Republic of	6,204,129	7,429,436	8,819,070	10,954,569
Japan	4,510,594	6,064,719	4,691,902	6,803,317
Korea, Republic of	55,836	75,348	154,822	216,578
Mexico	297,602	483,095	431,520	633,692
Netherlands	950,738	1,199,088	132,000	174,240
South Africa, Republic of	81,125	109,121	46,205	69,180
Taiwan	578,414	794,809	139,592	219,464
United Arab Emirates	--	--	264,022	406,108
United Kingdom	88,609	204,159	154,013	213,767
Venezuela	2,066,068	3,008,491	1,748,006	2,476,585
Other	r106,247	r203,382	108,962	177,135
Total	17,779,134	23,952,920	18,068,536	24,486,955
Lithium hydroxide:				
Argentina	143,085	256,062	430,312	766,887
Australia	--	--	102,400	183,440
Belgium	--	--	70,400	126,720
Brazil	693,930	1,226,102	709,068	1,229,638
Canada	24,000	45,540	4,225	8,758
Chile	211,179	395,980	76,084	158,111
Colombia	72,955	133,091	26,750	47,811
France	122,720	227,786	162,800	315,400
Germany, Federal Republic of	597,592	1,044,745	1,397,344	2,273,650
India	120,028	196,941	440,291	612,000
Indonesia	60,000	126,985	135,000	285,492
Israel	24,918	44,084	45,686	80,949
Italy	95,700	169,180	22,000	39,600
Japan	1,053,928	1,873,493	1,899,638	3,143,978
Korea, Republic of	81,877	148,847	110,994	169,145
Mexico	106,368	188,842	405,954	728,345
Netherlands	544,017	916,608	610,860	1,086,390
Pakistan	38,995	67,326	44,267	87,701
Philippines	197,800	349,001	67,100	116,413
Singapore	57,283	101,298	101,411	190,720
South Africa, Republic of	115,145	199,918	149,610	297,187
Spain	79,600	125,136	118,800	207,840
Sweden	26,729	71,820	--	--
Taiwan	13,412	23,438	91,172	144,586
United Kingdom	996,927	1,731,709	776,283	1,445,110
Venezuela	88,300	155,879	78,372	139,726
Other	r152,903	r338,992	121,133	222,058
Total	5,719,391	10,158,803	8,197,954	14,107,655
Other:				
Argentina	5,327	8,630	143	757
Australia	127,818	182,380	29,485	64,814
Belgium	5,071	13,845	2,160	4,578
Brazil	625,280	1,465,696	29,721	63,924
Canada	611,419	1,297,285	844,280	1,372,335
Chile	6,614	9,502	9,825	33,980
China	147	1,089	--	--
Colombia	19,871	65,207	13,274	25,255
France	12,008	31,990	33,384	94,588
Germany, Federal Republic of	118,908	184,246	879,079	1,277,981
India	5,665	21,226	3,086	13,401
Israel	15,644	103,002	5,235	139,984

See footnotes at end of table.

Table 3.—U.S. exports of lithium chemicals, by compound and country —Continued

Compound and country	1983 Gross weight (pounds)	1983 Value	1984 Gross weight (pounds)	1984 Value
Other —Continued				
Italy	23,252	$47,884	23,255	$43,357
Japan	793,757	1,167,463	986,107	2,006,854
Korea, Republic of	8,818	12,200	133,861	203,754
Mexico	93,543	239,046	67,131	186,307
Netherlands	69,473	98,991	219,641	279,400
Pakistan	31,250	44,095	26,734	47,420
Saudi Arabia	4,030	7,819	27	6,310
South Africa, Republic of	44,822	47,250	8,999	31,136
Spain	15	660	4,772	4,198
Switzerland	16,797	200,321	--	--
Taiwan	168,663	283,951	121,150	170,540
Turkey	7,576	7,939	7,962	23,361
United Kingdom	1,098,433	2,020,004	1,943,834	3,502,675
Venezuela	283,104	411,809	22,570	30,287
Other	r80,450	r209,080	14,733	137,460
Total	4,277,755	8,182,610	5,430,448	9,764,656

rRevised.

Source: Bureau of the Census.

Table 4.—U.S. imports for consumption of lithium-bearing materials, by commodity and country

Commodity and country	1983 Gross weight (pounds)	1983 Value (thousands) Customs	1983 Value (thousands) C.i.f.	1984 Gross weight (pounds)	1984 Value (thousands) Customs	1984 Value (thousands) C.i.f.
Lithium ores:						
Australia[1]	16,424	$1	$4	119,049	$15	$20
Canada	--	--	--	62	1	1
Peru	--	--	--	124	3	3
Total	16,424	1	4	119,235	19	24
Lithium compounds:						
Australia	--	--	--	4,198	35	39
Belgium	--	--	--	2,197	6	7
Canada	3,005	5	5	3,425	36	36
Chile	--	--	--	750,014	842	891
China	328,485	458	502	100,200	138	151
Denmark	18	1	1	50	3	3
France	6,972	1,228	1,233	6,131	765	770
Germany, Federal Republic of	36,455	164	170	42,594	292	305
Japan	321	19	20	91	25	26
Mexico	--	--	--	15	1	1
Netherlands	2	1	1	--	--	--
Switzerland	571	1	1	15	(2)	(2)
United Kingdom	1,759	44	46	15,117	81	85
Total[3]	377,588	1,920	1,978	924,047	2,226	2,313
Lithium salts:						
Chile	--	--	--	220	(2)	1
France	--	--	--	1	(2)	(2)
Germany, Federal Republic of	2,354	5	5	9	4	4
Japan	--	--	--	1	(2)	(2)
United Kingdom	2	(2)	(2)	--	--	--
Total[3]	2,356	6	6	231	5	5
Lithium metal:						
Germany, Federal Republic of	1,228	9	9	334	12	12
Japan	1,281	24	24	--	--	--
Total	2,509	33	33	334	12	12

[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.

WORLD REVIEW

Australia.—Greenbushes Tin Ltd. (GTL) expanded its mine and plant facilities during the year to operate at a capacity of 22,000 tons per year of spodumene concentrate.[10] The concentrate had a minimum Li_2O content of 7.0% and a maximum iron oxide content of 0.30%.[11]

GTL was conducting a feasibility study on a 11-million-pound-per-year Li_2CO_3 plant proposed for construction by 1987 at its mine near Perth, Western Australia. The study was being undertaken in partnership with Metallgesellschaft AG of the Federal Republic of Germany and C. Itoh & Co. Ltd., a large Japanese trading company. The wholly owned subsidiary of Metallgesellschaft, Chemetall GmbH, produced many lithium compounds and metal.[12]

Austria.—Mineral Exploration GmbH began exploration of an area near Koralpe in the summer of 1981 and discovered a pegmatite deposit mineralized with spodumene. In 1984, reserves of 5,500 tons of spodumene-bearing ore with an average Li_2O content of 1.7% were proven to a depth of about 890 feet, but were generally believed to be continuous to much greater depths.[13]

Canada.—The Bernic Lake spodumene deposit was owned by a consortium of Hudson Bay Mining and Smelting Co. Ltd., 37.5%; Kawecki Berylco Industries Inc., 37.5%; and Manitoba Development Corp., a Province of Manitoba government enterprise, 25%. The operating company for the consortium, Tantalum Mining Corp. of Canada Ltd. (TANCO), had operated North America's only tantalum mine and concentrate plant, which was also located at Bernic Lake. In late 1982, TANCO closed its tantalum operation because of a weakened market and was considering development of its spodumene deposit to produce spodumene concentrate. The low iron content of the proposed product was expected to make it attractive to the ceramics industry.

Chile.—In mid-July, the Sociedad Chilena de Litio Ltda. (SCL), a joint venture, 55% owned by Foote Mineral and 45% by the Chilean Government's company Corporación de Fomento de la Producción (CORFO), made its first export shipment of Li_2CO_3 from the northern Chilean port of Antofagasta.[14] Foote Mineral reported total production from the plant at La Negra of 2,819 tons of Li_2CO_3 equivalent, or 530 tons of contained lithium. The plant had a rated annual capacity of 7,000 tons Li_2CO_3.[15] The lithium source was the Salar de Atacama, which had a reserve base of about 1.5 million tons of contained lithium. Raw brine from the salar was extremely rich in lithium, averaging about 0.15% lithium, by weight. For comparison, the brine at Silver Peak, NV, contains 0.02% lithium.[16] At the salar, three wells, which penetrated to a depth of only 100 feet, were supplying enough brine to yield 14 million pounds of Li_2CO_3 per year.[17] Under the terms of the limited partnership agreement, SCL was limited to production of a maximum of 220,000 tons of lithium content and had exclusive rights to produce Li_2CO_3 from the salar until August 1988.

In a separate action to expand lithium development in the Salar de Atacama, CORFO accepted a proposal by AMAX Inc. to form a joint venture with AMAX controlling 62%; CORFO, 25%; and Molibdenos y Metales S.A., 13%. The joint venture company would construct and operate a large chemical and industrial complex to produce potassium chloride, potassium sulfate, boric acid, and possibly lithium from brine in the northern part of the salar. Pending successful negotiations, 3 more years of exploration would be required to reach a final feasibility decision.[18]

France.—Métaux Speciaux S.A., a subsidiary of Pechiney, began commercial production of aluminum-lithium alloys at its prototype foundry at Issoire. Ingots weighing 1.3 tons had been cast and test samples supplied to aerospace companies in Europe, Japan, and the United States. In a related action, another Pechiney subsidiary was in the process of starting up a pilot plant for production of lithium metal at Plombiere-Saint Michel.[19]

United Kingdom.—British Alcan was installing a casting unit at Birmingham for the production of aluminum-lithium alloys to be marketed under the name Lital. The new unit was planned to cast Lital slabs and billets initially up to 6,600 pounds and was expected to be operational in early 1985.[20]

Zimbabwe.—During the year, Bikita Minerals (Pvt.) Ltd. resumed supplying ground petalite to Corning Glass Works of the United States. Shipments had been stopped in 1965 when the United Nations Security Council imposed economic sanctions on Southern Rhodesia. Despite the lifting of these sanctions in 1980 after Zimbabwe gained independence, Corning continued to buy from an alternative supplier.

Table 5.—Lithium minerals: World production, by country[1]

(Short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina (minerals not specified)	88	28	125	168	160
Australia, spodumene[e]	--	--	90	[r]1,100	7,200
Brazil:					
Amblygonite	201	305	73	125	130
Lepidolite	56	2	82	1	5
Petalite	2,741	2,293	2,528	2,086	2,200
Spodumene	108	268	376	128	130
Chile (carbonate from subsurface brine)	--	--	--	--	[3]2,819
China (minerals not specified)[e 4]	15,400	15,400	15,400	[r]16,500	16,500
Namibia (minerals not specified)	NA	1,392	1,146	860	900
Portugal, lepidolite[e]	1,100	990	880	770	660
Rwanda, amblygonite[e]	33	28	--	--	--
U.S.S.R. (minerals not specified)[e 4]	60,600	60,600	60,600	60,600	60,600
United States, spodumene	W	W	W	W	W
Zimbabwe (minerals not specified)	21,982	18,126	10,788	10,472	18,700

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 7, 1985.
[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]Reported figure.
[4]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.

TECHNOLOGY

U.S. development of aluminum-lithium alloys for the aerospace industry, led by Alcoa, continued at an accelerated pace. The use of lithium, which is nature's lightest metal, offered lower density, weight, and cost than conventional aluminum alloys. For example, substituting aluminum-lithium alloys for those previously used in a 747 passenger jet could mean a weight savings of 14,000 pounds and cost savings of $5.6 million over the 20-year life of the plane.[21] Aluminum companies were developing new alloys in part to offset future competition from composite materials. An advantage of these alloys over composites was the relatively few changes expected in aerospace production lines, whereas the conversion from metal to composites might require retooling and retraining. By yearend, Alcoa had cast alloy ingots weighing from 8,500 to 10,000 pounds. More than 18% of these production-sized ingots had been rolled into plate at the company's Davenport, IA, works.[22]

On a small scale, the Bureau of Mines demonstrated a technique for recovering 75% of the lithium from a montmorillonite-type clay. The technique involves roasting a clay-limestone-gypsum mixture, leaching the calcine with water, concentrating the solution by evaporation, and adding sodium carbonate to the concentrated solution to precipitate Li_2CO_3.[23]

[1]Physical scientist, Division of Industrial Minerals.
[2]See 1984 10-K reports for Gulf Resources & Chemical Corp. and Newmont Mining Corp.
[3]Work cited in footnote 2.
[4]Work cited in footnote 2.
[5]Work cited in footnote 2.
[6]Foote Mineral Co., Chemicals and Minerals Div. Lithium Carbonate for Primary Aluminum Production. 1983, 11 pp.
[7]Ceramic Industry. Raw Materials Handbook. Lithia. V. 120, No. 1, Jan. 1983, p. 97.
[8]Berger, C. Planning for and Rationalization of the Battery Selection Process in the Army. Sec. Int. Seminar on Lithium Battery Technology and Applications. Florida Atlantic Univ., Fort Lauderdale, FL, Mar. 4-6, 1985.
[9]Industrial Minerals (London). Company Notes. No. 202, July 1984, p. 13.
[10]Greenbushes Tin Ltd. 1984 Annual Report. P. 3.
[11]Industrial Minerals (London). Greenbushes Tin—for Lithium. No. 206, Nov. 1984, p. 69.
[12]Metals Week. Australia May Get Lithium Plant. V. 56, No. 9, Mar. 4, 1985, p. 8.
[13]Industrial Minerals (London). Minerex Explores for Lithium. No. 203, Aug. 1984, p. 9.
[14]Coad, M. Lithium Production in Chile's Salar de Atacama. Ind. Miner. (London), No. 205, Oct. 1984, pp. 27-33.
[15]Work cited in footnote 2.
[16]Work cited in footnote 14.
[17]Foote Prints. New Lithium Frontier in Chile. V. 47, No. 1, 1984, pp. 2-14.
[18]Mining Journal (London). Chile's Lithium Venture. V. 303, No. 7776, Aug. 31, 1984, p. 148.
[19]———. Lithium Plant for Pechiney. V. 302, No. 7762, May 25, 1984, p. 353.
[20]Metal Bulletin (London). British Alcan Lital Go Ahead. No. 6920, Sept. 14, 1984, p. 15.
[21]Stone, S. Another Historic Flight for Aluminum, Alithalite Taxiing for Take-off. Alcoa News, Sept. 1984, 3 pp.
[22]Metal Bulletin Monthly. Aluminum-lithium Goes Commercial. No. 171, Mar. 1985, pp. 71 and 73-75.
[23]Lien, R. H. Recovery of Lithium From a Montmorillonite-Type Clay, With an Appendix on Process Economics, by D. A. Kramer. BuMines RI 8967, 1985, 32 pp.

Magnesium

By Deborah A. Kramer[1]

Domestic production of magnesium in 1984 increased sharply from that of 1983 owing to increased demand in most end-use sectors. Primary producers brought previously idled capacities on-stream, and new applications for magnesium diecastings in the automotive industry were introduced. Both imports and exports of magnesium materials increased from those of 1983.

Domestic Data Coverage.—Domestic consumption data for magnesium metal are developed by the Bureau of Mines by a voluntary survey of U.S. operations. Of the 159 operations to which a survey request was sent, 59% responded, representing 93% of the primary magnesium consumption shown in tables 1 and 3. Consumption for the 65 nonrespondents was estimated using reported prior year consumption levels.

Table 1.—Salient magnesium statistics

(Short tons unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production:					
Primary magnesium	[1]169,477	153,782	102,197	115,431	159,207
Secondary magnesium	40,461	46,256	43,232	46,329	48,090
Exports	56,761	34,855	39,613	46,690	48,337
Imports for consumption	3,757	6,897	4,784	6,350	9,381
Consumption, primary	95,788	91,461	74,599	81,976	90,217
Price per pound	$1.07-$1.25	$1.25-$1.34	$1.34	$1.38	$1.43-$1.48
World: Primary production	348,440	336,454	277,074	[p]286,488	[e]357,594

[e]Estimated. [p]Preliminary.

[1]Derived figure; U.S. production is not officially reported by the Bureau of Mines for 1980 to avoid disclosing company proprietary data; figure reported for 1980 represents the difference between total North American production reported by the International Magnesium Association and Canadian production reported by Canadian Department of Mines and Natural Resources.

DOMESTIC PRODUCTION

Production in 1984 increased significantly from that of 1983 and was about 85% of installed annual capacity. Three companies produced primary magnesium metal: The Dow Chemical Co., Freeport, TX; AMAX Magnesium Corp., Rowley, UT; and Northwest Alloys Inc., a subsidiary of Aluminum Co. of America, Addy, WA. Dow and AMAX produced magnesium from natural brines by the electrolytic process, and Northwest Alloys produced metal from dolomite using the silicothermic process.

Because of increased demand, domestic producers restarted idled capacities. AMAX announced the opening of its No. 4 building during the first quarter, and Northwest Alloys announced the start of construction of a 10th furnace at its plant during the 3d quarter. Dow restarted two cell rooms to increase its operating rate to 75% of capacity.[2]

AMAX and Kaiser Aluminum & Chemical Corp. announced a joint agreement in which Kaiser will supply AMAX with 300,000 short tons of magnesium chloride brine from its Wendover, UT, plant in exchange for 9,000 tons of magnesium metal.[3]

Magnesium recovered from all forms of scrap increased slightly from that of 1983. Aluminum alloys continued to be the dominant form of recovery.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1980	1981	1982	1983	1984
KIND OF SCRAP					
New scrap:					
Magnesium-base	5,929	2,833	2,455	2,873	2,868
Aluminum-base	16,978	19,240	17,346	18,718	18,339
Total	22,907	22,073	19,801	21,591	21,207
Old scrap:					
Magnesium-base	5,275	5,593	5,314	5,311	5,352
Aluminum-base	12,279	18,590	18,117	19,427	21,531
Total	17,554	24,183	23,431	24,738	26,883
Grand total	40,461	46,256	43,232	46,329	48,090
FORM OF RECOVERY					
Magnesium alloy ingot[1]	4,205	4,230	4,228	4,232	4,752
Magnesium alloy castings (gross weight)	836	806	746	952	1,053
Magnesium alloy shapes	3,144	13	--	--	--
Aluminum alloys	29,612	38,755	36,587	39,451	40,521
Zinc and other alloys	13	9	11	20	13
Chemical and other dissipative uses	9	55	3	4	3
Cathodic protection	2,642	2,388	1,657	1,670	1,748
Total	40,461	46,256	43,232	46,329	48,090

[1]Includes secondary magnesium content of both secondary and primary alloy ingot.

CONSUMPTION AND USES

Consumption of primary magnesium increased from that of 1983. Aluminum alloying continued to be the largest use of magnesium, but its share of the total primary consumption decreased slightly. The iron and steel desulfurization market showed a high growth rate. Consumption of magnesium for this use was estimated to be 7,500 tons. Increased demands for titanium and beryllium were reflected in a 42% increase in consumption for magnesium as a reducing agent for the production of these metals.

Automobile manufacturers introduced new magnesium diecastings in their 1984 models and thereby increased the use of magnesium components in automobiles. Reportedly, General Motors Corp. used magnesium grille assemblies and headlamp assemblies in its Fiero model; Chrysler Corp. substituted a magnesium component for a zinc shift handle on its Laser and Dodge Daytona models; and Ford Motor Co. used magnesium clutch housings on its Ranger II and Bronco trucks. New diecasting product developments were not limited to the automotive industry. Prince Manufacturing Inc. announced the introduction of a magnesium tennis racket, and a magnesium computer housing was developed by Grid Systems Corp. and Tennessee Die Casting Div. of Hayes Albion Corp.[4]

Table 3.—U.S. consumption of primary magnesium, by use

(Short tons)

Use	1980	1981	1982	1983	1984
For structural products:					
Castings:					
Die	3,190	2,812	1,600	1,937	601
Permanent mold	922	917	663	16	1,666
Sand	1,735	1,222	1,337	1,388	1,932
Wrought products:					
Extrusions	6,855	5,786	7,059	7,093	5,829
Sheet and plate	4,704	4,547	2,981	4,313	4,379
Other (includes forgings)	61	43	88	29	40
Total	17,467	15,327	13,728	14,776	14,447
For distributive or sacrificial purposes:					
Alloys:					
Aluminum	54,490	50,518	39,878	46,026	48,675
Copper	6	5	7	4	4
Zinc	11	9	3	3	5
Other	7	7	3	--	--
Cathodic protection (anodes)	3,930	6,449	5,964	5,686	4,776
Chemicals	6,278	5,315	4,823	5,664	5,822
Nodular iron	4,176	3,755	2,541	2,200	2,407
Reducing agent for titanium, zirconium, hafnium, uranium, beryllium	7,957	9,071	5,901	4,711	6,689
Other[1]	1,466	1,005	1,751	2,906	7,392
Total	78,321	76,134	60,871	67,200	75,770
Grand total	95,788	91,461	74,599	81,976	90,217

[1]Includes scavenger, deoxidizer, and powder.

STOCKS

Consumer stocks of primary magnesium ingot decreased from 11,329 tons at yearend 1983 to 6,963 tons at yearend 1984. Magnesium alloy ingot stocks increased slightly to 601 tons at yearend 1984 from 551 tons at yearend 1983.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States

(Short tons)

	Stocks, Jan. 1	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31[1]
1983:						
Cast scrap	1,573	6,065	412	5,836	6,248	1,390
Solid wrought scrap[2]	23	846	824	--	824	45
Total	1,596	6,911	1,236	5,836	7,072	1,435
1984:						
Cast scrap	1,374	6,294	410	5,881	6,291	1,377
Solid wrought scrap[2]	45	779	779	--	779	45
Total	1,419	7,073	1,189	5,881	7,070	1,422

[1]Ending stocks for 1983 do not equal 1984 beginning stocks because of reported beginning stock adjustments.
[2]Includes borings, turnings, drosses, etc.

PRICES

The quoted price for primary magnesium ingot at the beginning of the year was $1.43 per pound. In May, Dow and AMAX announced an increase of their prices to $1.48 per pound, effective immediately for spot customers and on July 2 for contract customers. The primary magnesium price remained at $1.48 per pound throughout the rest of the year.

At the beginning of January, Dow raised its price for diecasting alloy from $1.23 to $1.28 per pound, while AMAX held its diecasting alloy price to $1.23 per pound until the end of the quarter. In early April, both companies raised their prices—Dow to $1.30 per pound and AMAX to $1.26 per pound. These prices remained in effect throughout the rest of the year.

FOREIGN TRADE

Exports of magnesium increased slightly from those of 1983, both in quantity and value. Japan and the Netherlands continued to be the primary destinations. The United States remained a net exporter of magnesium.

Imports of magnesium in all forms increased significantly from those of 1983. Values for all categories also increased, except for powder, sheets, tubing, and other forms. Primary import sources were Canada and Norway, which accounted for 50% of the total.

Beginning January 1, 1984, the U.S. import duties for magnesium were as follows: unwrought metal (TSUS 628.55), 13.5% ad valorem for most favored nations (MFN) and 100% ad valorem for non-MFN; unwrought alloys (TSUS 628.57), 6.8% ad valorem for MFN and 60.5% ad valorem for non-MFN; and wrought metal (TSUS 628.59), 5.2 cents per pound on magnesium content plus 2.9% ad valorem for MFN and 40 cents per pound on magnesium content plus 20% ad valorem for non-MFN.

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)
1982	149	$349	37,281	$92,554	2,183	$11,942
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

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)
1982	1,873	$2,019	1,779	$3,713	955	$3,889	177	$5,982
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

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)
1983						
Argentina	--	--	471	$1,020	25	$82
Australia	--	--	2,838	6,589	504	1,884
Austria	--	--	188	495	5	67
Belgium-Luxembourg	11	$22	--	--	7	97
Brazil	--	--	4,667	11,298	38	102
Canada	283	652	4,055	10,183	217	1,031
China	--	--	1,105	2,960	--	--
Colombia	--	--	32	87	44	128
France	11	23	1	2	25	524
Germany, Federal Republic of	222	518	86	270	33	362
India	9	17	34	72	13	71
Israel	--	--	6	28	155	829

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)
1983 —Continued						
Italy	--	--	23	$108	111	$950
Japan	--	--	12,758	28,294	67	508
Korea, Republic of	--	--	328	820	23	72
Mexico	12	$22	2,187	5,267	236	751
Netherlands	--	--	14,029	40,668	51	551
New Zealand	--	--	37	74	2	30
Norway	--	--	172	1,290	4	55
Saudi Arabia	--	--	2	8	84	191
Singapore	34	321	87	190	16	31
South Africa, Republic of	--	--	605	1,277	41	204
Spain	--	--	--	--	7	107
Sweden	--	--	3	7	12	100
Taiwan	20	41	139	313	15	43
United Kingdom	36	58	51	200	118	1,286
Venezuela	--	--	--	--	1	14
Other	([1])	7	88	468	206	975
Total	638	1,681	43,992	111,988	2,060	11,045
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
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	60	507
Total	1,249	3,362	44,880	120,804	2,208	12,495

[1]Less than 1/2 unit.

WORLD REVIEW

World production of magnesium increased significantly from that of 1983 mainly in response to increased demand in the iron and steel desulfurization and diecasting sectors.

Norway.—In April, Norsk Hydro A/S reportedly started up the last of its 36 new electrolytic cells, which were said to be 15% more energy efficient and require less labor and maintenance than the old cells. The company also announced that it modernized its foundry and will install a new calciner in 1985 to replace two older units.[5]

United Kingdom.—Minerals Processing Licensing Corp. (MPLC) reportedly operated a 1.3-ton-per-day pilot plant for production of magnesium near Stockon-on-Tees. MPLC claimed to have developed technology to produce anhydrous magnesium chloride directly from magnesite and chlorine and carbon monoxide gases. Late in the year, MPLC and Davy McKee, its engineering associate, announced formation of a joint venture to build a 3.3-ton-per-day plant at Peterlee to refine production techniques.[6]

Table 7.—Magnesium: World primary production, by country[1]

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Canada	10,199	9,370	[r e]8,700	[r e]6,600	8,800
China[e]	7,700	7,700	7,700	7,700	7,700
France	10,282	8,006	10,593	13,007	12,100
Italy	8,693	8,623	8,466	8,473	[2]8,257
Japan	10,199	6,247	6,123	6,643	[2]7,830
Norway	48,890	52,472	39,598	32,954	55,000
U.S.S.R.[e]	83,000	86,000	89,000	91,000	94,000
United States	[3]169,477	153,782	102,197	115,431	[2]159,207
Yugoslavia	--	4,254	4,697	[r e]4,680	4,700
Total	348,440	336,454	277,074	286,488	357,594

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 28, 1985.
[2]Reported figure.
[3]Derived figure; U.S. production is not officially reported by the Bureau of Mines for 1980 to avoid disclosing company proprietary data; figure reported for 1980 represents the difference between total North American production reported by the International Magnesium Association and Canadian production reported by the Canadian Department of Mines and Natural Resources.

Table 8.—Magnesium: World secondary production, by country[1]

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Japan	26,314	31,345	23,887	14,343	16,900
U.S.S.R.[e]	8,000	9,000	9,000	9,000	9,000
United Kingdom[e]	3,000	[r]2,100	[r]1,940	[r]2,000	2,000
United States	40,461	46,256	43,232	46,329	[2]48,090
Total	77,775	[r]88,701	78,059	71,672	75,990

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 28, 1985.
[2]Reported figure.

TECHNOLOGY

Dow announced the development of a new high-purity, corrosion-resistant magnesium sand casting alloy, AZ91C/HP. The new alloy was developed for use in military aircraft exposed to saltwater environments. Specific applications include transmission housings, transfer cases in the power train, electrical system housings, and some engine components. Dow maintained that the new alloy will have corrosion-resistance rates higher than cold-rolled steel or die-cast 380 aluminum, if produced according to specification. The new alloy reportedly will be marketed at $1.43 per pound, the same price as standard AZ91C, which it replaces.[7]

Scientists at the General Motors Research Laboratories announced the development of an experimental electrolytic process to remove magnesium from scrap aluminum-base alloys. The electrolytic process uses a molten layer of the aluminum-base alloy as the anode on the bottom of the cell, a molten layer of chloride salts as the electrolyte in the middle, and a molten layer of magnesium as the cathode on the top. Magnesium in the alloy scrap is selectively oxidized, and because of the differences in densities among the three layers, it is deposited at the electrolyte-cathode interface, while refined aluminum remains at the anode. Magnesium is recovered in the form of salt-coated globules, which may be useful for iron and steel desulfurization. The new process reportedly could provide an alternative to the traditional chlorination process.[8]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Metals Week. V. 55, No. 14, Apr. 2, 1984, p. 9.
[3]———. V. 55, No. 43, Oct. 22, 1984, p. 8.
[4]Brunt, J. E. Finding innovative applications. Met. Bull. Monthly (London), No. 162, June 1984, pp. 91, 95-96.
[5]Kramer, D. Norsk Hydro to Increase Magnesium Exports to US. Am. Met. Mark., v. 92, No. 125, June 27, 1984, pp. 1, 10.
[6]Gilberston, D. Sea change in magnesium costs? Met. Bull. (London), No. 6938, Nov. 16, 1984, p. 8.
[7]Crisafulli, T. Anti-Corrosive Magnesium Alloy Bows. Am. Met. Mark., v. 92, No. 235, Dec. 5, 1984, p. 6.
[8]Tiwari, B. L., and R. A. Sharma. Electrolytic Removal of Magnesium from Scrap Aluminum. J. Met., v. 36, No. 7, July 1984, pp. 41-43.

Magnesium Compounds

By Deborah A. Kramer[1]

Magnesium compounds shipped or used by producers in the United States declined from those of 1983. About 70% of the consumption of magnesium compounds was for production of basic refractories used in high-temperature metallurgical furnaces, primarily in the iron and steel industry. The remainder was used to prepare caustic-calcined and specified magnesias and other magnesium compounds.

Natural brines continued to be the dominant source of domestically produced magnesium compounds. Magnesium oxide and other compounds were produced from seawater by six companies in California, Delaware, Florida, and Texas; by three companies from well brines in Michigan; and by two companies from lake brines in Utah. Magnesite was mined by one company in Nevada, and olivine was mined by three companies in North Carolina and Washington.

Both imports and exports of magnesite and magnesia increased from those of 1983. Canada remained a primary import source, as well as the primary destination for U.S. exports. World production of magnesite was essentially unchanged from that of 1983.

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, 61% responded, representing 48% of the total magnesium compounds shipped and used shown in table 3. Data for the seven nonrespondents was estimated using prior year production levels and other factors.

Table 1.—Salient magnesium compound statistics

(Thousand short tons and thousand dollars)

	1980	1981	1982	1983	1984
United States:					
Caustic-calcined and specified magnesias:[1]					
Shipments by producers:					
Quantity	157	160	148	r143	146
Value	$51,282	$58,420	$56,363	r$57,416	$50,087
Exports: Value[2]	$17,692	$14,559	$10,925	$8,426	$14,026
Imports for consumption: Value[2]	$2,122	$2,177	$2,055	$5,476	$9,594
Refractory magnesia:					
Sold and used by producers:					
Quantity	731	616	453	r456	374
Value	$162,697	$146,903	$112,101	r$98,473	$87,945
Exports: Value	$13,279	$4,727	$2,721	$1,955	$3,641
Imports for consumption: Value	$16,672	$22,990	$14,162	$11,495	$23,716
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	494	435	337	418	p581
Value	$28,308	$23,789	$19,136	$24,454	p$33,964
World: Production (magnesite)	r12,695	r12,327	12,304	p12,320	e11,953

eEstimated. pPreliminary. rRevised.

[1]Excludes caustic-calcined magnesia used in production of refractory magnesia.

[2]Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Natural brines from seawater and well and lake brines continued to be the dominant sources of domestically produced magnesium compounds. Magnesium compounds were also recovered from magnesite and dolomite. Olivine, mined from deposits in North Carolina and Washington, was ground to various grades for consumption by the foundry, steel, and refractory industries.

The Dow Chemical Co. announced that brine operations at the Midland, MI, plant would be phased out over the next 2 years. The company plans to relocate its magnesium hydroxide operation at its Ludington, MI, plant.[2]

Operations at Kaiser Aluminum & Chemical Corp.'s Wendover, UT, solar evaporation complex were suspended during part of 1984 because of excessive rain. The company announced plans to restart mill operations in January 1985. Kaiser concentrates magnesium chloride brine using solar evaporation.[3]

Table 2.—Magnesium compound producers, by raw material source, location, and production capacity

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
Kaiser Aluminum & Chemical Corp	Moss Landing, CA	150,000
Merck & Co. Inc	South San Francisco, CA	15,000
Western Magnesium Corp	Chula Vista, CA	5,000
Total		1,380,000

CONSUMPTION AND USES

Most of the domestic magnesium compound production was used in the manufacture of refractory products such as refractory brick. Magnesia refractories were used primarily by the iron and steel industry for furnace linings. Total shipments of refractory magnesia declined significantly from those of 1983.

Magnesium compounds in the forms of caustic-calcined and specified magnesias were used by diverse industries including agriculture, chemical processing, and construction. Shipments of caustic-calcined magnesia by the following sectors, in declining order, accounted for 80% of the total domestic shipments: animal feed, ceramics, rubber, petroleum additives, rayon, chemical, and oxychloride and oxysulfate cements. The following uses, in declining order, accounted for the remainder of the total shipments: stack-gas scrubbing, medicinals and pharmaceuticals, water treatment, sugar and candy, foundry, fertilizer, electrical heating rods, fluxes, pulp and paper, uranium processing, and insulation and wallboard. Total shipments of caustic-calcined magnesia in 1984 were essentially unchanged from those of 1983.

Table 3.—Magnesium compounds shipped and used in the United States

	1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Caustic-calcined[1] and specified (USP and technical) magnesias	r142,751	r$57,416	145,859	$50,087
Magnesium hydroxide (100% $Mg(OH)_2$)[1]	359,773	47,231	357,425	41,473
Magnesium sulfate (anhydrous and hydrous)	38,424	10,769	49,776	13,214
Precipitated magnesium carbonate[1]	6,003	1,101	7,032	1,181
Refractory magnesia	r455,834	r98,473	374,280	87,945

rRevised.
[1]Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

PRICES

At yearend, the Chemical Marketing Reporter published the following prices for magnesium compounds: 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, NF, powder (freight equalized), $0.78 per pound; and magnesium sulfate, technical, $0.115 per pound.

Prices for magnesia increased by $10 per ton from those of yearend 1983. Magnesium carbonate prices increased by $0.05 per pound from those of 1983. All other magnesium compound prices remained the same.

FOREIGN TRADE

Exports of crude and processed magnesium compounds in 1984 increased significantly from those in 1982 and 1983 in both quantity and value. Canada was the primary destination, and the bulk of the increase in total exports from 1983 to 1984 was reflected by an increase in exports to this country. Total imports of crude and processed magnesite in 1984 reached their highest level in more than 30 years. Additional magnesium compounds valued at more than $10 million were also imported.

Beginning January 1, 1984, U.S. import duties for magnesium compounds were as follows: crude magnesite (TSUS 522.61), $0.98 per ton for most favored nations (MFN) and $10.50 per ton for non-MFN; caustic-calcined magnesite (TSUS 522.64), $2.10 per ton for MFN and $21.00 per ton for non-MFN; refractory magnesia containing less than 4% lime (TSUS 531.01), 0.17 cents per pound for MFN and 0.75 cents per pound for non-MFN; refractory magnesia containing greater than 4% lime (TSUS 531.04), 6.0% ad valorem for MFN and 30.0% ad valorem for non-MFN.

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			
	1983		1984		1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	--	--	804	$344	562	$180
Australia	2,556	$551	--	--	132	187	135	186
Belgium-Luxembourg	--	--	--	--	369	453	444	448
Brazil	1	--	--	--	141	89	42	97
Canada	4,665	1,028	14,439	$3,273	7,369	2,744	23,115	8,032
Colombia	1,190	159	1,208	147	148	117	129	155
France	--	--	--	--	134	100	220	174
Germany, Federal Republic of	--	--	--	--	824	609	544	423
Israel	--	--	--	--	817	544	1,132	789
Italy	--	--	--	--	343	291	315	349
Japan	197	26	35	7	1	3	--	--
Mexico	81	12	--	--	75	81	1,047	398
Netherlands	--	--	--	--	286	313	663	506

Table 4.—U.S. exports of magnesite and magnesia, by country —Continued

Country	Magnesite and magnesia, dead-burned				Magnesite, n.e.c., including crude caustic-calcined, lump or ground			
	1983		1984		1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
New Zealand	--	--	--	--	1	$2	88	$130
Spain	--	--	--	--	341	212	227	235
Sweden	--	--	809	$83	118	133	197	145
United Kingdom	--	--	--	--	75	111	133	180
Venezuela	--	--	--	--	1,950	966	2,265	999
Other	2,165	$179	784	131	r2,693	r1,127	795	600
Total	10,855	1,955	17,275	3,641	16,621	8,426	32,053	14,026

rRevised.

Table 5.—U.S. imports for consumption of crude and processed magnesite, by country

Country	1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Lump or ground caustic-calcined magnesia:[1 2]				
Canada	16,256	$3,086	29,650	$5,961
China	3,589	386	1,550	157
Czechoslovakia	--	--	2,854	184
Greece	4,738	740	7,330	1,026
Japan	271	14	489	24
Netherlands	927	123	43	12
Spain	2,572	366	6,400	1,537
Turkey	2,685	670	4,726	566
United Kingdom	139	40	36	8
Other	252	51	948	119
Total	31,429	5,476	54,026	9,594
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4% lime:				
Brazil	6,652	996	9,573	1,528
China	4,827	458	30,556	4,138
Greece	6,889	938	48,844	7,056
Ireland	24,230	7,535	13,984	3,569
Japan	454	588	8,129	2,550
Mexico	1,474	337	6,345	1,667
Netherlands	1	(3)	7,209	1,806
South Africa, Republic of	1,222	567	552	273
United Kingdom	21	4	3,337	424
Other	r128	r72	1,255	705
Total	45,898	11,495	129,784	23,716
Containing over 4% lime:				
Austria	1,241	302	3,739	976
Canada	15,346	618	18,352	1,007
Germany, Federal Republic of	241	46	547	131
Greece	17,433	1,864	2,205	290
Mexico	46	4	394	34
United Kingdom	222	8	141	33
Other	r2	r3	--	--
Total	34,531	2,845	25,378	2,471
Total dead-burned and grain magnesia and periclase	80,429	14,340	155,162	26,187

rRevised.
[1]Data included for lump or ground caustic-calcined magnesia containing over 4% lime have been revised for 1983.
[2]In addition, crude magnesite was imported as follows, in short tons and thousand dollars: 1983—Canada, 23 (revised) ($4); the Federal Republic of Germany, 19 (revised) ($11); and Spain, 24 (revised) ($10). 1984—Australia, 117 ($30); Canada, 44 ($9); the Federal Republic of Germany, 20 ($7); Japan, 546 ($184); Mexico, 12 ($1); and the United Kingdom, 6 ($1).
[3]Less than 1/2 unit.

Table 6.—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)
1982	3,217	$3,766	173	$270	26	$11	1,086	$197	37,605	$2,184	2,690	$1,537
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

[1]In addition, magnesium carbonate, not precipitated, was imported as follows, in short tons and thousand dollars: 1982—125 ($69); 1983—12 ($28); and 1984—33 ($63).
[2]Includes magnesium silicofluoride or fluosilicate and calcined magnesia.

WORLD REVIEW

World production of magnesite remained essentially the same as that of 1983. Production of magnesite and synthetic magnesia met world demand for the manufacture of refractory, caustic-calcined, and specified magnesias.

China.—A review of the Chinese magnesite industry was published. It focused on magnesite deposits in Liaoning Province. Reserves of raw magnesite in this area have been estimated to comprise at least 3 billion tons. According to the report, high-quality, dead-burned magnesite could be produced from this deposit, but, because of inefficient calcining techniques and the use of high-ash containing coke, this has not been accomplished. Conversion to other fuels, such as purified coal gas and heavy oil, in addition to adoption of advanced calcining techniques was planned in order to fully utilize the potential of this deposit.[4]

Israel.—Dead Sea Periclase Ltd., a subsidiary of Israel Chemicals Ltd., announced plans to construct a $10 million plant to produce specialty magnesia chemicals for use by the pharmaceutical, plastics, and rubber industries. The new plant was to be designed to produce 8,800 short tons per year of a mixture of various grades of calcined magnesia, magnesium hydroxide, and magnesium carbonate. Magnesium chloride brine pumped from the Dead Sea will be used as the raw material, and conventional methods as well as the Aman process, which incorporates thermal decomposition of magnesium chloride brines, will be used for magnesia production. Production was expected to begin in the first half of 1986.[5]

Table 7.—Magnesite: World production, by country[1]

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Australia	35,492	[r]29,151	32,707	23,259	25,000
Austria	[r]1,452,845	1,277,414	1,136,927	1,108,668	1,100,000
Brazil[2]	348,166	[r]314,055	248,607	254,634	255,000
Canada[e 3]	69,000	76,000	75,000	74,000	76,000
China[e]	2,200,000	2,200,000	2,200,000	2,200,000	2,200,000
Colombia[e]	[4]1,744	1,800	1,800	1,800	1,800
Czechoslovakia	734,139	732,000	740,752	729,729	728,000
Greece	[r]1,166,477	909,674	881,848	981,618	827,000
India	419,002	499,798	448,718	507,063	452,000
Iran[e 5]	4,400	4,400	5,500	5,500	5,500
Kenya	1	10	([6])	--	--
Korea, North[e]	[r]2,095,000	[r]2,095,000	[r]2,095,000	[r]2,095,000	2,095,000
Mexico	17,488	13,357	24,793	25,559	25,400
Nepal[e]	16,500	22,000	22,000	[4]16,552	25,400
New Zealand	--	340	[e]330	--	--
Pakistan	1,681	1,710	1,861	2,033	2,200
Poland	[r]24,302	[r]12,436	17,637	17,086	18,000

See footnotes at end of table.

Table 7.—Magnesite: World production, by country[1] —Continued

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
South Africa, Republic of	[r]66,133	62,343	35,193	24,868	31,000
Spain	557,253	525,132	588,187	658,230	661,000
Turkey	[r]910,371	864,174	947,987	793,094	623,000
U.S.S.R.[e]	2,200,000	2,290,000	2,370,000	2,400,000	2,400,000
United States	W	W	W	W	W
Yugoslavia	288,630	330,336	362,060	335,102	336,000
Zimbabwe	86,219	66,352	67,000	[e]66,000	66,000
Total	[r]12,694,843	[r]12,327,482	12,303,907	12,319,795	11,953,300

[e]Estimated. [p]Preliminary. [r]Revised. 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 Apr. 30, 1985.

[2]Series reflects output of marketable concentrates. Production of crude ore was as follows, in short tons: 1980—868,620 (revised); 1981—681,228 (revised); 1982—556,667 (revised); 1983—535,723; and 1984—551,000 (estimated).

[3]Magnesitic dolomite and brucite. Figures are estimated on the basis of reported tonnage dollar value.

[4]Reported figure.

[5]Year beginning Mar. 21 of that stated.

[6]Revised to zero.

TECHNOLOGY

The Bureau of Mines published results of research on producing full-size magnesia refractory bricks from chemically modified periclase grains and magnesium hydroxide slurries. Strength values, both hot and cold, for these bricks were superior to those for a commercial 98 weight percent magnesia refractory. Test results indicated that these refractories could potentially substitute for magnesia-chromite refractories containing imported chromite.[6]

Research was conducted on a new method for preparing high-purity magnesia powders for use in fabrication of electronic and ceramic structural components. In this method, called evaporative decomposition, a salt solution is atomized to form a spray of droplets. These droplets dry when injected into a furnace, resulting in precipitation of the salt, which subsequently decomposes to form an oxide powder. Most other techniques used to prepare these powders require separate salt preparation and calcination steps to form the oxide powder; however, the evaporative decomposition technique reportedly accomplished both of these operations in one step.[7]

The status of olivine consumption and production in the United States and abroad was reviewed. Indications were that new uses for olivine were emerging, such as slag conditioners in blast furnaces, in waste incinerators, and as abrasive material for the blasting industry, that could increase consumption. New sources of olivine were being developed in Canada, Norway, and Pakistan.[8]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Chemical and Engineering News. V. 62, No. 43, Oct. 22, 1984, p. 10.

[3]Chemical Engineering. V. 91, No. 26, Dec. 24, 1984, p. 33.

[4]Schmid, H. China—the magnesite giant. Ind. Miner. (London), No. 203, Aug. 1984, pp. 27-45.

[5]Industrial Minerals (London). Specialty magnesia plant for 1986. No. 204, Sept. 1984, p. 19.

[6]Bennett, J. P., and T. A. Clancy. Magnesia Refractories Produced From Chemically Modified Periclase Grains and $Mg(OH)_2$ Slurries. BuMines RI 8848, 1984, 14 pp.

[7]Gardner, T. J., and G. L. Messing. Preparation of MgO Powder by Evaporative Decomposition of Solutions. Ceram. Bull., v. 63, No. 12, Dec. 1984, pp. 1498-1501.

[8]Griffiths, J. Olivine—exchanging new uses for old. Ind. Miner. (London), No. 204, Sept. 1984, pp. 65-79.

Manganese

By Thomas S. Jones[1]

World production of manganese ore rose slightly compared with that of 1983. Consumers in the major steel-producing regions of market economy countries generally paid higher prices for metallurgical ore, with the increases ranging up to 5%. China entered notably into international ore trade, making significant purchases from Australia and Gabon. These two countries also continued to supply high-grade concentrates to the U.S.S.R. Ore production and shipments in the United States again consisted of only manganiferous materials in relatively small quantity compared to overall domestic ore consumption.

Oversupply and overcapacity for manganese ferroalloys still was evident in the market economy countries. In the United States, ferroalloys and manganese metal were each produced by only two firms. The U.S. Government continued a program of upgrading ore in the National Defense Stockpile into high-carbon ferromanganese, but determined that imports of ferroalloys did not threaten national security, and therefore, the domestic ferroalloy industry should not be provided assistance on those grounds. A 9% increase in domestic raw steel production brought about a comparable increase in overall domestic consumption of manganese ferroalloys. Reported data indicated that the rate of manganese consumption in steelmaking increased only slightly.

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)

	1980	1981	1982	1983	1984
United States:					
Manganese ore (35% or more Mn):					
Imports for consumption	698	639	238	368	338
Consumption	1,071	1,077	609	531	627
Manganiferous ore (5% to 35% Mn):					
Production (shipments)	174	175	32	34	88
Ferromanganese:					
Production	189	193	119	86	W
Exports	12	15	10	8	7
Imports for consumption	606	671	493	342	409
Consumption	789	821	439	446	492
World: Production of manganese ore	r29,086	r25,896	26,595	p24,093	e25,341

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—As announced in May (49 FR 21391), the President determined that ferroalloy imports did not threaten to impair U.S. national security. This decision was in response to the domestic ferroalloy industry's 1981 petition filed under section 232 of the Trade Expansion Act of 1962. The decision took into account two actions instituted since filing of the petition: the termination of the Generalized System of Preferences tariff for high-carbon ferromanganese and the initiation of a 10-year program of upgrading ore in the National Defense Stockpile into high-carbon ferromanganese and high-carbon ferrochromium. Indicative of the progress of the stockpile upgrading program, stockpile data for manganese showed that the General Services Administration (GSA) accepted into inventory 24,332 tons[2] of high-carbon ferromanganese produced by Elkem Metals Co. in 1984, the first year of the upgrading program. In November, GSA awarded a $17.8 million contract, also to Elkem Metals, for upgrading 80,039 tons of metallurgical manganese ore in the stockpile into high-carbon ferromanganese in 1985. Originally, the solicitation made in August had called for conversion of 156,000 tons of ore. Payment by the Government in excess stockpile materials was to continue.

GSA's legislative authority to dispose of manganese materials in Government inventories was changed, starting in October with the beginning of fiscal year 1985, as follows: natural battery ore, stockpile grade, reduced by about 23,000 tons to 17,649 tons; chemical ore, reduced to zero; and metallurgical ore, nonstockpile grade, increased by 292,000 tons to 949,510 tons. The authority for disposal remained at 33,561 tons for natural battery ore, nonstockpile grade, and at zero for all other stockpiled manganese materials not mentioned. Sales and changes in inventory of manganese materials were as follows:

Material	Sales (short tons): Stockpile grade	Sales (short tons): Nonstockpile grade	Change in yearend inventory (short tons)
Natural battery ore	6,040	--	-1,516
Chemical ore	19,847	--	-15,803
Metallurgical ore	--	8,400	-47,951
High-carbon ferromanganese	--	--	+24,332

Table 2.—U.S. Government stockpile goals and yearend inventories for manganese materials in 1984

(Short tons)

Material	Stockpile goals	Physical inventory, Dec. 31				
		Uncommitted			Sold, pending shipment	Grand total
		Stockpile grade	Nonstockpile grade	Total		
Natural battery ore	62,000	175,593	33,561	209,154	8,965	218,119
Synthetic manganese dioxide	25,000	3,011	--	3,011	--	3,011
Chemical ore	170,000	171,717	89	171,806	20,710	192,516
Metallurgical ore	2,700,000	2,367,737	942,679	3,310,416	245,162	3,555,578
High-carbon ferromanganese	439,000	624,310	--	624,310	--	624,310
Medium-carbon ferromanganese	--	28,920	--	28,920	--	28,920
Silicomanganese	--	23,574	--	23,574	--	23,574
Electrolytic metal	--	14,172	--	14,172	--	14,172

A National Materials Advisory Board study found that manganese dioxide was the only manganese material in the stockpile in need of a quality assessment. This determination applied to natural and synthetic manganese dioxide, and both were assigned medium priority for urgency of need for assessment.[3]

The National Oceanic and Atmospheric Administration issued licenses for deep-sea-bed mining exploration to four U.S. applicants: Kennecott Consortium, Ocean Management Inc., Ocean Minerals Co., and Ocean Mining Associates. Designated sites in all licenses were in the Clarion-Clipperton Fracture Zone of the Northeastern Equatorial Pacific Ocean. These licenses were issued in September and October in accordance with the Deep Seabed Hard Mineral Resources Act (DSHMRA). Funding of $3 million to carry out regulatory and developmental programs of DSHMRA between October 1984 and September 1986 was authorized on November 8 under Public Law 98-623.

DOMESTIC PRODUCTION

Ore and Concentrate.—No manganese ore, concentrate, or nodules containing 35% or more manganese were produced or shipped in the United States, nor were ferruginous manganese ores or concentrates containing from 10% to 35% manganese produced. Ferruginous manganese concentrates averaging about 15% manganese continued to be shipped from the Cuyuna Range of Minnesota. Such shipments were about six times as great as in 1983, and were the most since 1981. Manganiferous schist, clay, or other earthy material associated with the manganiferous member of the Battleground schist of the Kings Mountain area was mined in Cherokee County, SC, by brick manufacturers or contractors for use in coloring brick. Manganese content of this material ranged from 5% to 15% but 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	1983 Gross weight	1983 Manganese content	1984 Gross weight	1984 Manganese content
Ferruginous manganese ore (10% to 35% Mn, natural):				
Minnesota	11,314	r1,655	68,019	8,754
Manganiferous iron ore (5% to 10% Mn, natural):				
South Carolina[2]	22,209	1,987	20,404	1,799
Total	33,523	r3,642	88,423	10,553
Value	$215,693	XX	$860,226	XX

rRevised. 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.—Publication of production and shipments data was precluded by further contraction of the domestic industry. Closure of the silicomanganese plant of Autlan Manganese Corp. near Mobile, AL, was made permanent toward yearend. The plant's electric furnace, which had not operated since July 1982, was to be moved to the parent company's facilities in Mexico. Sale of the Globe Metallurgical Div. of Interlake Inc., which included silicomanganese production facilities at Beverly, OH, was completed in November. The buyer was Pickands Mather & Co., a subsidiary of Moore McCormack Resources Inc., which was to operate its acquisition under the new name of Globe Metallurgical Inc. The plant of Roane Alloys Div. of Samancor Metals and Minerals Ltd. at Rockwood, TN, remained in mothballed status. The plant of SKW Alloys Inc. at Calvert City, KY, continued on strike throughout the year. The furnace that was operated there by salaried personnel did not produce manganese ferroalloys.

Among the two producers of manganese ferroalloys, Elkem Metals underwent a change in ownership structure. In August, Elkem A/S of Norway increased its participation in Elkem Metals from 49% to a majority of 67% by buying an additional 18% share from the Jebsen Group, also of Norway. This reduced the Jebsen Group's shareholding to 10% while the balance of 23% continued to be held by a group of Norwegian investors. Elkem Metals was the only domestic producer of high-carbon ferromanganese. Chemetals Inc. produced low- and medium-carbon ferromanganese sold under the trade name of Massive Manganese.

Those 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 1984

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.
Kerr-McGee Chemical Corp	Hamilton, MS	--	--	X	--	Electrolytic.
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[1] consumed[2]: Total quantity	Manganese ore[1] consumed[2]: Per ton of ferromanganese and silicomanganese made
1980	189	80	194	188	162	726	1.9
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

W Withheld to avoid disclosing company proprietary data.
[1]Containing 35% or more manganese (natural); foreign ore plus small quantities from U.S. Government excess stockpile disposals.
[2]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 remained at 1.1 pounds per ton of raw steel. This rate was calculated from a reported consumption of about 117,000 tons of manganese ore containing more than 35% manganese, all of foreign origin, in iron blast furnaces and production of 92.5 million tons of raw steel as ingots, continuous- or pressure-cast blooms, billets, slabs, etc. Iron blast furnaces consumed an additional 116,000 tons of domestic manganiferous iron ore containing 5% to 10% manganese, part of which appeared to have been a blend of iron and manganese materials. No manganese ore containing 35% or more manganese was reported to have been used directly in steelmaking.

Unit manganese consumption in steelmaking as ferroalloys and metal increased only slightly over the decreased level reached as of the latter part of 1982. For reported consumption in the production of 93.5 million tons of raw steel and steel castings in 1984, pounds of manganese consumed per ton of raw steel was 7.9 as ferromanganese, 1.4 as silicomanganese, and 0.2 as metal, for a total of 9.5. In 1983, the corresponding unit consumption in production of 85.3 million tons of raw steel and steel castings totaled 9.2, of which ferromanganese accounted for 7.8; silicomanganese, 1.2; and metal, 0.2. Reported data also indicated that the proportion of ferromanganese and silicomanganese consumed in making carbon steel was somewhat higher, and in making alloyed steels somewhat lower, than in 1983.

Table 6.—U.S. consumption and industry stocks of manganese ore,[1] by use

(Short tons)

Use	Consumption		Stocks, Dec. 31	
	1983	1984	1983	1984
Manganese alloys and metal	274,280	W	270,933	257,698
Pig iron and steel	105,505	W	101,971	96,679
Dry cells, chemicals, miscellaneous[2]	150,874	W	244,584	227,890
Total	530,659	626,789	617,488	582,267

W Withheld to avoid disclosing company proprietary data.
[1]Containing 35% or more manganese (natural); foreign ore plus small quantities from U.S. Government excess stockpile disposals.
[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 1984

(Short tons, gross weight)

End use	Ferromanganese			Silicomanganese	Manganese metal
	High carbon	Medium and low carbon	Total		
Steel:					
Carbon	308,410	73,151	381,561	71,654	4,689
Stainless and heat-resisting	12,064	608	12,672	4,683	1,912
Full alloy	33,613	8,893	42,506	14,331	1,340
High-strength low-alloy	27,956	6,643	34,599	5,608	604
Electric	(1)	(1)	(1)	(1)	(1)
Tool	303	(1)	303	(1)	74
Unspecified	440	139	579	660	132
Total steel	382,786	89,434	472,220	96,936	8,751
Cast irons	13,195	555	13,750	3,864	W
Superalloys	210	W	210	25	216
Alloys (excluding alloy steels and superalloys)	1,048	220	1,268	W	[2]18,455
Miscellaneous and unspecified	3,642	1,073	4,715	2,029	472
Total consumption	400,881	91,282	492,163	102,854	[2]27,894
Total manganese content[3]	313,000	73,000	386,000	68,000	28,000
Stocks, Dec. 31:					
Consumer	W	W	136,134	W	W
Producer	W	W	23,325	W	W
Total stocks	134,245	25,214	159,459	12,440	4,349

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.— Major battery manufacturers reported gains in sales of dry cells and were particularly emphasizing the alkaline-manganese dioxide type in which synthetic dioxide was used. Synthetic dioxide was also used as a blend with natural ore in carbon-zinc dry cells, mainly the heavy-duty type, and in specialized chemical applications. Foote Mineral Co. began converting part of its idled electrolytic manganese metal plant at New Johnsonville, TN, to production of electrolytic manganese dioxide (EMD). The conversion, expected to be completed by late 1985, will give Foote Mineral an EMD capacity of 10,200 tons per year. The conversion project was capitalized at $17.4 million, with funding to be spread among industrial development revenue bonds, an operating lease, and internally generated monies.

Developments affecting domestic production of manganese sulfate included an announcement by Tennessee Eastman Co., a unit of Eastman Kodak Co., that as of 1986 it would change its process for manufacturing hydroquinone, a photographic developer, from one requiring manganese ore to one based upon diisopropyl benzene technology. Manganese sulfate is a byproduct of the process Tennessee Eastman has been using at its Kingsport, TN, plant. Eagle-Picher Industries Inc. began limited production of manganese sulfate at Fairbury, NE, after having ended sulfate production at Cedartown, GA, in 1983. Manganese sulfate is used in animal feed, in fertilizer as a micronutrient, and as an intermediate in making other manganese chemicals.

PRICES

Manganese Ore.—Prices depend primarily on manganese content but also on other chemical constituents, and on 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' evaluations of the market.

Protracted negotiations between suppliers of metallurgical ore and Japanese consumers culminated about late May in an overall average price increase of less than 3% for a contract volume, about 20% greater than in 1983. A price increase of about 5% was reported about midyear for deliveries to West European ports. The average price, c.i.f. U.S. ports, for metallurgical ore containing 48% manganese was $1.42 per long ton unit, compared with $1.38 in 1983; per metric ton unit, these prices were $1.40 and $1.36, respectively. These prices convert to 6.3 and 6.2 cents per pound of manganese in ore, respectively.

Manganese Ferroalloys.—A published list price for domestically produced high-carbon ferromanganese was not available. About midyear, industry publications ceased reporting the nominal value of $490 per long ton of alloy, f.o.b. shipping point. This had been listed since 1982 for standard high-carbon ferromanganese with a minimum manganese content of 78%. The price of comparable imported high-carbon ferromanganese averaged marginally higher than in 1983, having risen from the yearend 1983 price of $320 to $335 per long ton of alloy, f.o.b. Pittsburgh or Chicago warehouse, to $330 to $340 by mid-1984 and then having decreased to $325 to $335 in October and for the rest of the year. The price of imported silicomanganese containing 2% carbon followed a similar trend of advancing and then falling back. The price of this ferroalloy had ended 1983 at 18.5 cents per pound of alloy, f.o.b. warehouse, dropped to 17.5 to 18.5 cents beginning in January 1984, rose to a peak of 20.5 to 21.5 cents by mid-June, and declined in the last quarter to a final value of 18 to 20 cents. The price of the same grade of domestically produced silicomanganese stayed at 21 cents per pound of alloy, f.o.b. producer, from 1983 through the first half of 1984, after which it increased to 23.5 cents, where it remained for the rest of the year.

Manganese Metal.—Domestic suppliers increased the list price of electrolytic metal in mid-March and again in the latter part of November. The first increase was from 70 to 76 cents and the second to 80 cents per pound for bulk shipments, f.o.b. shipping point. A similar degree of firming of metal price was reported in Western Europe and Japan. The increases in the United States gave a year-average price nearly 10% higher than that for 1983.

FOREIGN TRADE

Exports of ferromanganese, silicomanganese, and manganese metal (including alloys and waste and scrap) all decreased compared with those in 1983. About four-fifths of the unusually large shipments reported as exports of ore and concentrate were actually reexports to Canada, France, and Italy. Most of the rest of the ore exports appeared, as usual, to be metallurgical ore obtained from excess Government stocks shipped to Canada and Mexico and of imported manganese dioxide ore possibly ground, blended, or otherwise classified in the United States and shipped elsewhere. Additional shipments of ore to Canada and Mexico reported as reexports totaled 8,327 tons and were apparently metallurgical ore.

Gabon was again the leading source of manganese ore imports, but its share of the total dropped somewhat to about two-fifths. Average grade of imported ore increased to 48.7%. The quantity of manganese imported as ore and dioxide decreased to 42% of that imported as ferroalloys and metal. Imports of manganiferous ore consisted of 18,119 tons from Brazil with an average manganese content of 33% and 1,047 tons from Mexico with an average manganese content of 30%.

Imports of ferromanganese increased by

about one-fifth overall. Imports of medium-carbon ferromanganese showed an especially pronounced increase, particularly from the Federal Republic of Germany. Average manganese content of all ferromanganese imports rose to 78.6%. Silicomanganese imports were only slightly below the 1983 record-high total and included about 9,000 tons from Romania. Imports of unwrought manganese metal were a record-high at about 2.5 times those in 1983. Virtually all metal imported was shipped from the Republic of South Africa.

Imports for consumption of spiegeleisen were reported as 220 tons, composed of 132 tons from Canada and 88 tons from the Federal Republic of Germany, the latter having relatively high unit value.

Among imports of manganese chemicals, those of manganese dioxide increased, setting another record. All but 214 tons were apparently synthetic dioxide for battery or chemical applications. Manganese sulfate imports, varying considerably in unit value, were reported as 201 tons, including 94 tons from China, 74 tons from the Federal Republic of Germany, 20 tons from Belgium-Luxembourg, and 13 tons from Japan. Imports for consumption of potassium permanganate were 1,312 tons, of which the principal sources were Spain, 1,003 tons; China, 196 tons; the German Democratic Republic, 88 tons; and Czechoslovakia, 20 tons.

Tariffs.—Countervailing duties of 1.53% on medium- and high-carbon ferromanganese and silicomanganese imported from Spain on or after July 26, 1982, were ended on October 23, 1984, when the International Trade Commission (ITC) terminated its countervailing duty investigation of ferroalloys from Spain. This action came after The Ferroalloys Association, the petitioner, notified the ITC in August that it wished to withdraw its request for imposition of countervailing duties on ferroalloys from Spain.

Imports of potassium permanganate were the subject of several actions and investigations. As an outgrowth of investigations and determinations made in 1983, the International Trade Administration (ITA) of the U.S. Department of Commerce in January issued antidumping duty orders against imports from Spain and China. Margins were 5.49% for permanganate from Spain and 39.63% for permanganate from China. Countervailing duties against Spanish material lasted only until April 30, at which time an early determination by ITA found no dumping margins existed on Spanish permanganate imported between August 9, 1983, and January 10, 1984. Carus Chemical Co. of La Salle, IL, the sole domestic producer of potassium permanganate and on strike by production workers from June 1 and thereafter, was the U.S. company affected by these developments. Carus Chemical again petitioned the Government for import relief at the end of November, asking the ITC to determine under section 201 of the Trade Act of 1974 whether increased imports of potassium permanganate were causing or likely to cause serious injury to the domestic industry.

Table 8.—U.S. exports of manganese ore, ferroalloys, and metal, by country

(Gross weight)

Country	1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ore and concentrates containing 5% or more manganese:				
Brazil	4,509	$605	--	--
Canada	12,625	1,030	54,859	$4,225
France	--	--	109,664	6,300
Italy	--	--	38,181	2,212
Mexico	357	25	25,987	1,705
Other	1,823	312	8,915	1,201
Total	19,314	1,972	237,606	15,643
Ferromanganese:				
Canada	8,061	5,509	5,498	3,745
Mexico	83	71	277	241
Trinidad and Tobago	198	117	879	355
Other	91	68	110	55
Total	8,433	5,765	6,764	[1]4,397

See footnotes at end of table.

Table 8.—U.S. exports of manganese ore, ferroalloys, and metal, by country —Continued

(Gross weight)

Country	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Silicomanganese:				
Canada	175	$105	123	$97
Dominican Republic	--	--	466	243
Japan	3,549	593	--	--
Trinidad and Tobago	2,697	1,042	962	345
Other	5	6	3,783	1,552
Total	6,426	1,746	[1]5,333	2,237
Metal including alloys and waste and scrap:				
Belgium-Luxembourg	1,002	1,518	1,015	1,460
Canada	374	603	280	462
India	1,685	1,576	23	30
Japan	805	908	1,533	2,035
Netherlands	1,008	1,519	384	493
Sweden	903	1,552	182	256
Other	[r]614	[r]855	664	1,179
Total	6,391	8,531	[1]4,082	5,915

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

Table 9.—U.S. imports for consumption of manganese ore, ferroalloys, metal, and dioxide, by country

Country	1983 Gross weight (short tons)	1983 Manganese content (short tons)	1983 Value (thousands)	1984 Gross weight (short tons)	1984 Manganese content (short tons)	1984 Value (thousands)
ORE AND CONCENTRATES						
35% or more manganese:						
Australia	29,319	15,118	$1,740	39,689	21,005	$2,670
Brazil	78,928	39,112	3,742	88,333	44,259	3,135
Gabon	171,018	85,509	9,628	132,985	66,135	6,898
Mexico	63,588	25,598	3,575	40,831	[1]16,298	2,122
Morocco	39	[1]20	12	77	[1]39	21
South Africa, Republic of	25,406	12,703	1,170	36,179	17,286	1,178
Total[2]	368,297	178,060	19,867	338,094	165,023	16,024
Of which, more than 35% but less than 47% manganese: Mexico	59,053	23,428	2,815	38,028	14,897	1,975
FERROMANGANESE						
All grades:						
Australia	--	--	--	5,937	4,637	1,406
Belgium-Luxembourg	2,522	2,053	1,248	843	758	787
Brazil	28,550	22,022	5,971	9,425	7,266	2,477
Canada	2,366	1,761	600	2,052	1,408	352
France	117,142	91,611	32,494	123,031	96,445	33,271
Germany, Federal Republic of	5,696	4,552	2,688	24,308	19,794	11,650
Japan	2,757	2,231	1,638	2,756	2,225	1,385
Mexico	36,302	28,519	10,899	39,124	30,876	12,715
Norway	26,207	20,621	7,070	39,844	31,920	12,092
Portugal	17,637	13,565	3,212	17,444	13,475	3,237
South Africa, Republic of	87,664	67,988	22,841	133,708	104,497	34,599
Spain	4,404	3,523	1,923	6,320	4,972	2,587
Yugoslavia	10,362	7,914	2,498	4,519	3,427	1,120
Total[2]	341,608	266,360	93,083	409,310	321,699	117,678
Of which, 1% or less carbon:						
Belgium-Luxembourg	--	--	--	843	757	787
Canada	--	--	--	17	12	2
France	3,668	3,291	3,426	892	790	1,012
Germany, Federal Republic of	2,218	1,730	1,062	--	--	--
Norway	1,081	935	922	3,268	2,872	2,753
Total[2]	6,967	5,957	5,410	5,020	4,431	4,554

See footnotes at end of table.

Table 9.—U.S. imports for consumption of manganese ore, ferroalloys, metal, and dioxide, by country —Continued

Country	1983			1984		
	Gross weight (short tons)	Manganese content (short tons)	Value (thousands)	Gross weight (short tons)	Manganese content (short tons)	Value (thousands)
FERROMANGANESE —Continued						
All grades —Continued						
More than 1% to 4% or less carbon:						
Belgium-Luxembourg	2,522	2,053	$1,248	--	--	--
Brazil	--	--	--	606	497	$297
Canada	568	457	282	17	12	2
France	--	--	--	4,368	3,655	2,139
Germany, Federal Republic of	3,478	2,822	1,626	24,308	19,794	11,650
Japan	2,757	2,231	1,638	2,756	2,225	1,385
Mexico	10,578	8,542	4,889	15,830	12,727	7,540
South Africa, Republic of	5,136	4,108	2,345	649	527	313
Spain	4,404	3,523	1,923	4,976	3,980	2,347
Total[2]	29,442	23,735	13,952	53,509	43,419	25,674
SILICOMANGANESE						
Australia	16,227	10,654	4,286	14,181	9,344	4,096
Brazil	30,803	20,269	8,582	46,591	30,565	14,190
Canada	815	525	242	933	632	302
France	--	--	--	413	270	253
Mexico	5,731	3,839	1,695	15,447	10,311	5,002
Norway	6,628	4,219	2,926	11,854	7,680	5,137
Portugal	10,472	6,820	2,667	827	498	141
Romania	--	--	--	9,094	6,066	3,011
South Africa, Republic of	52,196	34,704	14,564	23,425	15,694	7,138
Spain	1,221	780	747	1,265	820	765
Yugoslavia	15,563	10,182	4,408	14,465	9,459	4,711
Total[2]	139,657	91,992	40,117	138,494	91,339	44,746
METAL						
Unwrought:						
South Africa, Republic of	5,295	XX	5,034	13,295	XX	12,951
United Kingdom[3]	--	XX	--	19	XX	27
Total	5,295	XX	5,034	13,314	XX	12,978
Waste and scrap: Canada	655	XX	289	--	XX	--
DIOXIDE						
Belgium-Luxembourg	495	XX	555	453	XX	381
Brazil	1	XX	1	788	XX	908
Greece	1,852	XX	2,082	2,600	XX	3,112
Ireland	118	XX	170	218	XX	302
Japan	18,174	XX	23,283	19,884	XX	25,165
Korea, Republic of[3]	--	XX	--	211	XX	256
United Kingdom	100	XX	123	240	XX	161
Other	r73	XX	r96	102	XX	91
Total[2]	20,813	XX	26,310	24,498	XX	30,378

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.

Table 10.—U.S. import duties on manganese materials

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
Ore and concentrate	601.27	Free	Free	1 cent per pound Mn.
Ferromanganese:				
Low-carbon	606.26	2.5% 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	1.6% ad valorem	1.5% ad valorem	10.5% ad valorem.
Silicomanganese	606.44	4.7% ad valorem[1]	3.9% ad valorem	23% ad valorem.
Metal	632.30	14% ad valorem	14% ad valorem	20% ad valorem.

[1]Free from certain countries under Generalized System of Preferences, not including Brazil for silicomanganese.

WORLD REVIEW

For ferromanganese, overcapacity in Western Europe was an unresolved problem. In May, the European Commission disallowed the formation of Euromang, a cartel of suppliers of high-carbon ferromanganese to the European Economic Community (EEC) that materialized late in 1983. Subsequently, the European Commission was reported to be working on a plan to reduce EEC capacity for high-carbon ferromanganese by 20%. Changes in the ferroalloy interests of French-based Pechiney, Carlo Tassara Stabilimenti Elettrosiderurgici S.p.A. in Italy, and Hidro Nitro Españolas S.A. in Spain signified greater participation in these companies and/or ore sourcing for them by Gabonese and South African manganese mining companies. Statistics on production of manganese ferroalloys are presented in the "Ferroalloys" chapter.

Australia.—Ore production and shipments by Groote Eylandt Mining Co. Pty. Ltd. (GEMCO) rose sharply, partly because of the addition of China as a customer and continuing sales to the U.S.S.R. GEMCO's total shipments were about 2,070,000 tons, of which about 1,610,000 tons was exported and about 460,000 tons was for domestic consumption. The largest quantities exported, in tons, went to Japan, 631,000; the Federal Republic of Germany, 212,000; China, 173,000; the U.S.S.R., 124,000; and the Republic of Korea, 116,000. GEMCO sought to establish a market in the battery industry for portions of its ore recently found to be battery active. The activity of this potential battery ore was traced to the presence of the mineral vernadite, a hydrated manganese oxide. The Broken Hill Pty. Co. Ltd. (BHP), the parent company of GEMCO and of Tasmanian Electro Metallurgical Co. Pty. Ltd. (TEMCO), announced that about $40 million would be spent to upgrade TEMCO's Bell Bay, Tasmania, ferroalloy plant by the end of 1987. TEMCO's export potential was to be increased by expanding its annual capacity for ferromanganese and silicomanganese production to about 210,000 tons from about 150,000 tons.

Brazil.—Exports and domestic shipments of manganese ore products from the Serra do Navio, Amapá Territory, operations of Indústria e Comércio de Minérios S.A. (ICOMI) increased. Total shipments via Porto de Santana on the Amazon River were 980,000 tons, of which 219,000 tons went to Brazilian consumers. Destinations for the 761,000 tons of exports were Europe, over 607,000 tons; the United States, 116,000 tons; Japan, over 25,000 tons; and Argentina, 12,000 tons.[4] In November, Cia. Auxiliar de Empresas de Mineração (CAEMI Group) became sole owner of ICOMI. In an ownership exchange, Bethlehem Steel Corp. gave up its 49% share in ICOMI for a 5% indirect interest in the iron mining interests of Minerações Brasileiras Reunidas S.A. in Minas Gerais State. Bethlehem Steel had been a joint venture partner with CAEMI in ICOMI since ICOMI's inception around 1950.

Construction of the rail line linking the Carajás mineral province with the future ocean shipping port of São Luiz moved ahead rapidly in 1984. This allowed the timetable for beginning full-scale open pit production of metallurgical ore from the Igarapé Azul deposit to be moved ahead to 1985, with ore to be partly transported temporarily by truck for loading onto ships at Itaqui. Cia. Vale do Rio Doce produced nearly 40,000 tons of metallurgical and battery ore combined from Azul, and made both domestic and foreign shipments of battery ore. Rights to the Buritirama deposits, a potential other source of manganese ore in the Carajás, passed to Australia's BHP when in April BHP finalized its acquisition of Utah International Inc. from General Electric Co.

S.A. Mineração da Trindade started up the Miguel Congo Mine for ferruginous manganese ore near Ouro Preto, Minas Gerais State. This new mine, with an annual capacity for crude ore of about 375,000 tons, was equipped for wet as well as dry beneficiation.

Production of manganese ferroalloys increased nearly 10% to a record-high total of 340,000 tons, according to preliminary data.

Canada.—Elkem and the Jebsen Group, both of Norway, became owners of the manganese ferroalloy plant at Beauharnois as of July 25. This consortium exercised an option to purchase this plant, another ferroalloy plant at Chicoutimi, and a hydroelectric plant, all in the Province of Quebec, from Union Carbide Canada Ltd. The newly acquired plants were to be operated by a new Quebec corporation, Elkem Metal Canada Inc., owned 90% by Elkem and 10% by the Jebsen Group.

China.—A significant amount of high-grade metallurgical ore was imported, presumably the first such instance in modern times. Imports included over 300,000 tons combined from Australia and Gabon. Imported ore of a higher quality than indigenous ore possibly was bought for use in upgrading domestic production of manganese ferroalloys.

France.—Blast-furnace production of high-carbon ferromanganese plus a small amount of spiegeleisen increased about one-fifth to 364,000 tons in 1984, according to preliminary data.

Gabon.—Production of manganese ore at the Moanda Mine of Compagnie Minière de l'Ogooué S.A. (COMILOG) increased to the greatest total since 1980, and shipments also were up in 1984. Sales included 200,000 tons to China and 130,000 tons to the U.S.S.R. Battery ore (dioxide) did not follow the rising trend, for which production decreased to about 90,000 tons and shipments fell substantially to about 80,000 tons.

The Trade and Development Program of the U.S. International Development Cooperation Agency financed engineering and economic evaluations of a possible mineral port for exporting manganese and perhaps eventually iron ore once the Trans-Gabon Railroad has been completed. The study indicated the most favorable site for such a port would be adjacent to Owendo in the Gabon Estuary south of Libreville.

Ghana.—Exports of manganese ore produced at the Nsuta Mine of Ghana National Manganese Corp. increased to 275,000 tons, compared with 154,000 tons in 1983. Shipments went through the Port of Takoradi to eight European countries and Japan.[5] Shipments were the largest since 1979.

Japan.—Compared with 1983, the most significant change in production and foreign trade of manganese ferroalloys was a 25% increase in ferromanganese production to 535,000 tons. Silicomanganese production advanced somewhat to 257,000 tons. Exports were 25,000 tons for ferromanganese and only about 100 tons for silicomanganese. Imports declined for both ferromanganese and silicomanganese, to about 15,500 tons and 126,000 tons, respectively.

Mizushima Gokintetsu, a subsidiary of Kawasaki Steel Corp., began converting a submerged arc furnace to a coke-fed shaft furnace for production of ferromanganese in the hope of lowering costs below those of electric smelting. The converted facility was targeted to be in operation about the middle of 1985 with a capacity for high-carbon ferromanganese of about 100,000 tons per year.

In electrolytic materials, comparatively modest increases were recorded for synthetic manganese dioxide, to 52,700 tons for production and to 40,300 tons for exports. Production of nearly 4,800 tons of manganese metal was the highest since 1980.

Mexico.—Cía. Minera Autlán S.A. de C.V. produced 714,000 tons of carbonate ore and 475,000 tons of oxide nodules from its mining and calcining operations in the Molango District of Hidalgo State in 1984. This was reasonably comparable to production levels in recent prior years except for 1983. Production of both carbonate ore and oxide nodules was unusually low in 1983, at 632,000 and 316,000 tons, respectively. Approximately three-fourths of production of carbonate ore at the Tetzintla Mine was by underground mining in 1983. Production of battery ore at the Nonoalco Mine was cut back to 21,000 tons in 1984 to control inventories, after having risen to 35,000 tons in 1983.

Norway.—Elkem reportedly raised its production rate for medium-carbon ferromanganese by about one-half to nearly 130,000 tons per year, and increased its manganese ferroalloy interests in Canada and the United States.

South Africa, Republic of.—Ore production increased slightly compared with that of 1983, and mine operations were again at reduced levels for both of the major producers, South African Manganese Amcor Ltd. (Samancor) and The Associated Manganese Mines of South Africa Ltd. (AMMOSAL). Ore shipments by AMMOSAL increased by over 50%, to about 1,320,000 tons from about 860,000 tons in 1983.[6] According to preliminary data, production of the various categories of ore was as follows:

	Quantity (thousand short tons)
METALLURGICAL ORE	
30% to 40% Mn	1,350
Over 40% to 45% Mn	476
Over 45% to 48% Mn	493
Over 48% Mn	830
Total	[1]3,150
CHEMICAL ORE	
35% MnO_2 and less	76
Over 35% to 65% MnO_2	135
Over 65% to 75% MnO_2	--
Total	211

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

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				
		1980	1981	1982	1983[p]	1984[e]	1980	1981	1982	1983[p]	1984[e]
Australia[4]	37-53	2,204	1,555	1,238	1,492	1,874	1,062	754	594	741	915
Brazil[5 6]	38-50	[7]2,515	[7]2,251	[7 8]2,580	[7]2,306	[7]2,425	1,129	1,010	1,158	1,035	1,088
Bulgaria	29	54	50	50	50	50	16	15	15	14	15
China[e 9]	30	1,760	1,760	1,760	1,760	1,760	530	530	530	530	530
Gabon[5 6]	50-53	2,366	1,640	1,667	2,058	[10]2,336	1,092	757	769	950	1,078
Ghana[5]	30-50	[r]275	246	176	191	132	110	98	71	76	53
Hungary[5 11]	30-33	91	78	91	65	66	27	23	27	20	20
India[5 6 12]	10-54	1,865	1,682	1,596	1,455	1,433	676	610	579	528	520
Japan	24-27	88	96	86	85	68	21	23	22	23	18
Mexico	27-50	[e]493	[e]637	[e]561	[e]386	571	177	229	202	147	217
Morocco[5]	50-53	145	121	106	81	63	77	64	56	43	33
South Africa, Republic of[5 6]	30-48+	6,278	5,555	5,750	3,181	[10]3,361	2,307	2,123	2,220	1,225	1,341
Thailand[5]	46-50	60	12	9	7	10	29	6	4	4	5
Turkey[5]	27-46	46	16	8	4	3	16	6	3	1	1
U.S.S.R	30-31	10,750	10,090	10,830	10,890	11,100	3,351	3,043	3,260	3,280	3,330
Yugoslavia	25-45	33	34	31	[r e]29	30	12	12	11	10	11
Other[e 13]	XX	[r]63	[r]72	56	54	59	23	28	22	20	22
Total[14]	XX	[r]29,086	[r]25,896	26,595	24,093	25,341	10,656	9,333	9,543	8,646	9,196

[e]Estimated. [p]Preliminary. [r]Revised. XX Not applicable.

[1]Table includes data available through June 4, 1985.

[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), 1980—7, 1981—3, 1982—4, 1983—5, and 1984—7; Czechoslovakia (about 17% Mn), an estimated 1 in each year; Malaysia (grade unspecified but apparently a ferruginous manganese ore), 1980—4, and 1981-84—zero; and Romania (about 22% Mn), an estimated 90 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]Gross weight reported; metal content estimated.

[6]Calculated metal content includes allowance for assumed moisture content.

[7]Figures are the sum of (1) sales of direct-shipping manganese ore and (2) production of beneficiated ore, both as reported in Annuário Mineral Brasiliero.

[8]Only about two-thirds of this quantity was marketed.

[9]Includes manganiferous ore.

[10]Reported figure.

[11]Concentrate.

[12]Much of India's production grades below 35% Mn; average content was reported as about 37% Mn in 1980.

[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.

At Samancor, suspension of operations at the Lohathla Mine that began near the end of 1983 continued throughout 1984. Production from Lohathla of ferruginous ore was being replaced by comparable ore from the Middelplaats and Wessels Mines. Because demand for manganese ferroalloys remained relatively weak while that for ferrochromium was strong, several small furnaces at Samancor's Metalloys Works at Meyerton in Transvaal Province were used to produce ferrochromium rather than ferromanganese, continuing a switchover made in the latter part of 1983. About midyear, control of Samancor by General Mining Union Corp. Ltd. (Gencor) became direct rather than indirect upon Gencor's acquisition from South African Iron and Steel Industrial Corp. Ltd. of the remaining shares of African Metals Ltd. not already held by Gencor.

U.S.S.R.—Overall mine production increased slightly owing to a recovery in output from the Chiatura Basin in Georgia, where development of a surface mine having concentrates capacity of about 200,000 tons per year was completed. The methods and benefits of adapting mechanized longwall mining techniques for coal mining to the underground mining of the manganese ore seam in the Marganets complex of the Nikopol' Basin in the Ukraine were described.[7]

Mine production was again supplemented by imports of high-grade concentrates. Soviet purchases were at least 290,000 tons, as contracts for roughly one-half this amount were made each with Australia and Gabon.

Future production of manganese ore and ferromanganese was being planned for East Siberia in the vicinity of Krasnoyarsk. An East Siberian ferroalloys plant was to be located near the Sredneyeniseyskaya hydropower plant to be built on the Yenisey River. The Soviets had thought that ore feed for the smelter would have to come from the distant Nikopol' Basin. It was now considered feasible to obtain at least part of the ore required through development of the Porozhinskoye deposit in the region.

In 1983, average grade of ore and concentrates was 30% manganese, the same as in 1982, according to official statistics. Mine production had made a nominal advance in 1983, but ore exports decreased nearly 6% to 1,189,000 tons. Principal destinations, accounting for over 90% of the export total, were, in tons, Poland, 594,000; Czechoslovakia, 325,000; the German Democratic Republic, 94,000; and Bulgaria, 89,000.

United Kingdom.—The Government disclosed in November that the stockpile of strategic materials built up beginning in 1983, which reportedly included manganese, would be disposed of during the next few years.

TECHNOLOGY

Arthur D. Little Inc. completed a study for the Bureau of Mines on manganese recovery from domestic sources. Data on low-grade domestic deposits were evaluated, and those deposits having the greatest resource potential were identified. Column flotation was indicated to be one of the newer beneficiation technologies whose applicability to ores from these deposits merited study. The three technologies appearing to have the most promise for extracting manganese from domestic feed material were processes involving leaching with either ammonia, sulfur dioxide, or nitric acid.[8]

The Bureau identified two recently located deposits in Alaska as having moderate mineral development potential for manganese. Samples from deposits on Chenega and Hinchinbrook Islands in the Chugach National Forest along the south-central Alaskan coast contained as much as 37% manganese.[9]

Manganese resources were the topic of several other studies. As part of its Minerals Availability System Program, the Bureau appraised the economic potential for producing metallurgical ore from the demonstrated resources of nine market economy countries other than the United States.[10] Under the cooperative program of the International Strategic Minerals Inventory, information was given on manganese supply and resources of 13 market economy and centrally planned economy countries.[11] The economic potential for manganese, cobalt, nickel, and copper in crusts on raised portions of ocean floors within the U.S. Exclusive Economic Zone was reviewed for the Central Pacific, the Blake Plateau and other Atlantic areas, and the Caribbean. A potential for manganese in excess of 100 million tons was identified for crusts in the Central Pacific Ocean. Present information was considered insufficient for quantitative economic evaluation of such resources.[12]

Use of fused-salt mixtures of alkali and alkaline-earth metal chlorides to extract manganese from low-grade domestic minerals was investigated at the Argonne National Laboratory of the U.S. Department of Energy. Manganese extractions of 70% or more were obtained with lithium chloride-potassium chloride eutectic, and extractions of 85% or more were achieved by adding either bismuth chloride or zinc chloride to this eutectic. Testing was performed at 400° to 500° C on samples of the manganese carbonate type from Aroostook County, ME.[13]

New steelmaking practices in Japan for removing phosphorus, sulfur, and carbon from hot metal were found to reduce the consumption of manganese ferroalloys. Ferruginous manganese ore was used instead of mill scale to dephosphorize and desulfurize hot metal. This, combined with the higher manganese recovery of slagless refining, lowered ferromanganese requirements. Other developments in converter technology permit addition of manganese as ferruginous manganese ore rather than as ferromanganese. These new technologies had little net effect on the total amount of manganese used in making a ton of steel, but ferroalloys were being partly displaced by ferruginous manganese ore.[14]

Adoption of the Lance Bubbling Equilibrium (LBE) process in the plant of a U.S. steelmaker decreased manganese alloying requirements 40% or more in production of carbon steels, mostly those of less than 0.1% carbon. The nonautomated LBE system allowed a higher manganese residual after blowing.[15]

Liquid and solid phase equilibria in the carbon-iron-manganese ternary system and in the underlying binary systems were reviewed in 1984. Isothermal sections depicting solid-state equilibria at 600° to 1,100° C and a liquidus projection were presented for ternary compositions containing up to 9% carbon.[16]

The electrochemical technology of synthetic and natural manganese dioxide was discussed at a meeting of The Electrochemical Society. Mining in Australia, Brazil, and Gabon of ore for battery use was described.[17]

Laboratory and plant testwork showed that Caro's acid, H_2SO_5, provided several operating advantages to pyrolusite for use as an oxidant in uranium extraction in Australia. Choice of whether to use Caro's acid or pyrolusite was noted to depend on local reagent cost.[18]

The U.S. Environmental Protection Agency issued a review of the forms and effects of human exposure to manganese. Acute poisoning by manganese was noted to be very rare. Health concerns from chronic exposure to manganese pertained to neurological and pulmonary disorders.[19]

A brief history of manganese from antiquity to the present citing milestones in its industrial use and understanding was compiled, including significant literature references.[20]

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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.

[3]National Materials Advisory Board. Priorities for Detailed Quality Assessment of the National Defense Stockpile Nonfuel Materials. Natl. Acad. Sci., Washington, DC, NMAB-403, 1984, 58 pp.

[4]Skillings' Mining Review. V. 74, No. 11, Mar. 16, 1985, p. 11.

[5]———. V. 74, No. 14, Apr. 6, 1985, p. 21.

[6]———. V. 74, No. 15, May 11, 1985, p. 21.

[7]Chernenko, A. R., and A. S. Sidorov. Updating the Technology and Machinery for Underground Manganese Ore Mining. Paper in Optimal Exploitation of Solid Mineral Resources; Challenges and Constraints (12th World Min. Congr., New Delhi, India, Nov. 19-23, 1984). Organizing Committee, 12th World Min. Congr., Inst. Eng., Calcutta, India, v. 2, 1984, 15 pp.

[8]Malhotra, S., S. Margolin, R. F. Machacek, V. Vejins, W. S. Kelly, and M. Laurila. Recovery of Manganese From Low-Grade Domestic Sources. BuMines OFR 201-84, 1984, 166 pp.

[9]Hoekzema, R. B. Strategic and Critical Mineral Development Potential of the Chugach National Forest, Southcentral Alaska. BuMines OFR 215-84, 1984, 64 pp.

[10]Coffman, J. S., and C. M. Palencia. Manganese Availability—Market Economy Countries. BuMines IC 8978, 1984, 26 pp.

[11]DeYoung, J. H., Jr., D. M. Sutphin, and W. F. Cannon. International Strategic Minerals Inventory Summary Report—Manganese. U.S. Geol. Surv. Circ. 930-A, 1984, 22 pp.

[12]Commeau, R. F., A. Clark, C. Johnson, F. T. Manheim, P. J. Aruscavage, and C. M. Lane. Ferromanganese Crust Resources in the Pacific and Atlantic Oceans. Paper in Proceedings of Oceans '84 (Washington, DC, Sept. 10-12, 1984). Individual papers available from Engineering Societies Library, Photoduplication Dept., New York, pp. 421-430.

[13]Maroni, V. A., and R. M. Yonco. Pyrochemical Solvolysis of Ore-Bound Transition Metals. Paper in Proc. International Symposium on Electrochemistry in Mineral and Metal Processing, ed. by P. E. Richardson, S. Srinivasan, and R. Woods (Cincinnati, OH, May 6-11, 1984). Electrochem. Soc. Inc., Pennington, NJ, 1984, pp. 417-431.

[14]TEX Report (Japan). Existing State of BF Steelmakers' Hot Metal Pretreatment. V. 16, Nov. 27, 1984, p. 3; Nov. 28, 1984, pp. 6-7; Nov. 29, 1984, pp. 4-5; Nov. 30, 1984, pp. 14-16.

[15]Wardrop, R. M. L.B.E. Operations at Gary Works. Proc. 67th Steelmaking Conf. (Chicago, IL, Apr. 1-4, 1984). AIME, Warrendale, PA, 1984, pp. 107-112.

[16]Rivlin, V. G. Critical Review of Constitution of Carbon-Chromium-Iron and Carbon-Iron-Manganese Systems. Int. Met. Rev., v. 29, No. 4, 1984, pp. 299-327.

[17]Schumm, B., Jr., R. L. Middaugh, M. P. Grotheer, and J. C. Hunter (eds.). Manganese Dioxide Electrode Theory and Practice for Electrochemical Applications (Proc. Symp., Electrochem. Soc., New Orleans, LA, Oct. 10-12, 1984). Electrochem. Soc. Inc., Pennington, NJ, 1985, 685 pp.

[18]Ring, R. J., M. Yamine, and D. J. Waters. Caro's Acid—An Oxidant for Acid Leaching of Uranium Ores. CIM Bull., v. 77, Feb. 1984, pp. 77-83.

[19]Environmental Protection Agency. Health Assessment Document for Manganese. EPA-600/8-83-013F, Aug. 1984.

[20]Morral, F. R. Manganese—A Chronology and Bibliography. CIM Bull., v. 77, Feb. 1984, pp. 72-75.

Mercury

By Linda C. Carrico[1]

Domestic mercury mine production by three mines, all located in Nevada, decreased for the fourth consecutive year. Secondary production decreased more than 60%, while imports for consumption increased almost 100% and accounted for 46% of total demand. An overall increase in reported consumption was led by increased demand for electrical and electronic uses, especially for use in batteries. Owing partly to increased demand, consumer and dealer stocks fell sharply. However, the domestic supply of mercury remained ample during 1984, and the average New York dealers' price declined for the second consecutive year.

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 385 firms to which this survey request was sent, 84% responded, representing an estimated 97% of the reported U.S. consumption shown in tables 1 and 4. Consumption for the 61 nonrespondents was estimated using prior years' consumption levels.

Table 1.—Salient mercury statistics

	1980	1981	1982	1983	1984
United States:					
Producing mines	4	3	3	3	3
Mine production flasks	30,657	27,904	25,760	25,070	19,048
Value thousands	$11,939	$11,549	W	W	W
Secondary production:					
Industry flasks	6,793	4,244	4,473	r13,751	5,217
Government[1] do	10,013	7,000	--	--	--
Industry stocks, yearend[2] do	33,069	27,339	r28,827	r31,018	26,742
Shipments from the National Defense Stockpile[3] do	--	--	r7,076	6,000	4,092
Imports for consumption do	9,416	12,408	8,916	12,786	25,327
Exports do	NA	NA	NA	NA	NA
Consumption, reported do	58,983	59,244	48,943	49,138	54,602
Consumption, apparent[4] do	51,392	57,286	r44,737	r55,416	57,960
Price: New York, average per flask	$389.45	$413.89	$370.93	$322.44	$314.38
Employment, mine and mill, average	46	48	45	45	41
World:					
Mine production flasks	197,426	210,897	197,933	p180,824	e174,488
Price: London, average per flask	$398.07	$417.52	$376.96	$313.33	$306.40

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.
[4]Mine production plus secondary production plus imports for consumption minus exports, plus Government stockpile shipments, and plus or minus changes in industry stocks.

Legislation and Government Programs.—During 1984, the General Services Administration (GSA) auctioned mercury on an "as-is" basis from the National Defense Stockpile (NDS) on the third Tuesday of each month, offering 1,500 flasks[2] per month. GSA sold 4,593 flasks and shipped 4,092 flasks during the year, leaving 163,723 flasks in physical inventory in excess to the stockpile goal; the goal remained at 10,500 flasks.

In March, GSA resumed auctions of mercuric oxide from the NDS, which had been suspended since late 1982, and continued them throughout the year. On the first Wednesday of each month, GSA offered 50,000 pounds of mercuric oxide on an "as-is" basis. For the year, GSA sold 359,100 pounds and shipped 321,300 pounds, leaving 390,902 pounds of mercuric oxide available for disposal.

On October 19, the President signed Public Law 98-525, the Defense Authorization Act, 1985, terminating all previous authorizations for disposal of mercury and mercuric oxide from the NDS, effective September 30, 1984. Section 902 of the act authorized the disposal of 5,000 flasks of mercury and 500,000 pounds of mercuric oxide from the NDS, effective October 1, 1984. GSA, acting as sales agent for the Government, continued to auction the mercury materials.

GSA's auctions of surplus secondary mercury, managed by the U.S. Department of Energy (DOE) in Oak Ridge, TN, remained suspended for the third consecutive year.

Public Law 98-616, The Hazardous and Solid Waste Amendments of 1984, was enacted on November 8. Section 201 of this law, effective July 8, 1987, prohibits any further land disposals of mercury and/or its compounds at a concentration equal to or greater than 20 milligrams per liter of liquid waste.

The Environmental Protection Agency (EPA), under the Clean Water Act, proposed new regulations for nonferrous metals manufacturing plants, limiting their effluent discharges. The proposed regulations were to provide 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. Primary and secondary mercury manufacturing facilities were 2 of 24 subcategories for which EPA proposed effluent limitations.[3]

EPA issued revised regulations on September 12, under Section 307 of the Clean Air Act, on a test method (method 105) used in determining the content of mercury in waste water treatment plant sewage sludges after dewatering and before incineration or drying. This regulation does not impose any additional emission measurement requirements on any facility but simply revises the existing testing method to improve its precision and accuracy.[4]

Under Section 112 of the Clean Air Act, EPA proposed changes to the existing national emission standards for mercury-cell chlor-alkali plants, sludge incineration and drying plants, and mercury ore processing plants. The proposal included additional monitoring, recordkeeping, and reporting on the amount of mercury emitted by each plant.[5]

DOE continued its investigation on mercury that had been spilled and/or lost at its Oak Ridge, TN, facility in the years 1950-63. Sampling, monitoring, and cleanup were continued. A report[6] compiled by a 1983 task force stated that there was no immediate or foreseeable major health risk as a result of the mercury discharge.

DOMESTIC PRODUCTION

For the third consecutive year, Nevada was the only mercury producing State, with producers operating at about 54% of capacity. Total reported mine production in 1984, including byproduct mercury, was 19,048 flasks, compared with 25,070 flasks in 1983. This decrease was ascribed to the presence in the market of a large quantity of secondary mercury that had been recovered in 1983. Three mines were in operation during the year: the McDermitt, the Carlin, and the Pinson. The McDermitt Mine, operated by Placer U.S. Inc., remained the principal mercury producer in the United States. The Carlin Mine, operated by Newmont Mining Corp., and the Pinson Mine, operated by Pinson Mining Co., produced mercury as a byproduct from their gold mining operations.

Exploration work by Placer continued at its McDermitt Mine and at other prospects in the Western States. The McDermitt Mine reportedly had about 6 years of proven reserves, based on an annual production rate of about 19,000 flasks.

In early 1984, FMC Corp. announced plans to develop the Paradise Peak gold mine near Gabbs, NV. FMC's geologists predicted that the mine would yield about 2,600 flasks of mercury per year as a byproduct from gold mining. Startup was scheduled for mid-1986.

The processing of primary and/or scrap mercury was reported by five companies in 1984. The companies were as follows: 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. Industrial secondary mercury production declined from the record high level of 1983, which had been a result of the permanent closure of mercury-cell chlor-alkali plants, to a more normal level. Secondary mercury accounted for 10% 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 released from the NDS.

Table 2.—Mercury ore treated and mercury produced in the United States[1]

Year	Ore treated (short tons)	Mercury produced: Flasks	Mercury produced: Pounds per ton of ore
1980	356,043	30,623	6.5
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

[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
1980	6,793	10,013	16,806
1981	4,244	7,000	11,244
1982	4,473	--	4,473
1983[r]	13,751	--	13,751
1984	5,217	--	5,217

[r]Revised.

CONSUMPTION AND USES

Mercury was consumed in about 405 plants, of which more than one-half were located east of the Mississippi River. Primary mercury accounted for 63% of the total reported consumption, followed by redistilled mercury,[7] 33%; and secondary mercury, 4%.

Overall domestic mercury consumption increased 11%, led by a 27% increase in consumption by battery manufacturers. The battery industry continued to be the dominant consumer of mercury, followed by industries producing chlorine and caustic soda, paints, measuring and control instruments, and wiring devices and switches.

Table 4.—Mercury consumed in the United States, by use

(Flasks)

SIC code	Use	1980	1981	1982	1983	1984
28	Chemical and allied products:					
2812	Chlorine and caustic soda manufacture	9,470	7,323	6,243	8,054	7,347
2816	Pigments	W	W	W	W	W
2819	Catalysts, miscellaneous	765	815	499	484	359
2821	Catalysts for plastics	W	W	W	W	W
2819	Laboratory uses	363	328	281	280	217
2851	Paints	8,621	7,049	6,794	6,047	4,651
2879	Agricultural chemicals	W	79	36	--	--
--	Other chemicals and allied products	W	W	W	W	W
36	Electrical and electronic uses:					
3641	Electric lighting	1,036	1,043	826	1,273	1,487
3643	Wiring devices and switches	3,062	2,641	2,004	2,316	2,723
3692	Batteries	27,829	29,441	24,880	23,350	29,700
--	Other electrical and electronic uses	144	W	W	W	W
38	Instruments and related products:					
382	Measuring and control instruments	3,049	5,671	3,064	2,465	2,842
3843	Dental equipment and supplies	1,779	1,613	1,019	1,597	1,432
--	Other instruments and related products	190	253	194	W	W
--	Other	790	242	984	1,356	1,404
	Total	58,983	59,244	48,943	49,138	54,602

W Withheld to avoid disclosing company proprietary data; included in "Total."

STOCKS

NDS, as of December 31, 1984, contained 174,223 flasks of mercury and 390,902 pounds of mercuric oxide. DOE held 35,305 flasks of secondary mercury in Oak Ridge, TN. Reported yearend industry stocks of mercury declined, primarily in response to higher demand.

Table 5.—Stocks of mercury in the United States, December 31

(Flasks)

Year	Producer (mine)	Consumer and dealer	Total
1980	11,095	21,974	33,069
1981	11,783	15,556	27,339
1982	r13,598	15,229	r28,827
1983	r18,323	12,695	r31,018
1984	19,552	7,190	26,742

rRevised.

PRICES

During the summer of 1984, the New York dealers' price for mercury declined, owing partly to seasonal weak demand coupled with increased imports of mercury from Algeria and Spain, the imports having been encouraged by a strong U.S. dollar. Analysts attributed the subsequent large price increase in September to purchases for immediate consumption, especially in the electrical industry.

Table 6.—Average prices of mercury at New York and London

(Per flask)

Period	New York	London
1980	$389.45	$398.07
1981	413.89	417.52
1982	370.93	376.96
1983	322.44	313.33
1984:		
January	304.48	306.44
February	288.26	297.31
March	303.59	302.72
April	326.10	314.88
May	329.86	310.78
June	319.29	305.39
July	308.19	301.78
August	296.30	305.00
September	318.37	308.81
October	329.14	311.00
November	327.00	307.61
December	322.00	305.06
1984 average	314.38	306.40

Sources: Metals Week (New York) and Metal Bulletin (London).

FOREIGN TRADE

Imports for consumption of mercury, which included mercury imported for immediate consumption plus material withdrawn from bonded warehouses, almost doubled. Spain was the leading supplier, followed by Algeria, Turkey, and the Netherlands. The average unit value of imports was $287.20 per flask, compared with $298.22 per flask in 1983.

The U.S. rate of duty on imported mercury metal, TSUS 632.34, as of January 1, 1984, from countries with most-favored-nation status was 6.6 cents per pound.[8] A duty of 25 cents per pound applied to other countries.

Table 7.—U.S. imports for consumption of mercury, by country

Country	1982		1983		1984	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Algeria	--	--	1,795	$560	8,201	$2,441
Canada	5	$14	4	19	14	33
China	100	42	--	--	350	112
Denmark	390	161	--	--	14	8
Dominican Republic	--	--	100	23	--	--
Finland	--	--	--	--	120	54
Germany, Federal Republic of	2	1	13	20	--	--
Italy	--	--	500	122	800	196
Japan	4,345	1,444	511	179	500	120
Mexico	182	59	1,590	426	21	9
Netherlands	200	62	1,501	359	1,556	392
Philippines	881	293	--	--	--	--
Spain	1,404	484	3,408	1,063	11,749	3,344
Turkey	900	286	1,333	385	2,002	564
United Kingdom	507	157	2,031	657	(1)	1
Total	8,916	3,003	12,786	3,813	25,327	7,274

[1]Less than 1/2 unit.

WORLD REVIEW

World mine production decreased for the third consecutive year, owing partly to a large supply of world secondary mercury and to depressed prices. Production utilized 46% of available capacity.

World mercury reserves were estimated by the Bureau of Mines at 4 million flasks, of which 85% is located in market economy countries. Spain had the largest share of world reserves, 65%.

Table 8.—Mercury: World mine production, by country[1]

(Flasks)

Country	1980	1981	1982	1983[p]	1984[e]
Algeria[e]	[2]24,403	25,000	11,000	10,000	10,000
China[e]	20,000	20,000	20,000	20,000	20,000
Czechoslovakia	4,612	4,438	4,380	4,177	4,300
Dominican Republic	159	77	49	[e]40	30
Finland	2,170	1,949	2,085	1,871	1,900
Germany, Federal Republic of	1,624	2,205	1,537	2,005	2,000
Italy	96	7,427	4,612	--	--
Mexico	4,206	6,962	8,558	6,411	7,000
Spain	43,038	46,008	48,808	41,075	40,000
Turkey	4,461	5,927	7,144	4,675	4,210
U.S.S.R.[e]	62,000	63,000	64,000	64,000	64,000
United States	30,657	27,904	25,760	25,070	[2]19,048
Yugoslavia	--	--	--	[e]1,500	2,000
Total	197,426	210,897	197,933	180,824	174,488

[e]Estimated. [p]Preliminary.
[1]Table includes data available through Apr. 16, 1985.
[2]Reported figure.

Japan.—Sixteen 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 a 1983 Japanese Ministry of International Trade and Industry (MITI) order. Since the 1983 MITI order, seven producers have converted to the ion-exchange membrane-cell process. Analysts predicted that over the next several years about 77,000 flasks of secondary mercury would be generated by the conversion or scrapping of these plants.

MITI and several Japanese battery firms agreed to conduct technical research on reducing the amount of mercury used in dry-cell batteries. Initial plans are aimed at reducing the amount of mercury used in a battery to about one-third of its present level.

Spain.—Three mines in the Almadén mining region remained the only producers of mercury in Spain. The mines, the Almadén, El Entredicho, and Las Cuevas, were operated by Minas de Almadén y Arrayanes S.A., a mining company owned by the Spanish Government. The company operated two of its four furnaces intermittently during the year. It was expected that in 1985, the four furnaces, with a collective capacity of about 600 short tons of ore per day, would be replaced with a single furnace capable of refining all of the company's concentrates.

Sweden.—The 45,000-ton-per-year mercury-cell chlor-alkali plant at Skoghall, in the southwest, was converted to the membrane-cell process. This plant reportedly was the first in Europe to convert from the mercury-cell process to the membrane-cell process.

Yugoslavia.—Operations continued at the Idria mercury mine in Slovenia, northwestern Yugoslavia. The mine was operated by Rudnik Zivega Srebna and was state-owned. According to reports, new mine shafts were expected to open over the next 3 years, with an expected annual production rate of 8,700 flasks.

TECHNOLOGY

Many low-grade gold ores in the Western United States contain small quantities of mercury that interfere with extraction of the gold and pose a potential health hazard. Researchers at the Bureau of Mines found that the addition of a small quantity of calcium sulfide to an ore being leached in the grinding circuit suppressed mercury extraction effectively. They also found that the addition of calcium sulfide to a leach slurry containing dissolved mercury complexes precipitated the mercury. In both cases, mercury in solution was reduced to less than 0.5% of the mercury in the ore.[9]

A study was conducted to determine whether industrial mercury pollution has reached deep ocean water—the habitat most remote from continental and atmospheric sources of anthropogenic mercury. Comparing the mercury levels in 66 specimens of a common deep sea fish, the blue hake (*Antimora rostate*), collected in the 1970's, with levels in 21 museum specimens of hake collected in the 1880's, researchers demonstrated that the mercury content of this species had not increased in the last century.[10]

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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]Federal Register. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards. V. 49, No. 125, June 27, 1984, pp. 26352-26483.

[4]———. National Emission Standards for Hazardous Air Pollutants; Reference Methods; Method 105 Revision. V. 49, No. 178, Sept. 12, 1984, pp. 35768-35771.

[5]———. National Emission Standards for Hazardous Air Pollutants Review and Proposed Revision of the Standards for Mercury From Mercury-Cell Chlor-Alkali Plants, Sludge Incineration and Drying Plants, and Mercury Ore Processing Facilities. V. 49, No. 249, Dec. 26, 1984, pp. 50146-50152.

[6]The 1983 Mercury Task Force. Mercury at Y-12, a Study of Mercury Use at the Y-12 Plant, Accountability, and Impacts on Y-12 Workers and the Environment—1950 to 1983 (U.S. DOE Contract W-7405-eng-26). Rep. Y/EX-24, Aug. 18, 1983, 418 pp.

[7]Redistilled mercury is primary mercury further processed or refined to a higher grade.

[8]Federal Register. Proclamation of Trade Agreement With Japan and Spain Providing Compensatory Concessions. V. 48, No. 247, Dec. 22, 1983, pp. 56553-56559.

[9]Sandberg, R. G., W. W. Simpson, and W. L. Staker. Calcium Sulfide Precipitation of Mercury During Cyanide Leaching of Gold Ores. BuMines RI 8907, 1984, 13 pp.

[10]Barber, R. T., P. J. Whaling, and D. M. Cohen. Mercury in Recent and Century-Old Deep-Sea Fish. Environ. Sci. and Technol., v. 18, No. 7, July 1984, pp. 552-555.

Mica

By Lawrence L. Davis[1]

In 1984, a total of 161,000 short tons of scrap and flake mica was reported produced in the United States, a 15% increase over 1983 production.

Nearly all sheet mica supply continued to be imported. Consumption of mica block decreased by 14% to 71,000 pounds. Consumption of mica splittings increased 12% to 2.4 million pounds. The value of sheet mica exports increased 10% to $4.5 million. Imports of sheet mica decreased 12% to 2.3 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, domestic surveys and one mandatory domestic survey. Of the 55 canvassed operations to which 1 or more of the 4 survey forms were submitted, 53 operations, or 96%, responded. Responses to the scrap and flake mica production form, the ground mica production form, and the mica block and film form were 100%, representing 100% of the totals shown in table 1. Of the 12 canvassed operations to which the mica splittings consumption form was sent, 10 operations, or 83%, responded, representing 96% of the splittings consumption shown in table 1. Consumption for the nonrespondents was estimated using prior year production data.

Table 1.—Salient mica statistics

	1980	1981	1982	1983	1984
United States:					
Production (sold or used by producers):					
Scrap and flake mica ---- thousand short tons--	116	133	106	140	161
Value ---------- thousands--	$6,262	$8,212	$6,398	$6,479	$7,139
Ground mica ---------- thousand short tons--	111	117	96	130	146
Value ---------- thousands--	$14,870	$17,440	$16,106	$18,702	$21,334
Consumption:					
Block ---------- thousand pounds--	156	166	95	83	71
Value ---------- thousands--	$1,886	$1,533	$1,366	$993	$873
Film ---------- thousand pounds--	4	3	3	3	2
Value ---------- thousands--	$18	$13	$15	$16	$13
Splittings ---------- thousand pounds--	4,383	4,386	2,639	2,120	2,366
Value ---------- thousands--	$3,101	$3,064	$2,032	$1,394	$1,679
Exports ---------- thousand short tons--	15	12	12	11	9
Imports ---------- do----	12	13	10	8	13
World: Production---------- thousand pounds--	[r]503,169	[r]520,640	472,871	[p]528,934	[e]575,375

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

Legislation and Government Programs.—The Government inventory of stockpile-grade natural sheet mica was reduced by 9% to 23.1 million pounds by yearend. The General Services Administration sold 42,000 pounds of muscovite film, 2.2 million pounds of muscovite splittings, and 154,000 pounds of phlogopite splittings.

Table 2.—Stockpile goals and Government inventories for mica, December 31, 1984

(Thousand pounds)

Material	Goal	Inventory: Stockpile grade	Inventory: Non-stock-pile grade	Available for disposal	1984 sales
Block:					
Muscovite, Stained and better	6,200	5,006	207	--	--
Phlogopite	210	17	114	--	--
Film: Muscovite, 1st and 2d qualities	90	1,179	1	1,035	42
Splittings:					
Muscovite	12,630	15,405	--	752	2,182
Phlogopite	930	1,519	--	--	154

DOMESTIC PRODUCTION

Scrap and Flake Mica.—U.S. production of scrap (flake) mica[2] was 161,000 tons valued at $7.1 million. North Carolina remained the major producing State with 49% 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, Pacer Corp., Custer, SD; Mineral Industrial Commodities of America Inc. (M.I.C.A.), Santa Fe, NM; Kings Mountain Mica Co., Kings Mountain, NC; Lithium Corp. of America Inc., Gastonia, NC; and The Feldspar Corp., Spruce Pine, NC.

Ground Mica.—Production (sold or used) of ground mica, from scrap and flake mica, increased 12% to 146,000 tons, valued at $21.3 million. Dry-ground mica, 91% of the total, increased by 13%, and wet-ground mica increased by 8%. 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, United States Gypsum Co., Chicago, IL; Pacer, Custer, SD; Harris Mining Co., Spruce Pine, NC; M.I.C.A., Santa Fe, NM; and Kings Mountain Mica, Kings Mountain, NC.

Production of low-quality sericite, primarily for use in brick manufacturing, was 32,000 tons valued at $80,000. Approximately 43,000 tons of ground sericite valued at $277,000 was sold or used. Low-quality sericite is excluded from tabulated data contained in this report.

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
1980	116	6,262
1981	133	8,212
1982	106	6,398
1983	140	6,479
1984:		
North Carolina	79	3,762
Other States[2]	82	3,377
Total	161	7,139

[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.

Table 4.—Ground mica[1] sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Dry-ground Quantity	Dry-ground Value	Wet-ground Quantity	Wet-ground Value	Total[2] Quantity	Total[2] Value
1980	100	11,381	10	3,490	111	14,870
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

[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 62,100 pounds, a decrease of 16% from that of 1983. Of the total muscovite block fabricated, 79% went into electronic uses; of this, about two-thirds was used in vacuum tubes. Of the muscovite block fabricated for nonelectronic uses, 17% went into gauge glass and diaphragms. Most of the decrease in consumption was in Stained quality, although it remained in greatest demand, accounting for 75% of consumption. Combined consumption of grade No. 4 and larger sizes increased slightly, while consumption of sizes smaller than No. 4 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 76% of the total.

Phlogopite block fabrication totaled 9,200 pounds, a decrease of 6% from that of 1983. The block was consumed by five companies in five States.

Consumption of mica splittings increased 12% to 2.4 million pounds. Muscovite splittings from India accounted for 98% 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 setting of overlapping splittings and alternate layers of binders and splittings, was as electrical insulation material. Total production, sold or used, of built-up mica increased 11% from that of 1983. Segment plates and molding plates were the major end products, accounting for 32% and 27% of the total, respectively. Other end products included flexible plates, heater plates, and tapes.

Reconstituted Mica (Mica Paper).—Five companies consumed 5.5 million pounds of scrap mica to produce 3.9 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 Film Inc., West Townsend, MA; General Electric Co., Schenectady, NY; Kirkwood-Acim Corp., Hempstead, NY; Proctor-Silex Div., SCM Corp., Mount Airy, NC; and U.S. Samica Corp., Rutland, VT.

Ground Mica.—The major end uses were joint cement, 47%; well-drilling muds, 16%; and paint, 13%. Other end uses included roofing and rubber.

Table 5.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica in the United States in 1984, by quality and end-product use

(Pounds)

Variety, form, and quality	Electronic uses: Capacitors	Electronic uses: Tubes	Electronic uses: Other	Electronic uses: Total[1]	Nonelectronic uses: Gauge glass and diaphragms	Nonelectronic uses: Other	Nonelectronic uses: Total[1]	Grand total[1]
Muscovite:								
Block:								
Good Stained or better	700	300	(2)	1,000	2,200	800	3,000	4,100
Stained	--	30,400	13,800	44,200	--	2,500	2,500	46,700
Lower than Stained[3]	--	1,900	2,100	4,000	--	7,200	7,200	11,200
Total[1]	700	32,500	16,000	49,200	2,200	10,600	12,800	62,100
Film:								
1st-quality	1,000	--	--	1,000	--	--	--	1,000
2d-quality	1,400	--	--	1,400	--	--	--	1,400
Total[1]	2,500	--	--	2,500	--	--	--	2,500
Block and film:								
Good Stained or better[4]	3,200	300	(2)	3,500	2,200	800	3,000	6,500
Stained[5]	--	30,400	13,800	44,200	--	2,500	2,500	46,700
Lower than Stained	--	1,900	2,100	4,000	--	7,200	7,200	11,200
Total[1]	3,200	32,500	16,000	51,700	2,200	10,600	12,800	64,500
Phlogopite: Block (all qualities)	--	--	400	400	--	8,700	8,700	9,200

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 50 pounds.
[3]Includes punch mica.
[4]Includes 1st- and 2d-quality film.
[5]Includes other quality film.

Table 6.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1984, by quality

(Pounds)

Form, variety, and quality	No. 4 and larger	No. 5	No. 5-1/2	No. 6	Other[1]	Total[2]
Block:						
Ruby:						
Good Stained or better	3,200	400	200	300	--	4,100
Stained	8,600	18,600	12,400	3,700	1,200	44,600
Lower than Stained	2,000	200	900	1,400	5,400	9,900
Total[2]	13,800	19,100	13,600	5,400	6,700	58,600
Nonruby:						
Good Stained or better	100	(3)	--	--	--	100
Stained	800	--	300	600	400	2,100
Lower than Stained	800	--	--	400	--	1,300
Total	1,800	(3)	300	1,000	400	3,500
Total block (ruby and nonruby)[2]	15,600	19,200	13,900	6,400	7,100	62,100
Film:						
Ruby:						
1st-quality	--	300	200	200	--	700
2d-quality	(3)	600	400	200	--	1,200
Total[2]	(3)	800	600	400	--	1,900
Nonruby:						
1st-quality	--	--	200	200	--	400
2d-quality	--	--	200	--	--	200
Total	--	--	400	200	--	600
Total film (ruby and nonruby)	(3)	800	1,000	600	--	2,500

[1]Figures for block mica include all smaller than No. 6 grade and punch mica.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 50 pounds.

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:						
1980	4,216	2,543	167	557	4,383	3,101
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
Stocks on Dec. 31:						
1980	2,917	NA	69	NA	2,986	NA
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

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	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Flexible (cold)	192	842	237	1,072
Heater plate	101	370	103	397
Molding plate	634	1,803	655	1,912
Segment plate	593	1,960	773	2,651
Tape	289	2,065	234	1,612
Other	356	1,935	404	2,155
Total	[2]2,164	8,975	2,406	9,799

[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	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Joint cement	61	8,955	68	10,193
Paint	18	2,897	19	3,195
Roofing	W	W	W	W
Well-drilling mud	13	1,364	23	2,416
Other[1]	39	5,486	36	5,530
Total	[2]130	18,702	146	21,334

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes mica used for agricultural products, molded electrical insulation, plastics, rubber, welding rods, textile and decorative coatings, and uses indicated by symbol W.
[2]Data do not add to total shown because of independent rounding.

STOCKS

Reported yearend consumer stocks of sheet mica decreased 25% to 1.2 million pounds; of this, mica splittings represented 81% and mica block represented 19%.

PRICES

Average reported values of consumed muscovite sheet mica increased as follows: block, 4% to $13.57 per pound; film, 4% to $5.40 per pound; and splittings, 18% to $0.71 per pound. The average value of phlogopite block increased 3% to $3.38 per pound while the value of phlogopite splittings remained at $3.35 per pound.

The average value of crude scrap (flake) mica, including high-quality sericite, was $44.46 per ton. The average value per ton for North Carolina scrap (flake) mica, predominantly a flotation product, was $47.85.

Table 10.—Average reported price for dry- and wet-ground mica sold or used by U.S. producers in 1984

(Dollars per short ton)

Kind	Price
Dry-ground	123
Wet-ground	392
End uses:	
Joint cement	149
Paint	170
Roofing	W
Well-drilling mud	107
Other[1]	154

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

[1]Includes mica used for agricultural products, molded electrical insulation, plastics, rubber, welding rods, textile and decorative coatings, miscellaneous, and use indicated by symbol W.

FOREIGN TRADE

The United States became a net importer of ground mica in 1984, importing 12.8 million pounds valued at $2.3 million while exporting 11.5 million pounds valued at $1.5 million. Ground mica was exported to 36 countries. The leading countries of destination were Mexico, 27%; Canada, 21%; and France, 10%. Canada supplied 99% of ground mica imports.

Imports of unmanufactured block, film, and splittings decreased by 22% to 1.5 million pounds. India remained the primary source, accounting for 97% of the imports.

The total value of exported cut, stamped, and built-up mica was $4.5 million, an increase of 13%. Canada continued to be the leading country of destination, accounting for 45% of the total. Mexico received 14%; Italy, 9%; and the remainder went to 42 countries. The total value of imports of these materials increased by 10% to $2.8 million. Of this, 53% by volume came from India, 24% from Belgium, and 13% from Japan.

The combined value of all mica exports was $7.1 million, an increase of 4%. The total imported mica value was $6.7 million, a 16% increase.

Table 11.—U.S. exports of mica and manufactures of mica in 1984, by country

(Thousand pounds and thousand dollars)

Country	Scrap and flake mica				Sheet mica		
	Ground or pulverized		Waste and scrap[1]		Unmanufactured block, film, and splittings		Manufactured, cut or stamped, built-up
	Quantity	Value	Quantity	Value	Quantity	Value	Value
Argentina	72	20	--	--	--	--	85
Australia	126	14	--	--	--	--	141
Bahamas	--	--	--	--	--	--	72
Brazil	--	--	--	--	--	--	179
Canada	2,382	237	1,522	206	--	--	2,022
Colombia	208	43	--	--	--	--	1
France	1,162	132	--	--	--	--	6
Germany, Federal Republic of	314	46	--	--	--	--	49
India	--	--	--	--	--	--	86
Italy	330	61	120	13	14	16	408
Japan	656	113	518	70	174	298	12
Korea, Republic of	326	87	--	--	2	9	5
Mexico	3,132	337	1,104	156	--	--	619
Netherlands	500	101	--	--	--	--	23
Philippines	76	20	--	--	--	--	11
South Africa, Republic of	--	--	--	--	2	1	34
Spain	420	42	--	--	122	156	220
Sweden	30	10	--	--	--	--	20

See footnotes at end of table.

Table 11.—U.S. exports of mica and manufactures of mica in 1984, by country —Continued

(Thousand pounds and thousand dollars)

Country	Scrap and flake mica				Sheet mica		
	Ground or pulverized		Waste and scrap[1]		Unmanufactured block, film, and splittings		Manufactured, cut or stamped, built-up
	Quantity	Value	Quantity	Value	Quantity	Value	Value
United Kingdom	268	32	--	--	34	69	288
Venezuela	902	101	150	34	--	--	92
Other[2]	596	108	392	53	--	--	144
Total[3]	11,500	1,506	3,806	532	348	549	4,519

[1]Some shipments of ground mica are included in this category.
[2]Includes Bahrain, Belgium, Belize, the Cayman Islands, Chile, Costa Rica, the Dominican Republic, Ecuador, El Salvador, the French Pacific Islands, Hong Kong, Indonesia, Iraq, Ireland, Israel, Jamaica, Kuwait, the Leeward and Windward Islands, Malaysia, Morocco, the Netherlands Antilles, New Zealand, Nicaragua, Pakistan, Panama, Peru, Portugal, Qatar, Saudi Arabia, Switzerland, Taiwan, Thailand, Trinidad and Tobago, the Turks and Caicos Islands, the United Arab Emirates, Uruguay, and Zambia.
[3] Data may not add to totals shown because of independent rounding.

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
1982	5,030	427	10,824	1,724
1983	3,787	316	10,304	1,873
1984:				
Brazil	551	26	--	--
Canada	2	(1)	12,672	2,200
China	11	1	--	--
France	110	15	--	--
Germany, Federal Republic of	--	--	(1)	(1)
India	9,696	941	37	5
Japan	--	--	105	60
Madagascar	11	1	--	--
Mexico	2	(1)	--	--
Total[2]	10,384	985	12,814	2,266

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

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
1982	89	244	3,084	1,181	(2)	24
1983	44	169	1,577	608	278	209
1984:						
Brazil	19	65	--	--	--	--
Canada	(2)	1	28	28	--	--
France	(2)	1	1	7	(2)	1
India	47	54	1,339	423	44	34
Japan	--	--	--	--	(2)	(2)
United Kingdom	2	29	--	--	--	--
Total	68	[3]151	1,368	458	44	35

[1]Including film.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

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
1982	67	730	157	798	468	1,042	32	366
1983	48	633	186	731	460	927	41	292
1984:								
Belgium	--	--	--	--	374	670	(1)	4
Canada	--	--	1	11	2	18	13	33
France	(1)	6	(1)	1	18	34	14	24
India	111	497	76	332	28	129	31	539
Japan	(1)	1	61	236	19	105	5	29
Netherlands	--	--	--	--	25	50	8	3
United Kingdom	--	--	10	14	--	--	45	35
Other[2]	2	13	3	17	--	--	7	35
Total[3]	114	517	152	610	467	1,007	123	702

[1]Less than 1/2 unit.
[2]Includes Brazil, the Federal Republic of Germany, Hong Kong, Ireland, Italy, the Republic of Korea, Mexico, Portugal, the Republic of South Africa, Switzerland, and Taiwan.
[3]Data may not add to totals shown because of independent rounding.

Table 15.—Summation of U.S. mica trade data

(Thousand pounds and thousand dollars)

	Scrap and flake mica: Ground or pulverized		Scrap and flake mica: Waste and scrap[1]		Sheet mica: Unmanufactured block, film, and splittings		Sheet mica: Manufactured, cut or stamped, built-up	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:								
1980	16,374	2,247	11,964	1,714	586	239	NA	7,665
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
Imports for consumption:								
1980	11,345	1,065	6,936	663	5,013	2,648	831	3,487
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

NA Not available.
[1]Some shipments of ground mica are included in this category.

WORLD REVIEW

World production of all forms of mica increased 9% to 575 million pounds, primarily because of increased U.S. production of scrap and flake. India continued to lead the world in production of sheet mica. The United States remained the leader in production of scrap (flake) mica.

Canada.—Samples of muscovite mica from a deposit near Kaladar, Ontario, were shipped to Japan by Koizumi Group Canada Ltd. Studies were underway to develop a technique for processing the mica into a product usable in the plastics industry.[3]

Finland.—Kemira Oy was constructing a 22,000-ton-per-year mica facility at Siilinjarvi. Phlogopite flake mica will be separated as a byproduct at a nearby apatite plant and processed into various grades for use in the oil-drilling, plastics, and construction industries. A 2,200-ton-per-year pilot plant began operating in 1984, and the main plant was scheduled to begin full operation in mid-1985.[4]

India.—In an effort to stimulate mica production in the State of Andhra Pradesh, the Mica Trading Corp. of India Ltd. (MITCO), Bharat Heavy Electricals Ltd. (BHEL), and the government of Andhra Pradesh were sponsoring research to determine if green scrap mica would be suitable for making mica paper. Green mica is abundant in Andhra Pradesh, but exports have nearly ceased because mica paper producers prefer ruby mica from the State of Bihar. The research project is being conducted at BHEL's laboratory in Hyderabad.[5]

MITCO was also in the process of setting up three mica paper plants. One plant was to be established at Abrak Nagar in Bihar in collaboration with BHEL and Nippon Rika Kogyosho Co. Ltd. (NRK) of Japan. It will utilize a mechanical disintegration process when production begins in 1985. NRK is supplying the equipment and expertise and will purchase one-half of the plant's production. The other plants, one using a calcining process and the other using a thermochemical process, were expected to be operational by 1986. The combined annual capacity of the three plants will be about 1,300 tons of mica paper.[6]

[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]Canadian Mining Journal. V. 105, No. 2, Feb. 1984, pp. 86-87.
[4]Industrial Minerals (London). No. 206, Nov. 1984, p. 11.
[5]———. No. 204, Sept. 1984, p. 19.
[6]———. No. 203, Aug. 1984, p. 13.

Table 16.—Mica: World production, by country[1]

(Thousand pounds)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina:					
Sheet	481	97	53	62	55
Waste, scrap, etc	1,358	1,012	481	628	600
Brazil (exports)	10,620	[r]1,735	1,936	7,926	7,800
Canada[e]	22,000	24,000	22,000	23,000	23,000
France[e]	15,400	[r]15,400	[r]15,400	[r]15,400	14,300
India:					
Exports:					
Block	1,737	2,610	[e]2,400	[e]2,400	2,400
Film and disk	724	768	[e]440	[e]400	400
Splittings	3,606	7,303	[e]8,800	[e]7,000	7,000
Scrap	15,603	14,274	[e]17,600	[e]15,500	15,500
Powder	30,876	25,674	[e]11,000	[e]9,000	9,000
Manufactured	3,861	925	[e]660	[e]1,100	1,100
Domestic consumption, all forms[e]	6,600	6,600	6,600	6,600	6,600
Total	63,007	58,154	[e]47,500	[e]42,000	42,000
Korea, Republic of (all grades)	22,773	[e]22,000	44,875	31,751	33,000
Madagascar (phlogopite)	[3]3,816	844	2,866	2,392	2,200
Mexico (all grades)	7,937	4,579	1,124	3,439	3,300
Peru	110	1,265	[e]1,200	[e]1,200	1,200
South Africa, Republic of:					
Sheet	([4])	--	--	--	--
Scrap	5,573	5,280	3,871	5,891	10,300
Spain	10,650	7,769	7,557	2,866	3,000
Sri Lanka (scrap)	320	401	642	377	440
Sudan	[e]3,300	4,409	364	22	--
Tanzania (sheet)	22	11	11	([4])	([4])
U.S.S.R. (all grades)[e]	101,000	104,000	106,000	108,000	108,000
United States:					
Sheet	NA	NA	NA	NA	NA
Scrap and flake[5]	232,000	266,000	212,000	280,000	322,000
Yugoslavia	549	584	3,093	[r e]3,100	3,300
Zimbabwe	2,253	3,100	1,898	[e]880	880
Grand total	[r]503,169	[r]520,640	472,871	528,934	575,375

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 14, 1985.
[2]In addition to the countries listed, China, Mozambique, Namibia, Norway, Pakistan, Romania, and Sweden are known to produce mica, but available information is inadequate to make reliable estimates of output levels.
[3]Excludes scrap mica.
[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 1984, worldwide mine production exceeded demand, and domestic consumer stocks were kept at a minimum. U.S. mine output of molybdenum increased 209% compared with that of 1983 and represented 50% of world production. This increase in domestic production was the result of the restarting of primary production. Reported end-use consumption of molybdenum in raw materials and apparent domestic demand increased compared with that of 1983. World demand for molybdenum rose, resulting in larger quantities of molybdenum exported from the United States. Domestic producer stocks of molybdenum decreased by 22%, 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 "Molybdenum Ore and Concentrate," "Molybdenum Concentrate and Molybdenum Products," and "Molybdenum Concentrates." Of the 26 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)

	1980	1981	1982	1983	1984
United States:					
Concentrate:					
Production	150,686	139,900	84,381	ʳ33,593	103,664
Shipments	149,311	118,916	76,135	ʳ48,805	102,405
Value	$1,344,181	$945,540	$504,089	ʳ$166,612	$326,780
Consumption	108,206	80,725	49,444	27,014	54,843
Imports for consumption	1,825	1,988	3,115	ʳ1,673	28
Stocks, Dec. 31: Mine and plant	18,101	35,043	38,510	11,637	12,450
Primary products:					
Production	106,284	105,824	65,381	37,533	79,689
Shipments	95,391	64,368	47,884	ʳ50,562	65,528
Consumption	53,265	50,189	27,665	27,225	34,792
Stocks, Dec. 31: Producers	27,007	44,961	49,402	ʳ28,352	22,155
World: Mine production	ʳ243,754	ʳ240,012	214,800	ᵖ140,295	ᵉ208,665

ᵉEstimated. ᵖPreliminary. ʳRevised.

DOMESTIC PRODUCTION

Domestic mine production of molybdenum increased to a total of 104 million pounds of contained molybdenum. The country's three largest producers were AMAX Inc., Anaconda Minerals Co., and Duval Corp., which together produced 70% of 1984 production.

Domestic producers attempted to correct oversupply conditions by reducing production and canceling or extending new project development. U.S. Borax & Chemical Corp. restricted the development of its Quartz Hill molybdenum project east of Ketchikan, AK.

Table 2.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	Molybdic oxides[1]		Metal powder		Ammonium molybdate	
	1983	1984	1983	1984	1983	1984
Received from other producers	[r]13,815	4,889	263	--	1,089	1,527
Gross production during year	27,705	62,131	4,587	5,863	2,731	3,332
Used to make other products listed here	16,558	21,946	921	1,561	1,676	2,215
Net production	11,148	40,186	3,667	4,302	1,055	1,116
Shipments	[r]38,642	50,253	3,874	4,178	2,058	W
Producer stocks, Dec. 31	[r]22,991	17,295	503	594	1,038	684
	Sodium molybdate		**Other[2]**		**Total**	
Received from other producers	49	W	1,511	63	[r]16,727	6,479
Gross production during year	191	W	2,319	8,363	37,533	79,689
Used to make other products listed here	--	W	91	614	19,246	26,336
Net production	191	W	2,227	7,749	18,288	53,353
Shipments	204	W	5,784	11,096	[r]50,562	[3]65,528
Producer stocks, Dec. 31	79	W	[r]3,741	3,582	[r]28,352	22,155

[r]Revised. 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, and molybdenum hexacarbonyl.

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

CONSUMPTION AND USES

The quantity of molybdenum in concentrate roasted domestically to produce technical-grade molybdic oxide increased to 55 million pounds, about 104% above that of 1983. The remainder of the mine production of concentrate, containing about 49 million pounds of molybdenum, was either exported for conversion, purified to lubrication-grade molybdenum disulfide, or added to the stocks at the 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 domestic consumption (calculated from mine production, imports minus exports, and change in industry stocks) increased by about 20% over that of 1983 to 35 million pounds of molybdenum. The increase in apparent consumption was the first since 1979. Likewise, total reported end-use consumption of molybdenum in raw materials increased about 28% over that of 1983. Molybdenum consumed in oxide form (technical-grade, purified, and briquets) accounted for about 64% of total reported consumption; in ferromolybdenum, 13%; and in other forms, 22%.

Molybdenum reported as consumed in the production of steel accounted for 58% of total consumption. Approximately 29% 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 13% of total consumption. Nearly all end-use areas exhibited an increase in molybdenum consumption compared with those of 1983.

Table 3.—U.S. 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
1983					
Steel:					
Carbon	540	82	--	18	640
Stainless and heat resisting	3,942	472	--	131	4,545
Full alloy	7,834	955	--	19	8,808
High-strength, low-alloy	422	251	--	21	694
Tool	1,192	456	--	10	1,658
Cast irons	201	834	--	24	1,059
Superalloys	1,081	124	--	1,339	2,544
Alloys (excludes steels and superalloys):					
Welding and alloy hard-facing rods and materials	--	106	--	16	122
Other alloys[3]	207	66	--	116	389
Mill products made from metal powder	--	--	--	3,210	3,210
Chemicals and ceramics:					
Pigments	W	--	318	--	318
Catalysts	1,611	--	W	51	1,662
Other	6	--	--	685	691
Miscellaneous and unspecified	421	57	349	58	885
Total	17,457	3,403	667	5,698	27,225
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

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 12% to 39 million pounds of contained molybdenum. Inventories of molybdenum in concentrate at mine locations registered an increase from 12 to 13 million pounds. Producers' stocks of molybdenum in consumer products, such as oxide, ferromolybdenum, molybdate, metal powders, and other types, decreased from 28 million pounds at the beginning of the year to 22.2 million pounds by yearend. Compared with monthly molybdenum shipments, yearend producers' stocks of these materials totaled almost a 4-month supply. Domestic consumers held inventories of about 4 million pounds throughout most of the year, representing approximately a 1.3-month supply compared with average monthly reported consumption.

Table 4.—Industry stocks of molybdenum materials, December 31

(Thousand pounds of contained molybdenum)

Material	1980	1981	1982	1983	1984
Concentrate: Mine and plant	18,101	35,043	38,510	11,637	12,450
Producers:					
Molybdic oxides[1]	22,825	38,999	41,855	r22,991	17,295
Metal powder	560	507	443	503	594
Ammonium molybdate	944	1,075	1,072	1,038	684
Sodium molybdate	48	27	48	79	W
Other[2]	2,630	4,353	5,984	r3,741	3,582
Total	27,007	44,961	49,402	r28,352	22,155
Consumers:					
Molybdic oxides[1]	3,816	3,217	2,103	1,467	1,552
Ferromolybdenum[3]	1,507	914	616	570	721
Ammonium and sodium molybdate	280	167	76	70	80
Other[4]	1,813	1,467	1,386	1,567	1,540
Total	7,416	5,765	4,181	3,674	3,893
Grand total	52,524	85,769	92,093	r43,663	38,498

rRevised. 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.

PRICES

The price of molybdic oxide (per pound of contained molybdenum) declined from $3.93 in January to $3.70 in March, then rose to $4.03 in May, declined to $3.60 in August, and further declined to the year's low of $2.88 at the end of December. The average price of oxide was $3.56 or $0.08 less than the average price in 1983.

Table 5.—Domestic price listings for molybdenum

(Per pound)

	1983	1984
Producer quotes:		
Concentrate	$3.12	$3.36
Ferromolybdenum-export	4.52	4.32
Oxide	3.64	3.56

FOREIGN TRADE

Exports.—Exports of molybdenum in concentrate and oxide increased to 63 million pounds, 35% above that of 1983. Molybdenum concentrate exports were about 61% of domestic mine production. Approximately 97% 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 increased from 58 million pounds in 1983 to 81 million pounds in 1984. Total value of exports increased from $224 million in 1983 to $318 million in 1984.

Imports.—Approximately 8 million pounds of molybdenum in various forms was imported into the United States, about the same as imported in 1983. This quantity represented 12% of supply and 23% of apparent consumption. Total value of all forms of molybdenum imported increased 9%, from $35 million in 1983 to $38 million in 1984. In terms of both value and quantity, the major forms imported were as concentrate and as materials in chief value molybdenum. The principal originating countries for these imports were Canada and China.

Table 6.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds of contained molybdenum)

	1983	1984
Molybdenite concentrate	r18,979	41,687
Molybdic oxide	r19,877	24,553
All other primary products	839	1,424

rRevised.

Table 7.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by country

(Thousand pounds of contained molybdenum and thousand dollars)

	1982		1983		1984	
	Quantity	Value	Quantity	Value	Quantity	Value
Austria	1,523	8,485	2,179	8,105	--	--
Belgium-Luxembourg	2,458	14,312	4,354	20,171	5,146	22,629
Brazil	30	167	55	246	82	258
Canada	1,482	4,236	475	1,377	281	632
Chile	3,197	6,062	1,394	1,988	208	679
France	304	413	274	593	--	--
Germany, Federal Republic of	7,502	22,712	6,148	20,918	6,576	14,936
Japan	5,411	37,394	4,531	17,706	6,896	25,979
Mexico	68	330	13	52	(1)	1
Netherlands	20,688	115,358	20,700	95,598	34,914	150,558
Sweden	1,928	5,099	1,475	3,032	789	1,674
Switzerland	40	135	--	--	--	--
United Kingdom	4,740	15,191	5,208	14,336	7,863	23,057
Other	412	2,320	262	1,000	611	2,367
Total	49,783	232,214	47,068	185,122	63,366	242,770

1Less than 1/2 unit.

Table 8.—U.S. exports of molybdenum products, by country

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1983		1984	
	Quantity	Value	Quantity	Value
Ferromolybdenum:[1]				
Australia	--	--	118	240
Canada	18	65	37	133
Japan	5	20	--	--
Malaysia	4	6	1	4
Mexico	--	--	66	169
Philippines	20	72	(2)	1
South Africa, Republic of	9	30	16	50
Other	116	494	411	970
Total[3]	171	687	650	1,567
Metal and alloys in crude form and scrap:				
Belgium	141	132	8	84
Canada	39	288	57	242
France	1	12	8	80
Germany, Federal Republic of	42	75	83	96
India	3	21	--	--
Japan	105	430	30	198
Netherlands	36	66	61	98
Spain	--	--	1	8
United Kingdom	112	592	53	357
Other	98	242	5	45
Total[3]	577	1,860	306	1,209
Wire:				
Argentina	2	53	2	52
Australia	--	--	1	9
Bahamas	141	212	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	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Wire —Continued				
Belgium-Luxembourg	4	69	9	138
Brazil	5	99	18	309
Canada	16	225	22	514
France	8	136	6	95
Germany, Federal Republic of	49	708	92	859
India	8	103	3	47
Italy	48	929	26	374
Japan	116	1,792	97	1,327
Mexico	7	204	15	548
Netherlands	33	902	21	526
Singapore	--	--	1	13
South Africa, Republic of	1	8	(2)	3
Spain	27	350	27	326
Sweden	6	82	11	196
United Kingdom	7	87	7	100
Other	132	1,126	39	400
Total[3]	610	7,085	474	5,954
Powder:				
Australia	1	3	(2)	2
Belgium-Luxembourg	(2)	2	--	--
Canada	3	26	4	33
France	68	305	25	362
Germany, Federal Republic of	1	15	16	73
Italy	2	44	2	33
Japan	13	50	23	191
Mexico	7	31	37	174
Netherlands	33	162	(2)	3
Sweden	9	71	6	39
Taiwan	121	1,502	148	1,668
United Kingdom	59	242	11	65
Other	80	284	189	630
Total[3]	396	2,737	461	3,272
Semifabricated forms, n.e.c.:				
Australia	(2)	5	3	74
Belgium-Luxembourg	39	380	1	25
Brazil	10	339	31	752
Canada	25	546	33	655
France	14	500	13	367
Germany, Federal Republic of	13	224	36	667
Japan	4	143	41	1,074
Mexico	1	11	2	44
Netherlands	24	618	29	873
Philippines	1	59	1	7
Singapore	2	63	(2)	12
South Africa, Republic of	2	59	1	16
United Kingdom	76	1,483	57	1,411
Other	6	159	9	390
Total[3]	216	4,589	257	6,368
Molybdenum compounds:				
Argentina	2	14	(2)	6
Australia	117	418	175	452
Belgium-Luxembourg	(2)	1	4,688	8,346
Brazil	27	84	5	26
Canada	223	832	513	1,937
Germany, Federal Republic of	880	1,464	1,296	2,481
Japan	6,310	17,118	5,127	14,908
Mexico	8	37	7	23
Netherlands	90	181	6,746	13,097
Sweden	32	55	953	1,816
Switzerland	--	--	7	25
Taiwan	(2)	2	--	--
United Kingdom	379	943	2,644	5,133
Other	529	1,009	4,440	8,204
Total[3]	8,597	22,158	26,602	56,453

[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.

Table 9.—U.S. imports for consumption of molybdenum

(Thousand pounds and thousand dollars)

Item	TSUS No.	1983			1984		
		Gross weight	Contained molybdenum	Value	Gross weight	Contained molybdenum	Value
Ore and concentrate	601.33	2,986	1,673	3,528	46	28	183
Material in chief value molybdenum	603.40	5,711	3,445	12,985	8,800	5,266	19,441
Ferromolybdenum	606.31	1,157	799	3,189	2,086	1,545	4,438
Waste and scrap	628.70	NA	406	2,141	NA	437	2,565
Unwrought	628.72	NA	97	1,398	NA	142	2,170
Wrought	628.74	94	NA	2,331	132	NA	3,023
Ammonium molybdate	417.28	1,718	1,037	3,966	95	54	287
Molybdenum compounds	419.60	2,407	677	3,048	883	599	2,547
Sodium molybdate	421.10	149	88	305	183	108	319
Mixtures of inorganic compounds, chief value molybdenum	423.88	41	18	265	250	42	731
Molybdenum orange	473.18	1,476	NA	1,841	2,026	NA	2,367
Total		15,739	8,240	34,997	14,501	8,221	38,071

NA Not available.

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
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 209 million pounds, an increase of 49% over that produced in 1983. Over 91% of the estimated world production was supplied by Canada, Chile, the U.S.S.R. (estimated), and the United States. Although comprehensive statistics on world consumption were not available, market evidence clearly indicated that for the fourth year in succession supply exceeded demand. World molybdenum consumption increased, and stocks continued to decrease but exceeded more than 1 year's demand.

Canada.—Molybdenum production (shipments) in Canada increased by about 8% in 1984 over that in 1983. Noranda Mines Ltd. maintained its Boss Mountain Mine on a standby basis but reopened its Gaspe, Quebec, mine in September 1984.

Brenda Mines Ltd., a Noranda subsidiary, reopened its Peachland, British Columbia, mining operation at the end of May after an 8-month shutdown. The mine was again closed in December 1984.

Teck Corp. closed indefinitely its Highmont copper-molybdenum mine in British Columbia in October. Teck also has a 22% interest in Lornex Mining Corp. Ltd. However, the majority of Lornex is held by Rio Algom Ltd. Production of molybdenum at Lornex remained at a relatively high level, as in 1983.

Chile.—Molybdenum production from Corporacíon Nacional del Cobre de Chile (CODELCO-Chile) in 1984 was up 10% compared with that of 1983. 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]	1980	1981	1982	1983[p]	1984[e]
Bulgaria[e]	330	330	330	330	330
Canada (shipments)	[r]26,892	[r]28,338	36,288	22,474	[3]24,174
Chile	30,133	33,863	44,198	33,651	[3]37,172
China[e]	4,400	4,400	4,400	4,400	4,400
Japan	123	163	214	214	265
Korea, Republic of	661	[r]1,023	796	313	220
Mexico	163	[r]994	11,442	12,932	4,740
Mongolia[e]	1,070	1,460	1,830	2,120	2,200
Niger	269	249	93	88	NA
Peru	5,926	5,485	6,378	5,794	6,800
Philippines	201	207	150	86	--
U.S.S.R.[e]	22,900	23,600	24,300	24,300	24,700
United States	150,686	139,900	84,381	33,593	[3]103,664
Total	[r]243,754	[r]240,012	214,800	140,295	208,665

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 24, 1985.
[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]

The worldwide nickel market continued to rebound from the 1982 low ebb. In 1984, both production and demand for nickel registered significant increases. World demand was insufficient, however, to avoid a continued overcapacity in world production facilities. With production at approximately 75% of rated capacity, the resultant keen competition for sales contracts among producers and traders kept prices from rising along with demand. Toward yearend, unusually heavy nickel purchases from the London Metal Exchange (LME) coupled with a dearth of Soviet shipments to the LME resulted in a drastic drop in LME nickel stocks. This caused the nickel prices to edge upward in December.

Table 1.—Salient nickel statistics

(Short tons of contained nickel unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Mine production:					
Nickel ore (gross weight)	1,751,900	1,794,000	432,488	--	1,674,600
Shipments	14,653	12,099	3,203	--	14,540
Plant production:					
Smelter, from domestic ores (includes byproduct nickel)	11,225	10,305	3,456	W	9,604
Refinery, from imported matte	33,000	38,500	41,500	33,400	35,329
Secondary recovery, from purchased scrap:[e]					
From ferrous scrap	30,797	34,459	30,034	30,076	39,858
From nonferrous scrap	18,494	17,617	12,934	19,776	19,428
Exports:					
Primary (unwrought)	19,463	19,674	37,356	23,359	27,927
Total (gross weight)	56,675	46,836	57,029	43,913	50,645
Imports:					
Primary	189,188	209,008	129,787	152,333	176,715
Primary (gross weight)	265,943	306,747	177,493	215,361	249,929
Total (gross weight)	275,346	315,837	186,913	225,537	264,778
Consumption:					
Reported:					
Primary	156,299	144,851	103,981	127,845	136,861
Secondary (purchased scrap)[e]	43,783	43,768	35,690	42,034	[p]49,649
Calculated:					
Primary	157,709	153,994	138,032	153,388	159,632
Secondary (purchased scrap)[e]	49,291	52,076	42,968	49,852	59,286
Stocks, yearend:					
Producer	60,000	100,000	62,000	[r]38,500	37,300
Consumer:					
Primary	15,231	22,508	18,853	20,448	20,934
Secondary[e]	9,121	11,326	10,004	10,304	[p]7,619
Employment:					
Mine	160	160	160	160	130
Smelter	230	230	230	230	170
Refinery	NA	NA	420	420	420
Price (cathode):[1]					
Producer (North American), per pound	$3.41	$3.43	$3.20	XX	XX
New York dealer, per pound	$2.85	$2.65	$2.24	$2.20	$2.22
World: Mine production	[r]858,850	[r]804,715	674,590	[p]723,473	[e]819,890

[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.

The strong U.S. dollar in relation to other major currencies dominated the world price for nickel. Although most producers incur the expenses in mining and processing nickel in local currencies, nickel is generally traded in U.S. dollars. A shrinking dollar equivalency throughout the year equalized any nominal gain in nickel prices that might have otherwise been realized by producers in the local currency.

Nickel production and consumption in the United States are integrally linked to world market conditions owing to the heavy import reliance. Consumption of primary nickel followed the worldwide upward trend as demand for nickel in alloy steel, nickel and nickel alloys, and electroplating products increased. Enthusiasm over the rebound dampened near yearend when consumption dropped off, mirroring drops in stainless steel and nickel-based alloy production.

Hanna Mining Co. brightened the domestic mining picture by resuming ferronickel shipments from its mine at Riddle, OR, (the only U.S. nickel mine) in January after reopening late in 1983. The sole U.S. nickel refinery, operated by AMAX Nickel Refining Co. Inc. in Braithwaite, LA, continued production at about the 1983 level. Prices paid for nickel in the New York trading market were fairly stable compared with the fluctuations experienced in the early 1980's and reflected a gradual shift toward a better balance between worldwide production and demand.

Domestic Data Sources and Coverage.—Domestic primary production data for nickel are obtained by the Bureau of Mines from a survey of the single nickel mine-smelter and shipments reported by the only operating nickel refinery. Domestic consumption data for nickel are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the 357 operations to which a survey request was sent, 357 responded, representing an estimated 86% of the total consumption (tables 3 and 4). Total consumption for the respondents and nonrespondents was estimated using U.S. production plus imports minus exports plus adjustments for Government and industry stock changes.

Legislation and Government Programs.—The U.S. Department of the Treasury's Office of Foreign Assets Control turned down a request by U.S. specialty steel producers to expand the ban on primary nickel from the U.S.S.R. to include products fabricated from Soviet nickel, citing potential negative trade impacts with strong allies such as the Federal Republic of Germany and Japan.

The Treasury-Postal Service Appropriations bill, which allocated $185 million for stockpile purchases in 1985, passed in October 1984. The strong "buy American" language in the bill created a stir among other signatory nations to the General Agreement on Tariffs and Trade wherein those nations, including the United States, agreed not to impose non-tariff trade restrictions.

The General Services Administration (GSA), purchasing agent for stockpile material, awarded contracts to two Canadian producers to provide 5,000 short tons of vacuum-melting-grade nickel to the stockpile for delivery in 1985. This purchase was the first for nickel since 1960. Even after the purchased nickel is delivered to the stockpile, it will remain well below the goal of 200,000 tons. Yearend 1984 inventory was 32,209 tons. During the year, the GSA categorized nickel in the stockpile and attempted to establish realistic standards for various grades. Material for which an exact composition was unknown was lumped into a classification that includes ferronickel and nickel oxide and would not be suitable for many defense-related purposes. Even with the imminent receipts of nickel, a relatively small portion of the inventory will be of the strategically important, high-purity grade.

Treasury's Bureau of the Mint awarded contracts for an April 26 tender for 3 million pounds of nickel cathodes and briquets. Contracts were awarded under a September 5 tender for an additional 1.9 million pounds of nickel. A third tender, dated November 27, resulted in contracts for 1.71 million pounds of nickel. All awards went to trading companies with U.S. offices.

Several governmental actions were directed at deep-seabed mining for nodules containing nickel, cobalt, copper, and manganese and for metallic sulfides deposited in crusts at hydrothermal vents that occur in the seafloor along the ridges that form where underlying magma is actively upwelling. Industry expressed very little interest in a proposed U.S. Department of the Interior plan to lease one of these crust deposits contained in a portion of the seafloor called Gorda Ridge off the coast of Oregon and California. The weak metals market and sophisticated technology that would have to be developed to exploit the crust deposits were cited as reasons for the low interest. In June, however, Interior's Minerals Management Service awarded $1.8 million to Hawaii to prepare an environmental impact statement (EIS) on the effects of mining a crust zone within the 200-nautical-mile exclusive economic zone surrounding the islands. On August 3, the United States joined seven market economy countries in signing a Seabed Mining Agreement that established the framework of seabed mining claims for those countries. The United Nations-sponsored Law of the Sea Preparatory Commission, led by centrally planned economy countries and developing nations, protested the agreement. The United States had previously refused to sign the treaty that established sea mining regulations developed under the Law of the Sea. The Federal Register carried National Oceanic and Atmospheric Administration announcements that exploration licenses have been issued to four firms pursuant to the Deep Seabed Hard Mineral Resources Act.[2] Also in accordance with the act, the Environmental Protection Agency (EPA) issued the final general discharge permit under the National Pollutant Discharge Elimination System for ships exploring or mining the deepsea beds under auspices of the Federal Water Pollution Control Act.[3]

Attempts to reauthorize Superfund prompted a flurry of legislative action, but no legislation was passed. Superfund is the source of funds, administered by EPA, for rehabilitating hazardous waste disposal sites. Created under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Superfund is financed by an excise tax collected by the Internal Revenue Service and levied against producers of certain chemical products listed in the act.[4] Nickel metal is one of those chemicals and hence is taxable at that point where it is first processed to, and sold in, the metal form. Since the act expires in 1985, considerable effort was devoted in 1984 to extending it.

A preparatory meeting for the formation of an International Nickel Discussion Group was held in October in Geneva, Switzerland. Delegations from 33 countries, including the United States, attended. No decision was reached on the formation of such a group, but it was decided to hold another meeting in early 1985 to continue the debate.

DOMESTIC PRODUCTION

Hanna resumed production of ferronickel in January after reopening the Nation's only nickel mine and smelter near Riddle, OR, late in 1983. A reduced power rate from the Bonneville Power Administration and labor contract concessions were instrumental in the reopening. To further improve unit costs, the company began processing the last of its high-grade ore in August. This raised the average ore grade for the year to 1.0%, up from recent yearly average grades of 0.87% to 0.89%. Hanna applied to Bonneville for extending to July 1, 1990, the 0.7 cent per kilowatt-hour power rate that it had secured for 20 months to reopen. Contingent upon the extension, Hanna announced plans to install a cost-cutting, wet-screening system at the mine. By screening the ore at the mine to remove the barren coarse-sized fraction, the ore would be concentrated by a factor of two. Mine-to-plant transportation costs would be halved, and the cost of roasting the coarse material would be eliminated. The company also considered integrating a slurry ore transportation system with the wet-screen unit to replace the current tramway haulage.

The Nation's only nickel refinery, AMAX Nickel's Port Nickel refinery in Braithwaite, LA, closed for 5 weeks during the summer. Production for the year remained roughly 85% of the refinery's capacity. The refinery imported about 60% of its nickel feed as matte from Bamangwato Concessions Ltd. (BCL), Botswana; AMAX Nickel owns a 29.8% share in Botswana RST Ltd. (BRST), the parent company of BCL. The other 40% of its feed originated from the Agnew Mine in Australia via Western Mining Corp.'s (WMC) Kalgoorlie smelter. Near yearend, Falconbridge Ltd., Canada, opened negotiations with BCL to secure the majority of BCL matte for its refinery in Kristiansand, Norway.[5] If Falconbridge is successful, AMAX Nickel would face a serious problem in supplying nickel matte to Port Nickel.

California Nickel Corp., the U.S. exploration and mining subsidiary of Ni-Cal Developments Ltd., was prevented by the U.S. Forest Service from implementing a 1984 Operating Plan to extract a bulk metallurgical sample from three pits totaling 1.5 acres on the Gasquet Mountain nickel laterite deposit, pending completion of a detailed

EIS by the Forest Service. Although Del Notre County and the Forest Service reportedly approved the 1984 Operating Plan in September, the Forest Service approval was still pending an administrative review requested by environmental groups. Meanwhile, Ni-Cal Developments applied to the Del Notre County Planning Commission for approval to build a research facility and an 85-ton-per-day demonstration plant in the town of Smith River, CA. The facility is intended for testing an acid leaching process developed with Raymond Kaiser Engineers for the Gasquet Mountain deposit. A subsidiary, Ni-Cal Technology Ltd., was formed to operate the facility and market the technology worldwide. An agreement also was signed to test the technology at a nickel refinery operated by Nonoc Mining and Industrial Corp. in the Philippines (formerly Marinduque Mining and Industrial Corp.). When it passed the California Wilderness Act of 1984, the 98th Congress removed an additional hurdle blocking mining on Gasquet Mountain. The act specifically directs the Forest Service to manage the North Fork Smith roadless area in the Six Rivers National Forest for multiple use rather than setting it aside as a wilderness area.[6] The Gasquet Mountain deposits included in this area cover 8,000 acres and contain a demonstrated resource of 14.8 million tons averaging 0.75% nickel.[7]

Interest mounted in developing the nearby Pine Flat deposit in northern California. Interstrat Resources Inc. announced that new exploration surveys indicated a 25-million-ton deposit grading 0.78% nickel as well as 24% magnesium, 0.6% cobalt, and 1.1% chromium. The deposit is contained in contiguous claims held by Interstrat and by Coastal Mining Co., a subsidiary of Hanna. An agreement with Coastal reportedly provides Interstrat with a 50% interest in the Coastal claims if production occurs on the joint properties. A preliminary engineering evaluation prepared by Davy McKee Corp. indicated that a 4,000-ton-per-day processing complex could produce 12,000 tons per year of nickel plus chromite, cobalt, and magnesium for a minimum 10-year mine life. The sulfuric acid leaching system designed for recovering nickel and cobalt also features recovery of magnesium in a proprietary process developed by Mineral Process Licensing Co. and licensed to Davy McKee.

Red Flats Nickel Corp. and Big Basin Nickel Corp. announced findings of 24 million tons of nickel-cobalt laterite on their joint claims in the Red Flat District of southern Oregon.

Contrary to the minor domestic production of primary nickel, the production of domestic secondary nickel in the form of scrap recovery is 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, perhaps reflecting additional availability of stainless steel scrap, the major scrap form, owing to heavier stainless steel imports in 1983. The nickel recovered from scrap stainless steel is calculated from the gross weight of the scrap and an estimated nickel content of 6.9%, which is the weighted average content of all stainless steels produced since 1962.[8]

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)

	1983	1984
KIND OF SCRAP		
Aluminum-base	2,651	2,449
Copper-base	3,658	3,493
Ferrous-base	30,076	39,858
Nickel-base	13,467	13,486
Total	49,852	59,286
FORM OF RECOVERY		
Aluminum-base alloys	2,954	2,542
Chemical compounds	390	390
Copper-base alloys	7,412	7,948
Ferrous alloys	30,557	40,951
Metal	--	21
Nickel-base alloys	8,539	7,434
Total	49,852	59,286

[e]Estimated.

CONSUMPTION

Domestic nickel consumption continued to rebound from the low consumption recorded in 1982, especially in nickel alloys, electroplating, and miscellaneous uses. Reflecting the 6.8% growth in gross national product (the largest since 1951) and a similar boom in industrial production (up 10.7% over that of 1983), the demand for nickel swelled along with consumer expenditures on durable goods and private capital investments. The return of healthy U.S. automotive sales triggered the boost in nickel consumed in electroplating.

Although the U.S. economic recovery was more pronounced than the world recovery, domestic nickel consumption gains did not match estimated gains in market economy countries as a whole. Domestic production of products containing nickel has been eroded by a rising undercurrent of foreign production of such products (notably stainless steel) at prices that compare favorably with those of U.S. products on the world market. The trend toward smaller cars containing less nickel electroplating also restrained the consumption rebound from reaching levels that might otherwise have been expected considering the boom in automotive sales.

Toward yearend, nickel consumption leveled off, reflecting an overall slowdown in the U.S. economic recovery. During that time, the most sobering decline was the drop of stainless steel production from its high-water mark during the first two quarters.

Commercially pure unwrought nickel (Class I) in the form of electrolytic cathodes, pellets, or briquets was again the dominant form of primary nickel consumed. These forms comprise most of the nickel consumed in all products except in stainless and heat-resistant steels where they were a major but not dominant nickel source. The Class II materials—ferronickel, nickel oxide, oxide sinter, and utility-grade nickel—were primarily used in producing stainless and heat-resistant steels.

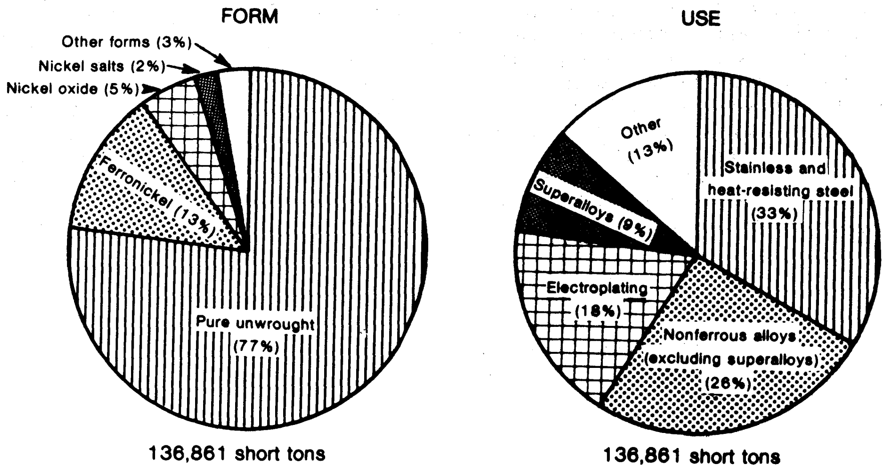

Figure 1.—U.S. nickel consumption in 1984, by form and use.

Consumption of nickel in scrap was a major form of consumption in stainless steel production. Since stainless steel scrap was generally cheaper than the sum of its primary components' costs (chromium, iron, and nickel), steelmakers charged furnaces with as much scrap as was available. Carbon steel was then added to provide the desired iron units, and primary nickel was added until the desired nickel content was achieved. 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, up slightly from that of 1983. Consumption statistics include only this outside scrap to avoid double counting.

Although the nickel consumed as ferrous scrap to make stainless steel rose above the previous years' levels, the use of scrap nickel in producing nonferrous alloys remained constant. About one-fourth of the nickel in nonferrous alloys and one-third of that in cast iron originated as outside scrap. For chemicals, 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.

Table 3.—U.S. consumption of nickel,[1] by form

(Short tons of contained nickel)

Form	1980	1981	1982	1983	1984
Primary:					
Ferronickel	29,919	26,290	15,426	15,595	18,419
Metal	111,609	101,847	79,032	96,981	104,958
Oxide powder and oxide sinter	8,492	9,412	4,196	9,670	7,087
Salts[2]	3,330	4,197	3,874	4,402	2,962
Other	2,949	3,105	1,453	1,197	3,435
Total primary	156,299	144,851	103,981	127,845	136,861
Secondary (scrap)[3]	43,783	43,768	35,690	42,034	[p]49,649
Grand total	200,082	188,619	139,671	169,879	186,510

[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 1984, 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	782	126	108	3	448	1,467	809	2,276
Chemicals and chemical uses	1,645	--	195	172	220	2,232	390	2,622
Electroplating (sales to platers)[1]	22,197	1	2	2,559	61	24,820	--	24,820
Nickel-copper and copper-nickel alloys	6,354	--	7	--	295	6,656	7,948	14,604
Other nickel and nickel alloys	28,062	855	298	86	101	29,402	9,279	38,681
Permanent magnet alloys	217	--	--	--	--	217	160	377
Steel:								
Stainless and heat-resistant	24,049	16,183	5,561	2	33	45,828	[p]29,389	75,217
Alloys (excludes stainless)	7,796	1,189	742	--	2,125	11,852	[p]956	12,808
Superalloys	12,636	64	24	92	103	12,919	245	13,164
Other[2]	1,220	1	150	48	49	1,468	473	1,941
Total reported by companies canvassed	104,958	18,419	7,087	2,962	3,435	136,861	49,649	186,510
Total all companies, calculated	XX	XX	XX	XX	XX	[3]159,632	59,286	218,918

[e]Estimated. [p]Prelimiary. 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.

Table 5.—Nickel in consumer stocks in the United States, by form

(Short tons of contained nickel)

Form	1980	1981	1982	1983	1984
Primary:					
Ferronickel	2,046	2,257	1,122	893	692
Metal	10,825	18,355	16,743	17,359	17,479
Oxide and oxide sinter	1,503	1,039	488	1,677	2,259
Salts	547	508	226	268	229
Other	310	349	274	251	275
Total primary	15,231	22,508	18,853	20,448	20,934
Secondary (scrap)	9,121	11,326	10,004	10,304	[p]7,619
Grand total	24,352	33,834	28,857	30,752	28,553

[p]Preliminary.

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 slightly during the year. Although the trading company stocks represent only a small fraction of the total, the sharp drop in their stocks pulled the total stock figure down. Several trading companies stopped or drastically curtailed nickel trading, citing a lethargic market and low profitability as reasons. The primary stocks held by producers and traders at yearend represented approximately 3 months of domestic consumption. Nickel stocks on the LME plummeted during the year to end at about 8,100 tons, primarily owing to a shortfall in Soviet shipments and heavy yearend buying.

Despite a midyear dip, the consumer stocks of primary nickel finished the year at about the same level as at yearend 1983. Although during 1984 consumer stocks averaged slightly more than 1 month's consumption, the yearend level approached 2 months' consumption.

Stocks of nickel in ferrous scrap held by iron and steel producers dropped. Stocks of nickel in the National Defense Stockpile remained at 32,209 tons, considerably less than the 200,000-ton goal.

PRICES

The LME price remained the bellwether for world nickel prices after supplanting Canadian producer prices that dictated world prices until the price collapse of 1982. The weighted-average LME price for 1984 crept up to $2.16 per pound for electrolytic cathode nickel (Class I) and finished the year with a strong $2.28 per pound December average, pushed by the drastic drop in LME stockpiles.[9]

In the United States, the New York dealer price for electrolytic cathode nickel best indicated prices paid by domestic consumers, and at a weighted-annual average of $2.22, it closely paralleled the LME price. For ferronickel, the price per pound of contained nickel averaged about 1.5% less than the cathode price. Nickel oxide-oxide sinter cost 2.5% less than cathode. The high-purity plating and vacuum grades of nickel used in superalloys and other high-nickel specialty alloys averaged about 1% more than that of the standard cathodes. Although the essentially meaningless producer list prices remained in the vicinity of $3.20 per pound, major producers generally discounted nickel prices to levels that yielded 10 to 15 cents per pound more than the LME prices.

The stagnant nickel prices directly reflected the impact of the strong U.S. dollar on all commodities traded in the dollar. Normally, a price rise would be expected for any commodity subjected to increasing consumption and shrinking free-market stockpiles as experienced by nickel in 1984. Any price gains that were realized by the producers relative to local currencies were, however, negated by the steady strengthening of the U.S. dollar throughout the year. When compared with 15 other major currencies, the value of the dollar at yearend rose 12% above its value against those same currencies at the beginning of the year.[10] The British pound sterling, the medium of exchange on the LME, was particularly hard hit in this regard.

FOREIGN TRADE

Since the United States had a net import reliance of 69% for its nickel supplies, 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 of the nickel matte purchased from sources in those countries to supply AMAX Nickel's Port Nickel refinery in Louisiana.

The embargo on importation of unfabricated nickel originating from the U.S.S.R., imposed by the U.S. Department of the Treasury in December 1983 because of Soviet refusal to certify that its shipments contained no Cuban nickel, dried up the flow of imports of primary nickel from the U.S.S.R. It also apparently contributed to lower shipments of Soviet nickel into European markets. Certification procedures were established with other countries to ensure that no Cuban nickel was imported into the United States.

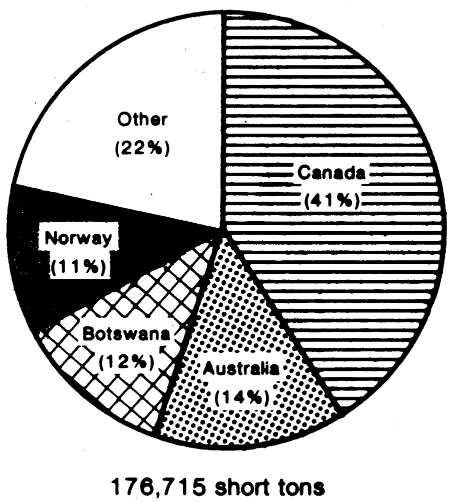

Figure 2.—Major sources of U.S. primary nickel imports in 1984.

The return of the Hanna Mine at Riddle, OR, to production of ferronickel enabled primary nickel exports to rise compared with the artificially depressed 1983 exports. Hanna exported some of its ferronickel to Japan. AMAX Nickel's refinery continued to sell refined nickel to foreign customers, partially dictated by terms of loan obligations that financed the source mine in Botswana. Although nickel exports may seem unusual given the Nation's overall heavy reliance on imports for its nickel supplies, individual sales were dictated by a variety of market and technical factors that resulted in sales to foreign consumers.

Table 6.—U.S. exports of nickel and nickel alloy products, by class

Class	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Primary:						
Cathodes, pellets, briquets (unwrought)	33,772	$178,337	22,165	$99,097	25,997	$118,453
Powder and flakes	3,457	22,441	1,017	6,973	1,790	12,062
Electroplating anodes	127	1,231	177	1,235	140	965
Total[1]	37,356	202,009	23,359	107,305	27,927	131,480
Wrought:						
Bars, rods, angles, shapes, sections	2,589	28,018	1,582	18,747	3,342	34,808
Plates, sheets, strip	2,218	29,460	1,430	18,351	1,968	21,316
Wire	481	6,011	1,039	8,831	1,119	11,166
Tubes, pipes, blanks, fittings, hollow bar	488	9,807	348	7,447	428	7,929
Nickel-compound catalysts	2,874	19,654	3,165	13,940	2,718	15,156
Nickel waste and scrap	11,023	20,136	12,990	17,106	13,143	23,566
Grand total (gross weight)	57,029	315,095	43,913	191,727	50,645	245,421

[1]Nickel content assumed equal to gross weight.

Table 7.—U.S. imports for consumption of nickel products, by class

Class	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Primary:						
Smelter products:						
Ferronickel	21,352	$28,215	45,134	$65,264	43,048	$68,429
Matte and/or salts (includes slurry)	58,568	105,633	62,454	83,613	82,509	116,956
Refined nickel:						
Cathodes, pellets, briquets (unwrought)	82,297	446,850	90,839	418,943	103,017	461,371
Flakes	179	1,020	96	427	759	3,306
Oxide and oxide sinter	3,144	13,461	4,209	19,083	5,526	22,413
Powder	11,953	71,825	12,629	65,320	15,070	75,430
Total primary (quantities are gross)	177,493	667,004	215,361	652,650	249,929	747,905
Wrought products:						
Bars, plates, sheets, anodes	1,384	11,217	1,235	11,531	2,000	18,036
Pipes, tubes, fittings	1,366	19,688	575	54,774	1,171	11,034
Rods and wire	2,362	19,217	2,241	17,935	5,419	28,544
Shapes, sections, angles	8	226	54	313	60	506
Nickel waste and scrap	4,300	13,349	6,071	17,691	6,199	20,542
Grand total	186,913	730,701	225,537	754,894	264,778	826,567
Nickel content, primary[1]	129,787	XX	152,333	XX	176,715	XX

XX Not applicable.
[1]Based on estimated nickel content and gross weight of primary nickel products.

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)	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
Australia	11,096	7,680	2,023	3,545	1,302	--	--	--	10,684	13,487
Botswana	121	75	--	--	--	--	--	--	16,354	21,324
Canada	42,435	55,689	7,753	10,644	1,922	4,255	--	--	1,060	1,961
Dominican Republic	--	--	--	--	--	--	8,014	8,291	--	--
Finland	3,367	4,072	--	--	--	--	--	--	158	122
France	563	2,035	--	1	--	--	--	--	25	89
Germany, Federal Republic of	2,972	536	82	166	--	--	--	5	247	257
Japan	143	29	--	--	--	--	899	877	55	--
Netherlands	176	567	182	--	--	--	322	--	50	9
New Caledonia	--	--	--	--	--	--	2,564	3,045	--	--
Norway	12,342	18,947	110	--	17	--	--	--	--	--
Philippines	1,217	3,923	1,880	818	--	--	--	--	--	26
South Africa, Republic of	4,382	3,964	558	479	--	--	6	10	--	4
Sweden	20	566	1	4	--	--	--	--	--	41
U.S.S.R	4,420	60	20	--	--	--	--	--	--	--
United Kingdom	2,635	878	96	170	--	--	--	15	46	3
Zimbabwe	4,831	3,147	--	--	--	--	--	--	--	--
Other	119	849	20	2	--	--	4,891	3,604	153	444
Total	90,839	103,017	12,725	15,829	3,241	4,255	16,696	15,847	28,832	37,767

[e]Estimated.

WORLD REVIEW

As the world's largest producer over the past few years, the U.S.S.R. wields considerable influence over nickel markets. During 1983, this influence was spotlighted by allegations that Soviet nickel was being dumped on European markets at below cost, and some observers felt that the alleged dumping was a prime reason for the continued depressed nickel prices. Although a formal appeal to the European Economic Community Commission to impose a duty on Soviet nickel was eventually denied, further petitions for duties on Soviet nickel were threatened if the market deteriorated further. In 1984, however, Soviet nickel shipments dwindled considerably, drastically reducing nickel stocks in LME warehouses. The low LME stocks of nickel were at least partially responsible for the slight upward movement in nickel prices at yearend. Shrinking Soviet shipments and the upward price movement removed the threat of additional dumping charges being brought against the U.S.S.R.

Producers, worldwide, gradually expanded operations to about 75% of effective capacity. Major difficulties, technical and financial, kept Nonoc Mining in the Philippines from achieving the production levels it had hoped for and prevented Cuba's Punta Gorda refinery from reaching production targets. The civil strife in New Caledonia plus several strikes in Canadian and Australian nickel operations hampered nickel production. Canada regained a tie for the production lead with the U.S.S.R., and Australia remained the third largest nickel producing country. Indonesia stayed ahead of New Caledonia as fourth largest. Since about 40% of the world's nickel production was produced by companies that were partially or totally Government controlled, private mining companies were compelled to emphasize cost-cutting efforts to remain competitive.

Australia.—Ground control problems at the Agnew Mine, jointly owned by Seltrust Holdings Ltd., a subsidiary of British Petroleum Ltd. and Mount Isa Mines Holdings Ltd., reportedly restricted the amount of nickel sold to AMAX Nickel's Port Nickel refinery. A feasibility study conducted on a new deposit adjacent to the mine, containing 37 million short tons of material averaging 1.9% nickel, indicated that it could be mined at a rate of 22,000 short tons of nickel per year. Although mine development work and mill expansion were accordingly initiated, British Petroleum drastically curtailed expenditures to the mine in October, citing continuing heavy financial losses. This halted the new development and expansion efforts besides cutting the current work force by 110 contract miners and 60 staff members. The highly fractured nature of the rock spawned consideration of caving mining techniques at Agnew to replace the current stoping system. WMC's Kalgoorlie smelter continued to smelt the concentrate from the Agnew Mine into matte before it was shipped to AMAX Nickel's Port Nickel refinery in Louisiana.

Although production dropped at the Greenvale laterite mine, owned by Metals Exploration Ltd. and Freeport Queensland Ltd., the Yabulu refinery stepped up from 50% of capacity to 70%, buoyed by higher ore grades and improved operational efficiency. An intermittent strike staged by workers in September during labor negotiations apparently did not adversely affect shipments of nickel from the refinery. Conversion to coal from fuel oil resulted in significant cost savings. Most of Greenvale's nickel was refined to nickel oxide sinter (containing 90% nickel) and sold to Japanese steelmakers. Some nickel-cobalt concentrate was sold to Nippon Mining Co. Ltd. in Japan for production of nickel and cobalt metal. Greenvale also maintained a U.S. sales office for a portion of its oxide sinter production.

WMC essentially maintained nickel production at previous year's levels. Although a record amount of ore was produced, contained nickel in ore mined at Kambalda, WMC's largest mine, fell slightly as the average grade declined. A new rod mill was commissioned at the mine in September, increasing ore throughput rate by 444,000 tons of ore per year. At Mount Windarra, a sublevel caving system replaced the previous long-hole stoping method, providing potentially reduced mining costs. WMC's Kalgoorlie smelter, which processed concentrates from other companies as well as from its own mines, enjoyed record high production. Nickel produced in briquets at its Kwinana refinery fell very slightly. The United States is the biggest market for WMC's nickel, with European markets comprising the remainder.[11]

Botswana.—AMAX Nickel, 29.8% owner of BRST, continued to purchase the entire production of matte from BCL, a subsidiary of BRST, for its Port Nickel refinery. BCL produced about 40,000 tons of matte per year from the Selebi and Phikwe Mines. Late in the year, Falconbridge began negotiating with BCL for nickel matte to feed Falconbridge's refinery in Kristiansand, Norway. Although the terms being negotiated would be profitable for BCL, which has required major emergency loans during 1982-83, they would require AMAX Nickel to withdraw from its contract with BCL.

Brazil.—The three Brazilian nickel producers enjoyed healthy production increases in ferronickel and electrolytic cathode nickel. The booming Brazilian stainless steel production soaked up the increased nickel production and actually caused a sharp drop in nickel exports. Cia. Níquel Tocantins, for instance, exported only 10% of the cathode nickel that it refined in São Paulo; the remainder went to domestic steel producers. Tocantin's nickel was accepted by the LME on September 21. The company also produced nickel carbonate from its laterite deposit.

Assets of the Empresa de Desenvolvimento de Recursos Minerais S.A. (CODEMIN) were obtained by a group consisting of the Anglo American Corp. of South Africa Ltd., 50%; De Beers Consolidated Mines Ltd., 25%; and Minerals and Resources Corp. Ltd., 25%. CODEMIN operated a mine-smelter complex producing ferronickel at Niquelandia, Goiás. Along with export cuts by Brazil's other ferronickel mine, operated by Morro do Níquel S.A., CODEMIN sharply cut nickel exports to satisfy heavy demand by Brazilian stainless steel producers. The perceived lackluster world market for nickel, however, caused the shelving of a project to expand the CODEMIN operation to 11,000 short tons from 8,800 short tons per year of contained nickel.

BP Mineraço, a subsidiary of British Petroleum, discovered a nickel sulfide deposit in the State of Minas Gerais near Pratopolis. The deposit contains 5.5 million tons of material averaging 2.5% nickel.

Burundi.—The Government continued efforts to locate and define possible mineral resources for future exploitation. Peat received considerable attention for development as an energy resource; the Government, along with the European Development Fund, sponsored peat investigations by the Irish Peat Board and Ekono Oy of Finland. Development of an inexpensive peat fuel is considered critical to the ultimate development of the huge nickel deposits located in the country.

Canada.—Canada apparently regained a tie with the U.S.S.R. for the lead as the world's number one nickel producer. Although the major producers are still not operating at full capacity, they boosted production to meet a gradually strengthening demand.

Inco Ltd. remained the largest nickel producer among market economy countries despite operating at a fraction of its capacity. Rigorous cost-cutting efforts reduced unit costs to $2.30 per pound, the same as they were in 1980. These efforts featured converting more of the underground mining from conventional stoping methods to the more efficient vertical-crater-retreat method, which reduced mining costs from $31 per ton to $18 per ton and improved productivity by 26%. Further savings accrued by switching to mining equipment tailored to the bulk concept of vertical-crater-retreat methods.

Inco closed its Creighton No. 5 shaft in the Sudbury District, Ontario, following a rock burst on July 6. Employees were offered incentives to accept early retirement, effective September 30, to reduce the work force as dictated by the mine closure.

A scheduled 4-week summer shutdown of the Sudbury smelter was modified to permit continued operations at a reduced rate to improve the average daily sulfur dioxide (SO_2) emissions. Inco continued to study smelter modifications to reduce SO_2 emissions and developed a smelting process that would halve them. The $450 to $500 million capital expenditure that would be required to implement the process is, however, considered prohibitive. The Canadian Ministry of Environment has adopted a nationwide target of 50% reduction of SO_2 emissions over the period 1980-94 and in 1984 began considering financial incentives to help companies comply with the reduction.

The nickel refinery in Port Colborne, Ontario, reopened in early February following a 5-week closure for inventory adjustment. Beginning June 4, an 8-week closure was imposed at the refinery, consisting of 4 weeks for vacation and another 4 weeks to balance nickel flow within the Ontario Div. Following the summer closure, Inco reorganized its production of refined nickel to better focus on projected markets. At Port Colborne, production of electrolytic cathode nickel ceased and all nickel was produced as utility grade. This resulted in trimming the work force by 490, a cut of over 50%. Reportedly, 177 workers volunteered for early retirement; the rest were laid off. Electrolytic nickel production henceforth has been totally concentrated at the Thompson, Manitoba, refinery—primarily in the form of "S" and "R" rounds for electroplating. Also under the reorganization, high-purity nickel pellet production was boosted at the Copper Cliff refinery in Sudbury.

Inco's Manitoba Div. continued to operate the Thompson underground mine and the Pipe open pit mine, which together comprise about 28% of Inco's nickel production capacity. The company continued dredging overburden from the new Thompson open pit that is being developed immediately above the underground mine. A rock mechanics study completed in October verified that the new open pit would not endanger workers in the underlying underground mine and, conversely, that underground blasting would not impair highwall stability in the pit. Workers in the Manitoba Div. averted a strike on September 15 by voting to accept a 3-year contract containing no across-the-board wage increases and linking cost-of-living adjustments to the price of nickel.

Falconbridge remained the second largest nickel producer among market economy countries. Responding to several quarters of losses, Falconbridge continued its vigorous program of austerity, achieving a remarkable 30% reduction in the unit cost of producing nickel since 1981. During that time, the work force was trimmed by over 50%, including a considerable number of management officials.

As the nickel market showed signs of awakening in 1984, Falconbridge was able to recall 63 workers in January, 45 in February, and 250 temporary workers during the summer. A 2-year labor contract was signed in March with office and technical staff who had been working without a contract since July 1983. Mine and mill workers voted to accept a 3-year contract on May 4; the pact provided an average wage increase of 12.1%.

On June 20, a tragic rock burst at the Falconbridge No. 5 mine shaft killed four miners. After evaluating the damage, Falconbridge decided to permanently close the mine. During its 55-year life, the mine produced 35 million tons of ore and was currently providing about 10% of Falconbridge's production. The East Mine, connected to the Falconbridge No. 5 shaft, remained open. To make up the nickel shortfall caused by the closure, the Onaping Mine was reopened after being closed since 1982. Production was also boosted at the other Falconbridge mines in the Sudbury District—Craig, Fraser, Strathcona, and Lockerby.

Throughout the year, Falconbridge aggressively sought new sources of nickel to feed its refinery in Kristiansand, Norway. A partnership called Falconbridge Trading Associates was formed with Alloys and Carbides Inc., Stamford, CT, to buy nickel scrap and residues. Falconbridge also formed a London-based trading firm called Arkay Metals by joining with Metdist Ltd., an LME member, and entered negotiations with BCL, Botswana, to obtain BCL matte for the refinery.

Sherritt Gordon Mines Ltd. continued to operate its refinery in Fort Saskatchewan, Alberta, although its nickel mine has been closed since 1976. In 1984, nickel output was down slightly from that of 1983. On October 22, an explosion inadvertently sparked by welders halted nickel production for 1 week. Production resumed at its previous rate, which ranged from 50% to 75% of the plant's annual capacity of 44 million pounds.

A new company was formed in Sudbury, to market innovative mining equipment developed in Sudbury District nickel mines. The new company, Continuous Mining Systems Ltd., a subsidiary of Inco, was financed with Federal and Provincial government loans under the Regional and Industrial Expansion Program.

China.—China launched a major program to become more self-reliant for nickel than it currently is. Toward this end, development continued at the Jinchuan Non-Ferrous Metals Complex, in the Gansu Province. The district is currently responsible for about 80% of China's nickel production. Development focused on a planned smelter with 350,000 tons per year capacity of nickel concentrate to be built near the city of Jinchung. Finland's Outokumpu Oy licensed its flash smelter design to China via an agreement signed with China's National Non-Ferrous Metals Import and Export Corp. WMC, Australia, reportedly agreed to provide technical consultation on smelter construction.

Colombia.—The Cerro Matoso S.A. ferronickel plant continued to improve its production rate and by yearend was operating at 90% of its 22,600-ton-per-year capacity. The electric-furnace problems reported during 1983 apparently have been solved. A granulating plant was constructed based on technology obtained from Uddleholm Licensing AB, Sweden, for converting ferronickel into a shot form to make the product more attractive to steelmakers. Granules were first shipped to customers late in the year. Depending upon demand, Cerro Matoso can convert up to 100% of its production to granules.

The ferronickel produced by Cerro Matoso, containing 37.5% nickel, was marketed by Billiton Metals in the United States and in Japan. Billiton Metals and Ores International Ltd. holds a 47% interest in the mine, while the Government mining company, Empresa Colombiana de Niquel Ltda., holds 45%. Hanna let its share slide from 20% to 8%.

Cuba.—Although hampered by technical difficulties in starting its Punta Gorda refinery, Cuba continued its aggressive quest to become one of the top world nickel producers. Cuba and the U.S.S.R. signed an agreement in November 1984 that increased long-term Soviet investments in nickel facilities and guaranteed a market for Cuban nickel. Undaunted by the continuing U.S. embargo on imports of Cuban or Soviet nickel, Cuba has targeted 50% of the production increases for market economy countries.

As the first major step in boosting production capacity, the Punta Gorda refinery was opened in November, representing considerable slippage from its original timetable. In December, reports indicated that only the first line of the refinery had opened and that it would produce 6,600 to 8,800 tons in 1985 rather than an anticipated 11,000 tons. Foundations were laid for the Las Camariocas plant in October.

Dominican Republic.—Falconbridge Dominicana C. por A. continued to operate its ferronickel mine and plant near Bonao in the La Vega Province throughout the year. Production was up to about 80% of the 30,000-ton-per-year capacity. Much of the production was shipped to the United States, making the Dominican Republic the fifth leading source of nickel imports into the United States.

Finland.—Outokumpu Oy, the largest state-controlled mining and metals group in Finland, began developing a new nickel mine at Enonkoski in eastern Finland. Reserves at Enonkoski include 4.2 million short tons of ore averaging 1.2% nickel and 0.3% copper. Mining is expected to begin in 1986 at a rate of 440,000 tons of ore per year. Ore will be concentrated by flotation on the site at a rate of 6,600 tons per year. The concentrates will be shipped to Outokumpu's smelter and refinery at Harjavalta for electrolytic nickel production. The reserves are expected to last about 8 years and the mine will employ 110 to 120 people. Plans to develop the Sutkimo deposit have been shelved.

The Hitura Mine, which was closed at the end of 1982, was reopened in April 1984 with mine production commencing in late June at an anticipated rate of 550,000 tons of ore per year. Remaining reserves of 0.5% nickel are expected to last 2 years. The Harjavalta refinery also received nickel concentrate from two other Finnish mines—Vammala and Kotalahti. The majority of its feed material was, however, imported. The refinery was shut down for 5 weeks during the summer for repair and maintenance. It operated at 80% to 85% of its total capacity of 77,000 short tons of nickel per year.

Sales offices were opened in Detroit, MI, in 1983 and in Tokyo, Japan, in September 1984, as Outokumpu sought to strengthen its marketing. Outokumpu continued to export its flash smelting technology. For example, China signed an agreement to obtain smelter designs from Outokumpu. Outokumpu continued to provide technical advice to the Noril'sk refinery complex in the U.S.S.R.

France.—Although France has no nickel mines, Société Métallurgique Le Nickel (SLN) operated two refineries at Le Havre. The original Le Havre refinery, which opened in 1890, produced only nickel salts in 1984. The main refinery, Sandouville, commissioned in 1978, continued to produce a high-purity (99.98%) nickel as well as nickel salts. Its combined capacity totals 22,000 tons. SLN's smelter on New Caledonia, the main source of nickel matte for the refinery, was able to continue matte shipments unhampered by civil strife that emerged on the island.

Greece.—The ferronickel producer, Larco S.A., continued to operate under 75% ownership by the Government following the financial restructuring of 1982. Production at the Larymna plant increased slightly to about 60% of its 25,000-ton-per-year capacity.

Plans to develop large, low-grade nickel laterite deposits at Triada Makytara on the island of Euboea were shelved owing to the nickel market's plummet in 1982.

India.—Inco Tech Inc. apparently dropped its proposal to develop a nickel matte roasting facility for producing nickel oxide sinter and a sulfuric acid leaching and electric arc furnace plant for producing a utility-grade nickel pig adjacent to the Vishakhapatnam smelter operated by Hindustan Zinc Ltd. Since the facilities would be fed by matte from P.T. International Nickel Indonesia's (P.T. Inco) Soroako Mine in Indonesia, India's duty on imported nickel remained an obstacle to this development.

The blossoming steel industry in India required active nickel purchasing by Minerals and Metals Trading Corp. (MMTC), the Government-owned purchasing agency. Nickel tenders at yearend contained clauses listing preference for suppliers willing to carry 3 months' inventories in India and to agree to resale by MMTC of purchased nickel to third countries. Some observers felt that these clauses were inserted so that MMTC could establish itself as a dealer.

Indonesia.—Although Indonesia has a tremendous potential for mineral development, nickel was produced from only two mines. Indonesian resources generally have been developed by foreign companies via a Contract of Work that provided for transferring at least 51% of the equity to Indonesia after 10 years of production and for training Indonesians to ultimately take over operations. In an attempt to spark more foreign investment in its resources, in 1984 the Government began to consider adjustments in its tax structure and to permit exploitation under joint venture agreements.

P.T. Inco experienced problems with one of its three furnaces producing nickel matte at the Soroako smelter soon after moving to full production capacity at the end of 1983. Although the furnace was closed for repairs from January 1984 through most of March, P.T. Inco nevertheless enjoyed a healthy production increase, which contributed to Indonesia's increased matte production.

P.T. Aneka Tambang (ANTAM), the Government-owned ferronickel producer at Sulawesi, continued selling directly to Japanese steel companies, Nippon Yakin Kogyo Co., Nisshin Steel Co., and Nippon Steel Corp. ANTAM also sold some ore directly to Japanese smelters. Although ANTAM'S ferronickel exports to Japan dropped slightly from those of 1983, Indonesia continued to rank second behind New Caledonia in supplying nickel to Japan.

Ivory Coast.—Interest in the Sipilow deposit in the Ivory Coast waned. Obtaining an adequate power supply was the big impediment; the price of nickel did not justify the expense of installing sufficient generating capacity for a mine-smelter complex.

Japan.—Japan was the second largest nickel consumer in the market economy countries behind the United States. The rebound in stainless steel production in Japan created a commensurate rebound in nickel consumption as well. Nickel processing facilities responded with sharp increases in production of ferronickel and nickel metals. Since there are no nickel mines in Japan, all nickel feedstock for smelters and refineries was imported, primarily from Indonesia, New Caledonia, and the Philippines. Most of the nickel arrived as ore concentrate and matte; ferronickel and refined nickel also were imported to augment domestic production.

Sumitomo Metal Mining Co. Ltd. suspended metallic nickel and cobalt production from its Niihama refinery in April after Nonoc Mining in the Philippines suspended shipments of nickel sulfide concentrates. During the shutdown, the refinery was remodeled to increase its capacity from 2,100 tons of nickel per month to 2,200 tons. The refinery reopened, processing nickel concentrates from Indonesia and New Caledonia, but experienced difficulties in obtaining cobalt concentrates.

Imports of nickel cathodes from the U.S.S.R. increased when the closure of Nonoc Mining tightened available sources of nickel.

New Caledonia.—After several years of declining production, New Caledonia registered a modest rebound in nickel produced in ore, matte, and ferronickel in 1984. Most of the ore was produced at SLN's Meaba Mine near Kouaoua and its Camp Des Sapins and Le Plateau Mines at Thio. Three independent operators on the northern end of the island also shipped significant quantities of nickel ore to Japan.

SLN began the year operating two of the three electric furnaces at its Doniambo smelter near Noumea. A crack in one of the operating furnaces necessitated its repair from January to March. In April, after restarting the repaired furnace, SLN announced a decision to fire the third furnace in September as nickel demand began to pick up.

In November, civil disorder flared on the island as Kanak natives demonstrated their desire for severing ties with France. A separatist roadblock of the mines at Thio beginning in November effectively closed the mines. Stockpiles of nickel ore at the Doniambo smelter as well as continued production from the Meaba Mine enabled the smelter to continue ferronickel and matte shipments without impairment.

Norway.—Falconbridge Nikkelverk A/S, a subsidiary of Falconbridge Ltd., operated its refinery at Kristiansand, primarily with feed from Falconbridge's Canadian smelters in Sudbury, Canada. The abundant low-cost hydroelectric power at the refinery made it more economical to refine nickel in Norway despite of the shipping costs from Canada. The refinery provided 11% of the U.S. nickel imports. Falconbridge began actively seeking additional sources of nickel to run the refinery at closer to full capacity. A company was formed in the United States to obtain nickel-bearing scrap and residues for the refinery; negotiations were opened with several companies—most notably BCL in Botswana—to purchase nickel matte.

The only nickel mined in Norway was a byproduct of ilmenite mining at Sokndal on the southern coast. Concentrate from this mine was processed at Outokumpu Oy's refinery at Harjavalta, Finland.

Papua New Guinea.—Nord Resources Corp., apparently still seeking a partner in the development of the Ramu River chromite-nickel-cobalt deposit located near Madang in Marum, announced that no development of the deposit would be undertaken before 1986.

Philippines.—Early in 1984, Marinduque was restructured to try to ease the oppressive debt burden. As part of the restructuring, the state-owned Development Bank of the Philippines and the Philippine National Bank increased their combined share of Marinduque from 36% to 87%. In April, a $9.6 million loan from Philipp Bros.,a metal trading firm, was used as operating capital for reopening the Marinduque's Surigao nickel mine-refinery complex. The loan reportedly ensured that Philipp would become the agency for Marinduque nickel. Operations resumed in June, although considerably below the rated capacity. Nickel briquets reportedly were delivered to Philipp for sale in the United States and Europe. On August 31, the two controlling banks bought the company at a foreclosure auction and formed a new operating company, Nonoc Mining. The banks instituted these proceedings to protect their interest in the operation from claims by a variety of lesser creditors. Several days later, typhoons extensively damaged two coal unloading cranes and a power transmission line at the refinery. Repairs and rehabilitation were completed in November. Operations resumed in November after a $5 million loan was secured from Marc Rich, another trading firm, in exchange for Marc Rich's becoming the agent for Nonoc nickel. By December, the refinery was operating at 75% of its capacity of 31,000 tons per year. In hopes of finding a process that would lower its costs, Nonoc Mining signed a letter of intent with Ni-Cal Technology to establish a pilot plant demonstration at the Surigao refinery of the acid-leach process developed by Ni-Cal Developments for the laterite deposits in northern California.

Despite the production difficulties at Nonoc Mining, the Philippines was able to boost nickel production over that of 1983, by dint of efforts at the other two mines in the Philippines. Rio Tuba Nickel Mining Corp. operated its mine on Palawan Island at about one-half of its rated capacity of 1 million tons of ore per year. An expansion in facilities was studied with assistance of Japanese and Swedish firms. The Japanese firms worked on an economical source of power while the Swedish firms conducted experiments on various metallurgical processes. Nickel ore was also produced from a mine operated by Hinatuan Mining Corp. on Hinatuan Island although its capacity is only one-tenth that of the Rio Tuba operation. Both mines shipped their ores to Japanese ferronickel smelters.

Saudi Arabia.—Interest in developing the Wadi Qatan deposit has essentially vanished owing to the excessive costs for developing the support infrastructure that would be required.

South Africa, Republic of.—Nickel production in the Republic of South Africa exhibited a healthy increase. Nickel was mined as a byproduct of underground mining for platinum in the Merensky Reef near Rustenburg, Transvaal. The strong demand for platinum enabled the companies to operate at near capacity. Rustenburg Platinum Mines Ltd. operated three mines in the district and produced a copper-nickel matte at its smelters. Nickel was produced at a refinery with a capacity of 21,000 tons per year, in Germiston, Transvaal. Rustenburg and Johnson Matthey PLC were joint owners of the refinery. Impala Platinum Holding (Pty.) Ltd. operated four mines near Rustenburg. A matte containing 50% nickel was produced at its plant on the minesite. Refined nickel was produced at the company's refinery in Springs, east of Johannesburg, using an ammonia leaching process. The refinery has a capacity of 8,800 tons of nickel per year. Western Platinum Ltd. (Wesplat) produced a copper-nickel matte from ore from its mine near Marikana at about the same rate as it did during 1983. The matte was shipped to Falconbridge's Kristiansand refinery in Norway for recovering the precious metals.[12] Wesplat announced plans to construct its own nickel refinery near Rustenburg to cut costs and shorten the processing time. The refinery is expected to be completed by the end of 1985 and to begin production early in 1986 with capacity of 4 million pounds of nickel per year contained in nickel sulfate.

Taiwan.—The refinery built by Talent Metals Corp. opened at yearend somewhat later than its March 1984 planned completion date. The 700-short-ton-per-year plant was established to convert nickel oxide provided by Inco Ltd., which has a 30% interest in Talent Metals, into a utility-grade nickel pig for Taiwan's growing stainless steel and nickel sulfate industries.

U.S.S.R.—The U.S.S.R. has been the world's top nickel-producing country since Canadian mines cut their production during the nickel market downturn in 1982. In 1984, a resurging Canadian production coupled with a modest increase in Soviet production enabled Canada to tie the U.S.S.R. for the lead. In 1983, large amounts of heavily discounted Soviet nickel sold on the LME were a major factor in the low price for nickel throughout the year. During 1984, Soviet nickel shipments dwindled, which caused the LME nickel inventories to shrink and allowed the price to inch upward by yearend.

The U.S.S.R. produced electrolytic cathode nickel from its 88,000-ton-per-year Noril'sk refinery in Siberia and its recently refurbished 82,000-ton-per-year Severonikel Montchegorsk refinery on the Kola Peninsula. Six Noril'sk mines accounted for about 70% of the Soviet nickel production. In the Ural Mountains, high-purity carbonyl nickel was produced at the Khalilovo plant. A small amount of ferronickel was also produced at the Pobuzhsk smelter in the Ukraine.[13]

The embargo imposed on Soviet nickel by the United States, owing to the refusal of the Soviets to certify that its nickel shipments contained no Cuban nickel, apparently did not drastically curtail the ability of the Soviets to market nickel. As long as the embargo does not extend to products containing Soviet nickel, the nickel can be sold to other countries that do not have to account for the nickel sources in products that may be sold to the U.S. consumers. Japanese consumers, for instance, hampered by failure of Nonoc Mining of the Philippines to achieve expected nickel production levels, purchased more Soviet nickel in 1984 than they did in 1983.

United Kingdom.—Inco Europe Ltd. operated its Clydach refinery in Wales at a rate of 50 million pounds per year compared with its rated capacity of 120 million pounds. Even at that low rate, refinery inventories swelled during the year. Stringent efforts to streamline its work force resulted in permanent layoffs by Inco Europe of 40% of the employees in its marketing staff effective in March. Inco Europe closed its large nickel alloys rolling mill at Wednesbury, laying off over 300 workers. Early in the year, Inco Ltd. merged Wiggin Alloys with its U.S. subsidiary, Huntington Alloys, to form Inco Alloys International.

International Metals, the recycling division of Billiton (United Kingdom) Ltd., closed its nickel alloy segregation and processing facility at West Winch and consolidated its production with that of the Rainham plant in Essex.

Yugoslavia.—After opening in August 1983, the ferronickel smelter at Glogovac in the Kosovo region operated throughout 1984 on ore from the Glavica and Cikatovo Mines. The plant was operated by Rudnik i Topionica Feronikl. The Kavadarci smelter, with its mine at Rzanovo in Macedonia, closed in March after absorbing high losses owing to continued depressed nickel prices and high unit operating costs. The Kavadarci complex was plagued with submarginal ore grades and erratic power supplies throughout its relatively brief life.

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

(Short tons of nickel content)

Country	1980	1981	1982	1983[p]	1984[e]
Albania (content of ore)[e]	6,100	6,200	6,400	6,400	6,600
Australia (content of concentrate)	81,927	[r]81,963	96,510	84,465	82,900
Botswana (content of matte)	17,022	18,200	19,573	20,079	19,300
Brazil (content of ore)	[r]2,504	[r]2,573	5,306	11,840	12,100
Burma (content of speiss)	15	22	[e]22	[e]22	22
Canada[2]	203,709	176,642	97,824	134,300	192,000
China[e]	12,000	12,000	[r]13,200	[r]14,300	15,400
Colombia (content of ferroalloys)	--	--	1,100	15,000	15,400
Cuba (content of oxide, sinter, sulfide)	40,338	42,489	39,790	[r e]41,500	35,050
Dominican Republic	18,019	20,601	5,838	23,369	[3]26,698
Finland (content of concentrate)	7,199	7,566	6,852	5,418	5,500
German Democratic Republic[e]	3,000	3,000	2,800	2,400	2,300
Greece (recoverable content of ore)[4]	16,796	17,200	[r e]5,500	[r e]18,500	18,400
Guatemala	7,650	--	--	--	--
Indonesia (content of ore)[4]	58,739	53,848	50,578	54,430	68,900
Morocco (content of nickel ore and cobalt ore)	148	[r]144	140	--	--
New Caledonia (recoverable content of ore)	95,451	86,079	66,250	43,542	45,200
Norway (content of concentrate)[e]	[r]2,200	[r]7,700	[r]3,900	[r]4,000	3,900
Philippines	51,934	32,239	22,183	17,522	18,300
Poland (content of ore)[e]	2,300	2,300	2,300	2,300	2,300
South Africa, Republic of	28,329	29,100	[e]24,250	[e]22,600	27,600
U.S.S.R. (content of ore)[e]	170,000	174,000	182,000	187,000	192,000
United States (content of ore shipped)	14,653	12,099	3,203	--	[3]14,540
Yugoslavia (content of ore)[e]	2,200	4,400	[r]4,400	[r]3,300	4,400
Zimbabwe (content of concentrate)	16,617	14,350	14,671	11,186	11,080
Total	[r]858,850	[r]804,715	674,590	723,473	819,890

[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 7, 1985.

[2]Refined nickel and nickel content of oxides and salts produced, plus recoverable nickel in exported mattes and speiss.

[3]Reported figure.

[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]	1980	1981	1982	1983[p]	1984[e]
Australia[3]	38,921	46,854	50,630	46,077	[4]42,615
Brazil[5]	2,760	2,574	5,305	11,840	13,200
Canada[6]	167,881	[r]120,486	64,635	[e]96,100	114,600
China[e]	[r]12,100	[r]12,100	[r]13,200	[r]14,300	15,400
Colombia[5]	--	--	[r]1,450	14,400	18,150
Cuba[7]	8,737	9,355	9,910	[e]10,000	8,800
Czechoslovakia[e]	[4]2,240	[r]2,400	[r]2,400	[r]2,400	2,400
Dominican Republic[5]	18,019	20,601	5,812	22,300	24,300
Finland	14,117	14,672	13,906	16,355	15,400
France[6]	10,802	[r]11,079	8,114	5,268	5,500
German Democratic Republic[e]	3,300	3,100	3,300	[r]3,300	3,300
Germany, Federal Republic of[e 8]	[4]1,361	1,320	1,320	1,320	1,100
Greece	15,300	14,000	[r e]5,000	14,174	16,500
Indonesia[5]	4,873	5,184	5,523	5,352	5,500
Japan	108,428	95,679	91,886	76,667	81,100
New Caledonia[5]	35,913	30,853	30,871	28,985	38,400
Norway	[9]40,921	[9]40,890	28,268	31,205	31,000
Philippines	27,978	23,683	12,458	10,460	4,740
Poland	1,984	1,653	772	331	330
South Africa, Republic of	19,950	19,800	15,900	18,740	19,840
U.S.S.R.[e]	189,600	196,200	198,400	204,000	214,000
United Kingdom	21,275	27,999	7,606	25,574	23,100
United States	44,225	48,805	44,956	33,400	[4]44,933
Yugoslavia	--	--	[r e]1,700	[r e]1,700	2,200
Zimbabwe[e]	15,500	13,200	[r]13,200	[r]10,100	10,000
Total	[r]806,185	[r]762,487	636,522	704,348	756,408

[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 7, 1985.

[2]In addition to the countries listed, Albania is known to have initiated smelter production in 1978, and 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 produce 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: 1980—35,825 (revised); 1981—36,223; 1982—54,444 (estimated); 1983—55,560 (revised, estimated); and 1984—56,330 (estimated); Botswana: 1980—17,022; 1981—20,143; 1982—19,573; 1983—20,080; and 1984—19,840 (estimated); Indonesia: 1980—22,634 (revised); 1981—21,980 (revised); 1982—15,150 (revised); 1983—20,469 (revised); and 1984—32,000 (estimated); and New Caledonia: 1980—17,063; 1981—16,954; 1982—7,875 (revised, estimated); 1983—7,800 (estimated); and 1984—7,800 (estimated).

[3]Refined nickel plus the nickel content of oxide.

[4]Reported figure.

[5]Nickel content of ferronickel only. (No refined nickel is 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 to avoid double counting, as they may be processed to metal elsewhere. Output of sinter was as follows in short tons: 1980—13,069; 1981—13,354; 1982—12,963; 1983—11,400 (estimated); and 1984—9,900 (estimated). Output of processed sulfide was as follows, in short tons: 1980—18,532; 1981—19,779; 1982—16,920; 1983—19,800 (estimated); and 1984—19,800 (estimated).

[8]Includes nickel content of nickel alloys.

[9]Data derived from estimated metal content of reported concentrate.

Zimbabwe.—The Eiffel Flats refinery of Rio Tinto (Zimbabwe) Ltd. (RTZ) remained closed, a result of losing matte from BCL in Botswana when AMAX Nickel contracted for BCL's entire output in 1983. Toward yearend 1984, negotiations by Falconbridge with BCL for most of BCL's matte sprouted feelers from RTZ for the remainder of the matte.

The Bindura Nickel Corp. Ltd. operated the only nickel mining and refining complex in the country. Nickel ore was produced from four mines: the Epoch, Madziwa, Shangani, and Trojan. Proven reserves at the four mines total 4.7 million tons at grades ranging from 0.56% to 0.63% nickel. If additional reserves are not found, the Madziwa and Epoch Mines will be exhausted in 9 years while the other two can remain open for 15 years. The Trojan Mine, largest of the four, produced sulfide ore in 1984 from underground workings by block-caving methods. The ore was crushed at the mine and concentrated by flotation. The concentrate was smelted to a matte that was in turn leached to produce cathode nickel in the refinery. Led by rising power costs, the unit cost for producing nickel rose 24% over that of 1983.[14]

TECHNOLOGY

Mining and Processing.—A new company was formed in Sudbury, Canada, to market innovative mining equipment developed in Sudbury District nickel mines. The new company, Continuous Mining, was financed as a subsidiary of Inco Ltd., with Federal and Provincial government loans under the Regional and Industrial Expansion Program. Initially, three new machines were marketed: a continuous loading machine for tunneling and drawpoint loading; an automated down-the-hole blasthole drill; and a remote-controlled, battery-operated locomotive. The company also negotiated for rights to produce a portable jaw crusher. Besides providing a means to market new mining ideas, the new company will help offset recent cutbacks in employment at nickel mines in the Sudbury District.[15] Canadians have been leaders in developing long-hole open-stoping techniques, vertical-crater-retreat mining systems, and underhand-cut-and-fill methods now being adapted by companies operating in deep hard-rock mines.

Much of the impetus in developing new nickel technology was the quest to develop techniques that are less energy intensive than are current ones. Burgeoning energy costs have burdened nickel producers with financial difficulties. Alternatives to the energy intensive direct calcining-smelting and ammonia leaching processes that are used for many laterites have been actively sought. In the United States, Ni-Cal Developments and its subsidiary, Ni-Cal Technology, announced a letter of intent from Nonoc Mining to negotiate an agreement whereby a pilot-scale acid leaching unit would be constructed at the Surigao refinery in the Philippines. The pilot facility would be based upon technology that Ni-Cal Developments and Raymond Kaiser Engineers have developed for the Gasquet Mountain nickel laterite deposit in northern California.[16] The process features an acid leach to provide intermediate nickel-cobalt hydroxide followed by an extraction step using ammonia that eventually enables a plant to recover metallic nickel and cobalt. Magnesium oxide, salable to chemical companies, is a significant byproduct of the process. Ni-Cal Developments claimed that its process offers possible significant cost savings in nickel refining by improving metal recovery rates, especially for byproduct cobalt, and reducing the energy consumption. Ni-Cal Technology, applied to the Del Norte County Planning Commission in California for approval to construct a research center and demonstration plant in the town of Smith River, CA, to facilitate marketing its process.

Compagnie Française d'Entreprises Minières, Métallurgiques et d'Investissements, the French mining company owned by Bureau de Recherches Géologiques et Minières of France, 51%, and AMAX Inc., 49%, announced that it too is offering the licensing of its hydrometallurgical technique for processing laterite nickel ores.[17] The process, involving high-pressure leaching with sulfuric acid, has been extensively tested during several thousand hours' operation in a 25-ton-per-day pilot plant at AMAX Nickel's facilities in Golden, CO. Originally developed for deposits on the island of New Caledonia, the process could be applied to other laterite deposits such as those of California and Oregon. The process yields nickel sulfates that would require additional refining. It also offers lower energy costs and doubled byproduct cobalt recovery over current ammonia leaching processes.[18]

Nickel Products.—The excitement in new nickel product development occurred in the production of metal powders and rapid solidification technology. A 5-year Air Force research program led to the development of two new superalloys that have extremely high resistance to corrosion and oxidation. Although their precise formulations were not revealed, the cobalt-free alloys (named Alloy X and Alloy Y) are basically nickel aluminides. Formed by rapid powder solidification at very high cooling rates, the alloys were tested for application as gas turbine components for a new series of fighter jet engines.[19]

Cabot Corp., Kokomo, IN, announced development of a new nickel alloy designated C-22. The alloy is claimed to offer improved high-temperature and acid corrosion resistance over that of previous nickel alloys containing chromium and will be targeted for various chemical industry applications.[20] Meanwhile, Marko Materials Inc., North Billerica, MA, reportedly has entered a partnership with two Japanese firms to produce and market amorphous powder alloys based on cobalt, copper, iron, and nickel. Marketed under the trade name Markomet, the alloys will be used for production of electronic parts, carbide tools, and specialty machine tools.

The Bureau of Mines introduced a new method to quickly and economically dissolve bulk superalloy scrap. Since superalloys are corrosion resistant, they are difficult to recycle because they cannot be readily dissolved in acids. The Bureau method features melting the superalloy scrap along with aluminum or zinc (30%), which upon cooling forms a brittle compound. This compound is easily crushed to a small particle size, which readily dissolves in acid.[21]

Several Japanese firms have joined the shift to producing a 42 nickel-ferroalloy lead frame material for integrated circuitry applications. The material is replacing a copper alloy because of its superior hardness, competitive cost, and adaptability to high-speed assembly procedures.[22]

The National Bureau of Standards announced that it received a patent for and will license a new process for electroplating nickel-chromium alloys onto carbon steel. Developed at the request of the American Electroplaters' Society, the new process could prompt substantial substitution of inexpensive, plated-carbon steel for stainless steel.[23]

End Uses.—The Maritime Administration, the Copper Development Association, and the Newport News Shipbuilding & Drydock Co. completed the second of three phases of a contract to determine the costs and benefits of sheathing ships' hulls with sheets of a 90% copper- 10% nickel alloy. The study indicated that by preventing corrosion and barnacle growth, the protective sheeting reduced drydock time and cut fuel consumption by 20%.[24]

The French automaker Peugeot announced the development of a prototype electric vehicle. The automobile, model 205E, was not intended for mass production but will be used to evaluate design concepts for future models. Based on the Peugeot European 205 subcompact, the automobile reportedly had a maximum range of 124 miles and a top speed of 62 miles per hour. It was powered by twelve 6-volt nickel-iron batteries driving a 17.5-kilowatt electric motor. Nickel-iron batteries were chosen because they could produce twice the energy as lead-acid batteries of the same weight and volume. Nickel-iron batteries also last longer with an estimated life of 125,000 miles and 1,500 recharge cycles.[25]

A nickel alloy, announced in 1983, may make inroads into the porcelain china market. Developed by Cabot Corp., Kokomo, IN, the 214 alloy is undergoing full-scale tests as a replacement for traditional materials used to support chinaware in kilns. The alloy contains mostly nickel with 16% chromium, 4.5% aluminum, and 3.5% iron. The alloy is readily workable into convenient shapes, can be subjected to numerous heating and cooling cycles, forms a nonflaking oxide when heated, and results in substantial energy cost savings during kiln firing.[26]

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[1]Physical scientist, Division of Ferrous Metals.

[2]Federal Register. National Oceanic and Atmospheric Administration. (Dep. Commerce). Deep Seabed Mining; Issuance of Exploration License. V. 49, No. 179, Sept. 13, 1984, pp. 35973-35974.

———. National Oceanic and Atmospheric Administration (Dep. Commerce). Deep Seabed Mining; Issuance of Exploration License. V. 49, No. 218, Nov. 8, 1984, pp. 44661-44662.

[3]———. Environmental Protection Agency. Issuance of Final General NPDES Permit for Portions of Deep Seabed Mining Exploration Activities in the Pacific Ocean. V. 49, No. 195, Oct. 5, 1984, pp. 39442-39461.

[4]U.S. Congress. Comprehensive Environmental Response, Compensation, and Liability Act. Public Law 96-510, Dec. 11, 1980, 94 Stat. 2767.

[5]Rogers, J. Falconbridge Eyes BCL's AMAX Output. Am. Met. Mark., v. 92, No. 242, 1984, pp. 1, 28.

[6]U.S. Congress. California Wilderness Act. Public Law 98-425, Sept. 28, 1984.

[7]Buckingham, D. A., and J. F. Lemons, Jr. Nickel Availability—Domestic. A Minerals Availability Program Appraisal. BuMines IC 8988, 1984, 27 pp.

[8]Calculated according to the procedure contained in "Chromium Contained in U.S. Produced Stainless and Heat Resisting Steels," by J. F. Papp. Proceedings of Bureau of Mines Open Industry Briefing on Chromite/Chromium, to be presented June 4-5, 1985; copy available from author, Bureau of Mines, 2401 E St. NW, Washington, DC 20241.

[9]Metals Week. Metals Week Annual Prices. V. 56, No. 1, Jan. 7, 1985, p. 10.

[10]Wall Street Journal. Plot of Morgan Guarantee Index Versus 15 Currencies. V. 205, No. 62, Mar. 29, 1985, p. 57.

[11]Western Mining Corp. Holdings Ltd. Annual Report 1984. Melbourne, Australia, Sept. 1984, 16 pp.

[12]Roskill Information Services Ltd. The Economics of Nickel, 4th Edition. London, 1984, 309 pp.

[13]Work cited in footnote 12.

[14]Butts, K. H. Trip report provided to U.S. Consulate General Office, Republic of South Africa. Available from author at U.S. Military Academy, Dep. of Geography and Computer Science, West Point, NY 10996-1695.

[15]Whiteway, P. Canadian Mine Machinery Company Opens in Sudbury. The Northern Miner, v. 70, No. 30, Oct. 25, 1984, pp. 1, 23.

[16]Rogers, J. Marinduque Eyes Acid Leaching for Nickel. Am. Met. Mark., v. 92, No. 207, Oct. 23, 1984, pp. 1, 11.

[17]AMAX Technical Services. The AMAX Acid Leach Process. Company brochure available from 1707 Cole Blvd., Golden, CO 80401.

[18]Kay, H., and E. J. Michal. The AMAX Acid Leach Process for Oxide Nickel Ores. Metallurgical Soc., AIME, Paper N. A 78-36. Metall. Soc., AIME, NY, 1978, 18 pp.

[19]Rogers, J. Air Force Develops Engine Superalloys "X", "Y." Am Met. Mark., v. 92, No. 201, Oct. 15, 1984, pp. 1, 35.

[20]———. Cabot Banking on New Hi-Temp Nickel Alloys. Am. Met. Mark., v. 92, No. 251, Dec. 31, 1984, p. 251.

[21]Atkinson, G. B. Increasing the Leaching Rate of Bulk Superalloy Scrap by Melting With Aluminum. BuMines RI 8833, 1983, 11 pp.

[22]Tex Report. 42 Ni-Ferroalloy Lead Frame: Existing State of Distribution. V. 16, No. 3,825, Oct. 30, 1984, pp. 19-20.

[23]Yahalom, J., D. S. Lashmore, and I. Weisshaus. Pulse Plated Ni-Cr Alloys—Electrochemical Evaluation. National Bureau of Standards report. Reviewed in Met. Prog., v. 126, No. 8, Dec. 1984. pp. 14, 16; available from second author at the National Bureau of Standards, Gaithersburg, MD 20899.

[24]Brooks, R. Costs To Be Calculated for Alloy Hull Sheathing. Am. Met. Mark., v. 93, No. 28, Feb. 11, 1985, p. 21.

[25]Advanced Battery Technology. Peugeot Unveils Nickel-Iron Electric Vehicle. V. 21, No. 1, Jan. 1985, pp. 1-2.

[26]Rogers, J. Nickel Alloys Bull Way Into Porcelain China Market. Am. Met. Mark., v. 93, No. 1, Jan. 3, 1985, p. 5.

Nitrogen

By Charles L. Davis[1]

U.S. production of anhydrous ammonia, 82.2% nitrogen, was 18% greater than in 1983, but about the same as in 1982. The total value of ammonia produced and sold was about $2.7 billion. The value of apparent consumption was about $3 billion. Production and apparent consumption values were based on average annual 1984 f.o.b. gulf coast spot prices. A 47% increase in total tonnage of exported ammonia was attributed to aggressive marketing practices by U.S. ammonia exporters. Imports of ammonia increased 24%. Efforts to pass protective national legislation were not successful.

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 130 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)

	1980	1981	1982	1983	1984[p]
United States:					
Production[1] [2]	16,244	[r]15,732	[r]13,029	11,297	13,309
Exports	681	506	610	298	438
Imports for consumption	1,921	1,719	1,737	2,169	2,699
Consumption[2] [3]	[r]17,754	[r]16,467	[r]14,145	13,719	15,287
World: Production	[r]81,169	[r]84,469	83,114	[p]85,414	[e]90,176

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Synthetic anhydrous ammonia and coke oven ammonia.
[2]Coke oven ammonia not available for 1984.
[3]Includes producers' stock changes in synthetic anhydrous ammonia and coke oven ammonia.

DOMESTIC PRODUCTION

The results of an improving U.S. economy extended to the agricultural chemicals industry. Production of anhydrous ammonia reached a level slightly higher than that of 1982. Some plants that had been idle came back on-line, and several plant retrofit projects to improve energy efficiency were initiated. Monthly production of ammonia was above that of 1983 for the entire year. The greatest production was in December and amounted to almost 1.5 million short tons. U.S. ammonia plants operated at better than 98% of capacity, not including inactive or permanently closed plants. Ammonia was produced by 46 companies at 59 plants in 25 States.

Table 2.—Fixed nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1980	1981	1982	1983	1984[p]
Anhydrous ammonia, synthetic plants[1]	16,155	15,655	12,968	11,246	13,309
Ammonium compounds, coking plants:					
Ammonia liquor	7	2	5	5	NA
Ammonium sulfate	82	75	56	46	NA
Ammonium phosphates	(2)	(2)	(2)	(2)	NA
Total	16,244	r15,732	r13,029	11,297	13,309

pPreliminary. rRevised. NA Not available.
1Current Industrial Reports, Bureau of the Census.
2Included with ammonium sulfate to avoid disclosing company proprietary data.

Table 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compound	1982	1983	1984[p]
Acrylonitrile	1,018	1,073	1,101
Ammonium nitrate	7,091	6,628	7,009
Ammonium sulfate[1]	1,768	1,964	2,107
Ammonium phosphates	10,307	12,814	14,468
Nitric acid	7,390	7,367	8,016
Urea	6,518	5,771	7,138

pPreliminary.
1Excludes ammonium sulfate from coking plants.

Sources: Bureau of the Census and International Trade Commission.

Table 4.—Domestic producers of anhydrous ammonia in 1984

(Thousand short tons per year of ammonia)

Company	Location	Capacity
Agrico Chemical Co	Donaldsonville, LA	468
Do	Verdigris, OK	840
Do	Blytheville, AR	407
Air Products & Chemicals Inc	New Orleans, LA	210
Do	Pace Junction, FL	100
Allied Chemical Corp	Hopewell, VA	425
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
CF Industries Inc	Donaldsonville, LA	1,590
Chevron Chemical Co	Pascagoula, MS	530
Do	El Segundo, CA	20
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. du Pont de Nemours & Co. Inc	Beaumont, TX	340
Do	Victoria, TX	100
Farmland Industries Inc	Hastings, NE	140
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 Co	Creston, IA	35
Hawkeye Chemical Co	Clinton, IA	220
Hercules Inc	Louisiana, MO	70
Hooker Chemical Co	Tacoma, WA	28
International Minerals & Chemical Corp	Sterlington, LA	400
Jupiter Chemical Co	Lake Charles, LA	78

Table 4.—Domestic producers of anhydrous ammonia in 1984 —Continued

(Thousand short tons per year of ammonia)

Company	Location	Capacity
Kaiser Agricultural Chemicals Co	Pryor, OK	68
Mississippi Chemical Corp	Yazoo City, MS	393
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 Chemicals International Inc	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		17,558

Source: Economics and Marketing Research Section, Tennessee Valley Authority. World Fertilizer Capacity, Ammonia. Muscle Shoals, AL, Jan. 10, 1985.

CONSUMPTION AND USES

The 11% increase in domestic ammonia consumption reflected an improved U.S. economy and demand. Imports of anhydrous ammonia increased 24%. 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 1.4 million tons of contained nitrogen. At yearend, stocks totaled about 1.7 million tons of contained nitrogen. The increase in stocks reflected an improving economy and demand that encouraged producers to keep more product on hand.

PRICES

Ammonia prices rose early in the year to the annual high of $203 per ton, then began a steady decline until they reached the annual low of $143 in mid-June. A small price increase occurred through the autumn; the yearend price was $145.

Table 5.—Price quotations for major nitrogen compounds at yearend 1984

(Per short ton)

Compound	Price
Anhydrous ammonia:	
F.o.b. gulf coast	$142-$147
Delivered Corn Belt	175- 195
Ammonium sulfate: F.o.b. Corn Belt	112- 123
Ammonium nitrate: Delivered Corn Belt	135- 150
Urea:	
F.o.b. gulf coast, prilled	147- 149
F.o.b. gulf coast, granulated	157- 160
Delivered Corn Belt	168- 200
Diammonium phosphate: F.o.b. central Florida	150- 152

FOREIGN TRADE

Anhydrous ammonia exports increased nearly 47% from the 363,000 tons exported in 1983. The gross weight of downstream ammonia compounds exported for industrial and fertilizer uses increased 39%. Diammonium phosphates and urea continued to lead in export tonnage of nitrogen compounds.

Imports of anhydrous ammonia for fertilizer use increased 24%. Canada was the leading foreign supplier of ammonia to the United States with 980,816 tons. The U.S.S.R. supplied about 974,000 tons; Trinidad and Tobago, more than 814,000; and Mexico, more than 329,000. Ammonia imports from Canada, Trinidad and Tobago, and the U.S.S.R. increased, whereas imports from Mexico decreased.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds in 1984

(Thousand short tons and thousand dollars)

Compound	Gross weight	Nitrogen content	Value
EXPORTS			
Industrial chemicals:			
Ammonia, aqua (ammonia content)	4	3	291
Ammonium nitrate	1	(1)	44
Ammonium phosphate	4	1	3,858
Ammonium sulfate	8	2	338
Fertilizer materials:			
Ammonium nitrate	26	9	3,680
Diammonium phosphates	6,996	1,259	1,200,580
Other ammonium phosphates	562	62	96,240
Ammonium sulfates	674	142	41,196
Anhydrous ammonia	533	438	85,812
Sodium nitrate	252	40	2,994
Urea	1,270	584	182,588
Nitrogen solutions	7	2	731
Other nitrogen fertilizers	50	10	3,815
Mixed chemical fertilizers	52	5	13,263
Total	10,439	2,557	1,635,430
IMPORTS			
Industrial chemicals:			
Anhydrous ammonia and chemical-grade aqua	2	2	253
Ammonium nitrate	125	44	16,186
Ammonium phosphate	697	130	297
Ammonium sulfate	204	43	66
Fertilizer materials:			
Ammonium nitrate	532	178	55,424
Ammonium nitrate-limestone mixtures	(1)	(1)	20
Diammonium phosphates	54	10	9,979
Other ammonium phosphates	139	15	24,258
Ammonium sulfate	363	76	28,801
Calcium cyanamide or lime nitrogen	9	2	586
Calcium nitrate	170	26	14,259

See footnote at end of table.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds in 1984 —Continued

(Thousand short tons and thousand dollars)

Compound	Gross weight	Nitrogen content	Value
IMPORTS —Continued			
Fertilizer materials —Continued			
Nitrogen solutions	255	82	26,587
Anhydrous ammonia	3,283	2,699	473,842
Potassium nitrate	39	5	7,594
Potassium nitrate-sodium nitrate mixtures	13	2	1,638
Sodium nitrate	122	20	12,594
Urea	2,200	1,012	269,606
Other nitrogenous fertilizers	132	26	17,607
Mixed chemical fertilizers	137	14	24,927
Total	8,476	4,386	984,524

[1]Less than 1/2 unit.

WORLD REVIEW

World ammonia production increased to approximately 90.2 million tons of contained nitrogen. Changes in the ammonia industry were apparent worldwide. Competition from developing countries increased with low-cost natural gas, and established companies tried to improve their market share and their competitive position. Some idle plants came back on-line in response to the slowly improving world economy. A few companies planned to increase existing plant capacity and construct new ammonia plants. Finland and Sweden planned new construction at domestic and foreign locations. New ammonia projects were under construction in Trinidad and Tobago and U.S. investors showed interest in becoming partners with the Government in those projects. The Venezuelan Government considered building a new ammonia plant. Petrochemical Industries Corp., a Burmese Government-owned firm, discussed building a world-scale ammonia and methanol complex. Fertilizer complexes were planned for some Eastern European countries; Mozambique planned to build a nitrogen plant based on natural gas. Tanzania planned to begin construction on an ammonia-urea plant as soon as financing was available. Contracts were being offered for an ammonia-urea plant in Bangladesh. A contract was awarded for revamping of an ammonia plant at Nanking, China, to increase capacity. Market economy countries had developed much of the technology to reduce energy consumption in ammonia production, and some retrofitting of less energy efficient plants in North America and Western Europe was completed, but most of the new capacity was installed in developing countries.

Bangladesh.—Ammonia Casale S.A., a Swiss company, was awarded a $464,200 contract to revamp the ammonia synthesis converter in the 65,000-ton-per-year ammonia plant owned by Bangladesh Chemical Industries Corp. The plant was located at Fenchuganj.[2]

Canada.—Construction began on the Peace River ammonia plant in northwestern Alberta. The plant, designed to have a capacity of 225 tons per day, was scheduled to come on-stream in late 1985.[3]

Sherritt Gordon Mines Ltd.'s new ammonia plant at Fort Saskatchewan, Alberta, had a design capacity of 1,100 tons per day. M. W. Kellogg Co. claimed that the plant used less than 25 million British thermal units per ton of ammonia.[4]

India.—Rashtriya Chemicals and Fertilizers Ltd.'s ammonia-urea project at Thal Vaishet in Maharashtra neared completion. The complex consisted of two 445,000-ton-per-day ammonia plants and three 277,000-ton-per-day urea plants.[5]

A contract was awarded to Haldor Topsoe to construct an ammonia plant at Vijaipur, near Guna, in Madhya Pradesh. The plant was planned to produce 1,350 tons per day of ammonia.[6]

Indonesia.—An industrial project comprising a 330,000-ton-per-year ammonia plant and a 320,000-ton-per-year urea plant was officially inaugurated at Lhokseumawe, Aceh, North Sumatra, in January. Technology for the ammonia plant was supplied by M. W. Kellogg. A second plant producing 330,000 tons per year each of ammonia and urea was under construction in Aceh for P.T. Iskandar Muda Fertilizer Corp.[7]

Japan.—Ube Ammonia Co. began production at its 1,100-ton-per-day ammonia-from-coal plant. The plant used the Texaco Inc. gasification process.[8]

Madagascar.—Les Usines d'Engrais Chimiques de Tamatave's 98,000-ton-per-year ammonia and 100,000-ton-per-year urea complex was Madagascar's first and was scheduled to start up by early 1985.[9]

Malaysia.—A 1,000-ton-per-day ammonia and 1,500-ton-per-day urea complex was under construction at Bintulu in East Malaysia for the Association of Southeast Asian Nations joint venture, Bintulu Fertilizer Sdn. Bhd.[10]

Netherlands.—Unie van Kunstmestfabrieken BV (UKF) brought its new 400,000-ton-per-year ammonia plant on-stream in September. One-third of the output would go to Société Carbochimique SA of Belgium, and the remainder would be used by UKF for downstream products.[11]

Portugal.—Quimica de Portugal E.P. was nearing startup operations at its new ammonia plant at Lavradio. The 300,000-ton-per-year unit was to operate on heavy fuel oil feedstock.[12]

Turkey.—Istanbul Gubre Sanayii AS awarded a contract to Uhde GmbH, of the Federal Republic of Germany, to revamp its ammonia plant at Izmir in 1985. The plant capacity was planned to be increased by 10% and energy consumption reduced by 12%.[13]

Table 7.—Ammonia: World production, by country[1]

(Thousand short tons of contained nitrogen)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Afghanistan[e]	11	10	9	[r]9	10
Albania[e]	83	84	84	84	88
Algeria	33	[r]51	[r] [e]120	145	165
Argentina	72	44	64	63	62
Australia	389	352	270	424	385
Austria	540	536	535	546	529
Bangladesh	154	168	201	197	386
Belgium	[r]597	[r]649	561	495	503
Brazil	388	414	555	814	830
Bulgaria	912	924	934	1,015	915
Burma[e]	66	65	56	[r]59	64
Canada	2,310	2,399	2,273	2,617	2,750
China[e]	11,012	13,440	14,010	[r]15,200	15,400
Colombia	77	101	108	112	116
Cuba	150	184	108	95	190
Czechoslovakia	930	937	937	937	937
Denmark	34	34	34	13	17
Egypt	441	571	704	998	990
Finland	77	76	71	75	77
France[e]	2,298	2,500	[r]2,200	[r]2,100	2,200
German Democratic Republic	1,303	1,328	1,290	1,335	1,300
Germany, Federal Republic of	2,253	2,163	1,731	1,877	1,984
Greece	249	248	248	248	254
Hungary	876	902	855	882	910
Iceland[e]	8	8	9	9	9
India[3]	2,448	3,520	3,824	3,886	4,200
Indonesia	1,034	1,014	1,133	1,267	1,320
Iran[e]	[4]240	220	[r]231	[r]248	248
Iraq	551	88	[e]88	[e]88	99
Ireland	280	321	276	325	320
Israel	60	[r]46	55	59	59
Italy	1,540	1,331	1,153	1,169	1,200
Japan	2,326	2,020	1,821	1,703	1,705
Korea, North[e]	500	500	500	500	500
Korea, Republic of	935	823	599	474	512
Kuwait	[r]236	[r]235	202	258	330
Libya[e]	165	165	[r]210	[r]230	230
Malaysia	45	41	31	32	32
Mexico	1,706	1,979	2,237	2,134	1,954
Netherlands	2,066	2,000	1,824	1,926	2,486
New Zealand	--	--	--	48	50
Norway	568	601	574	565	573
Pakistan[5]	474	654	760	1,108	1,100
Peru[e]	68	107	93	94	94
Philippines	43	36	16	22	22
Poland	1,629	1,531	1,569	1,571	1,571
Portugal	221	[r]147	146	149	154
Qatar	461	[r]404	478	531	572
Romania	2,478	2,625	2,852	2,866	2,920
Saudi Arabia	184	187	229	248	300

See footnotes at end of table.

Table 7.—Ammonia: World production, by country[1] —Continued

(Thousand short tons of contained nitrogen)

Country[2]	1980	1981	1982	1983[p]	1984[e]
South Africa, Republic of	605	608	629	634	640
Spain	818	819	593	678	683
Sweden	95	87	85	53	55
Switzerland	[e]50	36	36	36	36
Syria	[r]43	[r]33	72	125	130
Taiwan	457	448	350	342	307
Trinidad and Tobago	506	384	777	1,082	1,270
Turkey	[r]203	[r]359	338	353	360
U.S.S.R	[r]13,900	14,220	15,400	16,000	16,500
United Arab Emirates	--	--	--	--	330
United Kingdom	1,800	1,962	1,892	1,896	1,870
United States	16,244	[r]15,732	13,029	11,297	13,309
Venezuela	397	457	457	496	510
Yugoslavia	445	464	465	463	440
Zambia	22	20	30	31	31
Zimbabwe[e]	[r]63	[r]57	93	78	83
Total	[r]81,169	[r]84,469	83,114	85,414	90,176

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 14, 1985.
[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]Data are for years beginning Apr. 1 of that stated.
[4]Reported figure.
[5]Data as reported by Pakistan in fiscal year July 1 through June 30; production for 1982 includes some other forms of nitrogen.

TECHNOLOGY

Ammonia Casale designed a new mixed flow ammonia reactor for ammonia synthesis. The new reactor was a technological development that worked well with the United Kingdom's Imperial Chemical Industries PLC, high efficiency, low synthesis loop pressure ammonia process.[14]

Scientists at the Southwest Research Institute developed a system to produce ammonia from moisture saturated air, sunlight, a metal catalyst, and an activated silicate foam. The open-celled silicate foam was impregnated with the metal catalyst, then placed in a glass tube at the focal point of the parabolic solar energy collector. Moist air pumped through the tube was converted to hydrogen and oxygen. The hydrogen combined with nitrogen from the air to form ammonia and several derivatives. Ammonia was collected by an aqueous acid-scrubbing process. Production rates were 5 to 10 milligrams of ammonia per hour from 0.25 cubic foot of air. Further testing was directed toward increasing the ammonia output.[15]

The Federal Government in Ottawa, Canada, the Provincial government of Quebec, and a group of private companies were working on a $50 million project to demonstrate the West German Dornier System for producing hydrogen from water to produce ammonia at the Shawinigan, Quebec, ammonia plant. The technology promised to be competitive with technologies using hydrogen in natural gas.[16]

[1]Physical scientist, Division of Industrial Minerals.
[2]Nitrogen (London). No. 151, Sept.-Oct. 1984, p. 13.
[3]Green Markets. V. 8, No. 49, Dec. 10, 1984, p. 8.
[4]———. V. 8, No. 3, Jan. 23, 1984, p. 7.
[5]Nitrogen (London). No. 149, May-June 1984, p. 12.
[6]———. No. 150, July-Aug. 1984, p. 14.
[7]Work cited in footnote 5.
[8]Green Markets. V. 8, No. 43, Oct. 29, 1984, p. 9.
[9]Work cited in footnote 2.
[10]Fertilizer Focus. V. 1, No. 9, Oct. 1984, p. 24.
[11]Nitrogen (London). No. 152, Nov.-Dec. 1984, p. 14.
[12]———. No. 148, Mar.-Apr. 1984, p. 12.
[13]Fertilizer International. No. 176, Feb. 1984, p. 13.
[14]Chemical Marketing Reporter. V. 225, No. 10, Mar. 5, 1984, p. 15.
[15]Chemical Engineering News. V. 62, No. 14, Apr. 2, 1984, p. 28.
[16]Chemical Week. V. 135, No. 7, Aug. 15, 1984, p. 28.

Peat

By Charles L. Davis[1]

Peat production in the United States increased 14%. In decreasing order of quantity, Florida, Michigan, Indiana, Illinois, Minnesota, and Colorado were the major peat producing States. Reed-sedge peat was the most common kind produced, followed by humus, unclassified, hypnum, and sphagnum. Peat sold in packaged form by domestic producers decreased 12% in quantity, and 16% in value. Apparent consumption increased 10%. Imports for consumption, predominantly from Canada, increased 16% and represented about 42% 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 test burn projects.

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 119 operations to which a survey request was sent, 104 responded, representing 95% of the total production shown in table 1. Production for the 15 nonrespondents was estimated using prior year production levels adjusted by trends in employment and other guidelines.

Table 1.—Salient peat statistics

	1980	1981	1982	1983	1984
United States:					
Number of active operations	96	90	93	94	101
Production thousand short tons	785	686	798	704	800
Sales by producers do	788	757	769	725	814
Bulk do	298	276	259	223	373
Packaged do	491	481	511	503	441
Value of sales thousands	$16,190	$18,784	$16,871	$18,667	$19,907
Average per short ton	$20.54	$24.82	$21.94	$25.73	$24.47
Average per short ton, bulk	$15.46	$17.28	$16.34	$18.34	$20.47
Average per short ton, packaged or baled	$23.61	$29.14	$24.77	$29.00	$27.85
Imports for consumption thousand short tons	402	342	370	419	485
Consumption, apparent[1] do	[r]1,207	[r]1,089	[r]1,080	[r]1,042	1,146
Stocks, yearend producers' do	330	269	357	438	577
World: Production do	[r]338,538	[r]387,264	414,563	[p]411,868	[e]413,069

[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 101 active domestic operations. Eight large mines, with capacities greater than 25,000 tons per year, accounted for 41% of the production, compared with 46% in 1983: three were reed-sedge mines in Michigan, three reed-sedge mines in Florida, one reed-sedge mine in Illinois, and one unclassified mine in Florida. Reed-sedge production increased from 59% in 1983 to 68% of total output in 1984. Humus accounted for 19%; unclassified, 5%; hypnum, 4%; and sphagnum, 4%. Almost 11,000 tons of peat was produced for use as a fuel to generate electricity for public utilities and heat in public buildings.

Table 2.—Relative size of peat operations in the United States

Size in short tons per year	Active operations		Production (thousand short tons)	
	1983	1984	1983	1984
25,000 and over	8	8	322	329
15,000 to 24,999	6	7	103	137
10,000 to 14,999	7	11	92	131
5,000 to 9,999	9	14	69	97
2,000 to 4,999	25	25	91	81
1,000 to 1,999	12	13	17	18
Under 1,000	27	23	9	6
Total[1]	94	101	704	800

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

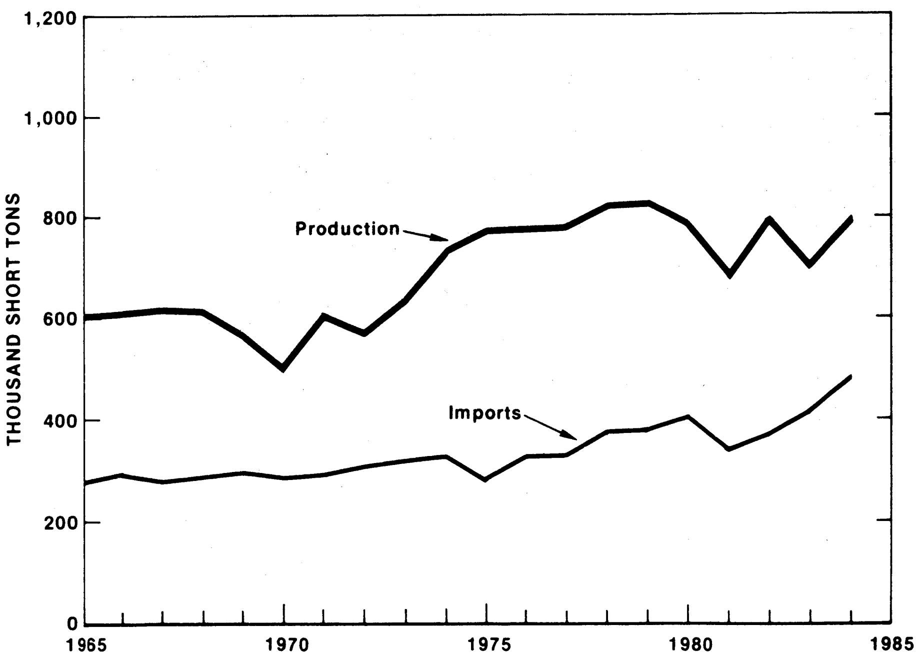

Figure 1.—Production and imports of peat in the United States.

CONSUMPTION AND USES

U.S. peat producers' domestic sales increased by 12% and consisted of 70% reed-sedge, 18% humus, 4% hypnum, 4% sphagnum, and 4% unclassified. Sales of bulk peat increased 68% and packaged sales decreased 12%. Sales of bagged or baled peat were 54% of total sales and consisted of 86% reed-sedge, 5% sphagnum, 5% hypnum, and 4% humus. Sales of peat for earthworm culture medium, general soil improvement, golf courses, potting soil, and nurseries increased. A decrease occurred in mixed fertilizers, packing flowers, and vegetable growing uses. Apparent consumption of peat increased as a result of increases in production, sales, and imports.

Table 3.—U.S. peat sales by producers in 1984, 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	1,035	$20	1,548	$17	2,583	$36
General soil improvement	100,951	1,775	404,699	9,738	505,650	11,513
Golf courses	29,076	739	500	35	29,576	774
Ingredient for potting soils	130,736	3,095	12,025	518	142,761	3,614
Mixed fertilizers	10,800	108	500	35	11,300	143
Mushroom beds	4,527	78	2,998	210	7,525	288
Nurseries	87,966	1,550	8,153	488	96,119	2,038
Packing flowers, plants, shrubs, etc	1,125	16	1,537	64	2,662	79
Seed inoculant	639	162	4,062	952	4,701	1,114
Vegetable growing	2,343	28	505	35	2,848	63
Other	3,794	64	4,050	180	7,844	244
Total[1]	372,992	7,636	440,577	12,272	813,569	19,907

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

Table 4.—U.S. peat production and sales by producers in 1984, 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	99
Colorado	4	W	W	W	35
Florida	14	292	263	$5,454	16
Georgia	2	W	W	W	99
Illinois	4	50	49	W	84
Indiana	8	51	61	1,358	80
Iowa	4	12	11	400	28
Maine	3	W	W	W	100
Maryland	1	5	5	W	17
Massachusetts	1	W	W	W	10
Michigan	16	166	227	4,341	78
Minnesota	5	38	24	W	82
Montana	2	2	W	W	95
New Jersey	5	11	5	128	43
New York	4	W	W	W	94
North Carolina	3	W	W	W	57
North Dakota	1	W	W	W	--
Ohio	6	16	13	345	75
Pennsylvania	8	26	24	693	29
South Carolina	1	5	5	W	92
Washington	4	W	W	W	--
Wisconsin	3	W	9	W	39
Total[2] or average	101	800	814	19,907	54

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 1984, by use

Use	Sphagnum moss: Quantity: Weight (short tons)	Sphagnum moss: Quantity: Volume[1] (cubic yards)	Sphagnum moss: Value (thousands)	Hypnum moss: Quantity: Weight (short tons)	Hypnum moss: Quantity: Volume (cubic yards)	Hypnum moss: Value (thousands)	Reed-sedge: Quantity: Weight (short tons)	Reed-sedge: Quantity: Volume (cubic yards)	Reed-sedge: Value (thousands)
Earthworm culture medium	302	1,007	$9	125	250	$2	1,742	3,553	$21
General soil improvement	19,700	118,240	1,135	21,469	54,353	749	393,413	812,366	8,328
Golf courses	815	6,046	42	840	1,680	11	20,124	39,782	582
Ingredient for potting soils	500	4,996	35	1,751	4,190	21	73,044	151,944	2,199
Mixed fertilizers	500	4,996	35	--	--	--	--	--	--
Mushroom beds	2,998	29,976	210	900	3,000	45	3,627	6,620	33
Nurseries	2,028	20,184	141	5,276	19,575	302	70,101	123,185	1,284
Packing flowers, plants, shrubs, etc	500	4,996	35	--	--	--	--	--	--
Seed inoculant	500	4,996	35	--	--	--	3,537	6,431	884
Vegetable growing	500	4,996	35	--	--	--	874	1,441	13
Other	570	1,900	13	--	--	--	6,300	12,000	216
Total[2]	28,913	202,333	1,725	30,361	83,048	1,130	572,762	1,157,322	13,561

Use	Humus: Quantity: Weight (short tons)	Humus: Quantity: Volume (cubic yards)	Humus: Value (thousands)	Other: Quantity: Weight (short tons)	Other: Quantity: Volume (cubic yards)	Other: Value (thousands)	Total[2]: Quantity: Weight (short tons)	Total[2]: Quantity: Volume (cubic yards)	Total[2]: Value (thousands)
Earthworm culture medium	200	380	$2	214	475	$3	2,583	5,665	$36
General soil improvement	68,468	119,537	1,263	2,600	5,500	38	505,650	1,109,996	11,513
Golf courses	7,797	15,453	138	--	--	--	29,576	62,961	774
Ingredient for potting soils	36,191	77,606	716	31,275	69,500	643	142,761	308,236	3,614
Mixed fertilizers	10,800	18,000	108	--	--	--	11,300	22,996	143
Mushroom beds	--	--	--	--	--	--	7,525	39,596	288
Nurseries	18,714	37,094	312	--	--	--	96,119	200,038	2,038
Packing flowers, plants, shrubs, etc	2,162	2,802	44	--	--	--	2,662	7,798	79
Seed inoculant	664	901	195	--	--	--	4,701	12,328	1,114
Vegetable growing	1,474	2,747	15	--	--	--	2,848	9,184	63
Other	--	--	--	974	2,185	15	7,844	16,085	244
Total[2]	146,470	274,520	2,793	35,063	77,660	699	813,569	1,794,883	19,907

[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.

Table 6.—U.S. peat production and producers' yearend stocks in 1984, by kind

Kind	Active operations	Production (short tons)	Percent of production	Yearend stocks (short tons)
Sphagnum moss	9	30,795	3.9	23,491
Hypnum moss	6	31,205	3.9	10,815
Reed-sedge	53	544,945	68.1	480,355
Humus	30	154,326	19.3	18,224
Other	6	38,671	4.8	44,250
Total	[1]104	799,942	100.0	577,135

[1]Includes three additional bogs.

PRICES AND SPECIFICATIONS

The average reported price per ton for all types of peat, f.o.b. mine, decreased 5%. The unit price for bulk peat increased 12% and packaged peat decreased 4%. The price per ton of imported sphagnum peat decreased 4%.

Table 7.—Prices[1] for peat in 1984

(Dollars per unit)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other	Average
Domestic:						
Bulk:						
Per short ton	21.74	23.52	23.42	15.92	19.99	20.47
Per cubic yard	10.69	9.22	12.11	8.40	9.01	10.44
Packaged or baled:						
Per short ton	69.58	41.51	23.81	42.91	16.00	27.85
Per cubic yard	8.38	14.86	11.53	24.94	8.00	11.54
Average:						
Per short ton	59.65	37.23	23.68	19.07	19.93	24.47
Per cubic yard	8.52	13.61	11.72	10.17	9.00	11.09
Imported, total, per short ton[2]	119.18	XX	XX	XX	XX	119.18

XX Not applicable.
[1]Prices are f.o.b. mine.
[2]Average customs price.

Table 8.—Average density of domestic peat sold in 1984

(Pounds per cubic yard)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Other
Bulk	983	784	1,034	1,056	902
Packaged	241	716	968	1,162	1,000
Bulk and packaged	286	731	990	1,067	903

FOREIGN TRADE

Peat imports for consumption increased nearly 16% in quantity and 11% in value. More than 99% of the imports was sphagnum moss peat from Canada. Canadian sphagnum moss peat is in demand because of its water retention qualities and consumer loyalty to brand. More than 43% of the peat entered the United States through customs districts in New York. Significant 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 and Ireland.

Table 9.—U.S. imports for consumption of peat moss in 1984, 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	31,639	$4,308	453,078	$53,448	484,717	$57,756
Germany, Federal Republic of	18	4	155	23	173	27
Ireland	22	5	20	1	42	6
Other[1]	6	1	134	19	140	20
Total	31,685	4,318	453,387	53,491	485,072	57,809

[1]Includes Botswana, Denmark, Finland, France, the Netherlands, Sweden, and the United Kingdom.

Source: Bureau of the Census.

Table 10.—U.S. imports for consumption of peat moss in 1984, 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	3	$2	2	$1	5	$3
Bridgeport, CT[2]	--	--	24	3	24	3
Buffalo, NY[2]	18,739	2,616	8,723	890	27,462	3,505
Chicago, IL	22	5	--	--	22	5
Detroit, MI[2]	12,538	1,649	43,921	4,046	56,459	5,695
Duluth, MN[2]	--	--	949	176	949	176
Great Falls, MT[2]	--	--	45,322	5,888	45,322	5,888
Houston, TX	2	1	--	--	2	1
Los Angeles, CA	--	--	143	17	143	17
Milwaukee, WI[2]	--	--	33	3	33	3
New Orleans, LA[2]	--	--	26	3	26	3
New York, NY	--	--	59	8	59	8
Norfolk, VA[2]	--	--	159	32	159	32
Ogdensburg, NY[2]	142	19	182,868	19,499	183,010	19,518
Pembina, ND[2]	--	--	73,901	11,072	73,901	11,072
Philadelphia, PA[2]	--	--	391	69	391	69
Portland, ME[2]	157	19	33,882	4,024	34,039	4,043
St. Albans, VT[2]	49	4	23,844	2,609	23,893	2,613
San Francisco, CA	17	1	17	2	34	3
San Juan, PR[2]	13	2	14	2	27	4
Seattle, WA[2]	1	([3])	39,109	5,148	39,110	5,148
Total[1]	31,685	4,318	453,387	53,491	485,072	57,809

[1]Data may not add to totals shown because of independent rounding.
[2]Predominately of Canadian origin.
[3]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Members of industry, the Provincial government of Ontario, and the company Peat Resources Ltd. discussed a possible joint venture to develop a peat pellet plant. There were approximately 600,000 acres of peat and wetlands under company control in northern Ontario. Initial work was to include geotechnical, mining, and economic studies. Preliminary estimates indicate that the peat could be produced for $63 per ton, which made it competitive with imported coal at $90 per ton. Long-range plans were for an operation of 100,000-ton-per-year capacity.

U.S.S.R.—The U.S.S.R. produced 205.3 million tons of peat for fertilizer and bedding for animals during 1981-83, which was the first 3 years of the present 5-year plan.

Table 11.—Peat: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina: Agricultural use	5	3	4	4	4
Australia[e]	13	[r]14	[r]11	14	15
Burundi	10	10	15	15	17
Canada: Agricultural use	538	509	537	600	550
Denmark: Agricultural use[3]	34	36	104	[e]110	110
Finland:					
Agricultural use	[r]571	225	637	302	441
Fuel	[r]3,382	1,436	6,063	3,698	4,409
France: Agricultural use[e]	155	[r]143	[r]132	[r]121	121
Germany, Federal Republic of:					
Agricultural use	[r]1,714	1,920	2,030	2,059	2,205
Fuel	[r]308	271	279	285	386
Hungary: Agricultural use[e]	77	77	77	77	77
Ireland:					
Agricultural use	97	89	105	[e]105	105
Fuel	4,879	5,906	5,819	[r e]5,842	5,842
Israel: Agricultural use[e]	22	22	22	22	22
Netherlands[e]	441	441	441	441	496
Norway:[e]					
Agricultural use	66	66	66	66	66
Fuel	1	1	1	1	1
Poland: Fuel and agricultural use[e]	223	222	220	220	220
Spain	49	43	66	44	44
Sweden: Agricultural use	148	144	136	138	138
U.S.S.R.:					
Agricultural use	259,000	309,000	[e]331,000	[e]331,000	331,000
Fuel[e]	66,000	66,000	66,000	66,000	66,000
United States:					
Agricultural use	785	686	798	703	[4]789
Fuel	--	--	--	1	[4]11
Venezuela: Agricultural use[e]	20	NA	NA	NA	NA
Total	[r]338,538	[r]387,264	414,563	411,868	413,069
Fuel peat included in total	[r]74,793	73,836	78,382	76,047	76,869

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through June 25, 1985.
[2]In addition to the countries listed, Austria, Iceland, and Italy produce negligible quantities of fuel peat, and the German Democratic Republic is a major producer, 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

Carolina Methane Inc., a new company, planned to test a process to extract methane from peat deposits without mining the peat. The peat bog water, in which the methane gas naturally occurred, would be pumped out of the bog, and the methane removed in a vacuum chamber. The water would then be returned to the bog. The methane would be used as an alternative energy source, or converted to a higher heat value product.[2]

[1]Physical scientist, Division of Industrial Minerals.
[2]News & Observer (Raleigh, NC). Firm To Try To Get Energy From Peat Without Mining. Apr. 3, 1984.

Perlite

By A. C. Meisinger[1]

U.S. production of both processed and expanded perlite increased modestly to reverse a 6-year decline. Processed perlite sold and used increased 5% to 498,000 short tons valued at $16.6 million, while sales of expanded perlite also increased 5% to 404,000 tons valued at $69.5 million. Construction-related uses of perlite, such as roof insulation board, ceiling tile, and concrete aggregate, accounted for 67% of domestic consumption, the same percentage as in 1983.

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, 8, or 67%, responded, representing 89% of the total processed ore sold and used shown in table 1. Mine data for the four nonrespondents were estimated using reported prior year production levels adjusted by trends in employment and other guidelines. Of the 70 expanding plants to which a request was sent, 65 plants were active; of these, 36 plants, or 55%, responded, representing 69% of the total expanded perlite sold and used shown in table 1. Plant data for the 29 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
1980	824	334	9,053	304	7,447	638	544	537	69,200
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	404	404	69,500

[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 6 Western States, was 653,000 tons, an increase of 7%. Of the total, five mines in New Mexico accounted for 87%. Other States with mine and/or processed ore production were Arizona, California, Idaho, and Nevada. The quantity of processed perlite sold and used increased 5% to 498,000 tons, and the value increased 6% to $16.6 million. New Mexico mines accounted for 84% 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; Delamor Perlite Co. and United States Gypsum Co. in Nevada; and Grefco Inc., Manville Products Corp., Silbrico Corp., and United States Gypsum Co. in New Mexico.

Expanded Perlite.—Expanded perlite was produced by 65 plants in 32 States. The quantity produced increased 4%, reversing a 6-year decline. Leading States, in descending order of sales, were Mississippi, California, Illinois, Kentucky, Pennsylvania, Texas, Virginia, Indiana, Florida, 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	1983				1984			
	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	1,100	1,100	W	W
California	44,900	43,700	$7,015	$160	48,100	47,500	$8,339	$176
Florida	21,200	21,300	3,527	166	20,600	20,500	3,470	169
Indiana	24,200	24,300	5,257	217	22,500	22,200	4,982	225
Massachusetts	2,700	2,600	792	302	2,400	2,300	779	339
Pennsylvania	31,700	31,400	5,059	161	32,500	32,400	5,743	177
Texas	27,700	27,400	5,704	208	27,200	27,100	5,805	214
Other[2]	233,500	233,000	36,144	155	249,900	250,900	40,360	161
Total[3]	387,000	385,000	63,500	165	404,000	404,000	69,500	172

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, Kansas, Kentucky, Louisiana, Maine, Michigan, Minnesota, Mississippi, Missouri, Nevada, New Jersey, New York, North Carolina, Ohio (1983), Oregon, Tennessee, Utah, Virginia, Wisconsin, Wyoming, and items indicated by symbol W.
[3]Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Domestic consumption of expanded perlite increased 5% to 404,000 tons. Construction-industry-related uses, such as aggregates for concrete, plaster, formed products, and loose-fill insulation, continued to account for two-thirds of sales. The largest gain in sales was for fillers.

Table 3.—Expanded perlite sold and used by producers in the United States, by use

(Short tons)

Use	1983	1984
Concrete aggregate	19,600	20,800
Fillers	4,200	12,100
Filter aid	63,900	60,600
Formed products[1]	210,800	222,500
Horticultural aggregate[2]	29,200	36,100
Low-temperature insulation	6,000	5,000
Masonry and cavity-fill insulation	13,600	15,100
Plaster aggregate	15,400	12,600
Other[3]	21,900	19,100
Total[4]	385,000	404,000

[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 decreased slightly to $33.53 per ton. The average price of expanded perlite used by producers in their own plants was $33.21 per ton, an increase of 5%. The average value of all processed perlite sold and used was $33.41 per ton, a slight increase over that of 1983. The value of expanded perlite sold and used averaged $172 per ton compared with $165 per ton in 1983.

FOREIGN TRADE

The United States imported approximately 45,000 tons of processed perlite from Greece, compared with 36,000 tons in 1983. Exports of perlite were estimated to be 20,000 tons to Canada, compared with 17,000 tons in 1983.

WORLD REVIEW

The United States, the U.S.S.R., and Greece continued to be the leading perlite producing countries and, together, accounted for 73% of estimated world production in 1984.

Canada.—The first perlite mining operation in Canada went on-stream in July, with initial production processed in a pilot plant near the mine. The mining and processing operation, at Aldergrove, British Columbia, is owned by Aurun Mines Ltd., Calgary, Alberta. Proven ore reserves were reported to be nearly 500,000 tons.[2]

[1]Industry economist, Division of Industrial Minerals.
[2]Industrial Minerals (London). World of Minerals. Canada. Aurun—A First for Perlite. No. 207, Dec. 1984, p. 9.

Table 4.—Perlite: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Australia[3]	2	2	1	2	2
Czechoslovakia	44	[r]47	[e]44	49	49
Greece	218	145	[e]150	167	154
Hungary[3]	109	105	99	102	105
Italy[e]	100	94	88	[r]83	77
Japan[e]	85	83	83	83	83
Mexico[3]	49	63	36	46	44
New Zealand[3]	1	1	2	1	1
Philippines	9	8	4	2	3
Turkey	28	50	134	32	33
U.S.S.R.[e]	400	400	400	400	400
United States (processed ore sold and used by producers)	638	591	506	474	[4]498
Total	1,683	[r]1,589	1,547	1,441	1,449

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Unless otherwise specified, figures represent processed ore output. Table includes data available through June 4, 1985.
[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 during the 1980-84 period, but output data are not reported and available information is inadequate for formulation of reliable estimates of output levels.
[3]Crude ore.
[4]Reported figure.

Phosphate Rock

By William F. Stowasser[1]

U.S. production of phosphate rock in 1984 continued to improve from the depressed production level of 1982. Most of the production was from Florida and North Carolina phosphate rock deposits, which contributed 86% of the total; the Western States of Idaho, Montana, and Utah contributed 11%; and Tennessee produced 3%.

Domestic agricultural consumption of fertilizer nutrients recovered substantially from the effects of the U.S. Government's "payment-in-kind" (PIK) program in 1983. Exports of phosphate fertilizers increased over 1983 exports in response to higher international demand. World stocks of coarse grain declined in 1983 from the effects of the PIK program and drought in the United States, but grain production recovered in 1984. With a record high world wheat harvest in the 1983-84 crop year, wheat stocks were high and, despite large purchases by the U.S.S.R., cereal prices declined. Since 1981, cereal production increased and demand stagnated. Cereal stocks increased as did downward pressure on prices.

Table 1.—Salient phosphate rock statistics

(Thousand metric tons and thousand dollars unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Mine production	209,883	183,733	104,135	125,691	163,012
Marketable production	54,415	53,624	37,414	42,573	49,197
P_2O_5 content	16,711	16,365	11,504	13,088	14,889
Value	$1,256,947	$1,437,986	$950,326	r$1,021,095	$1,182,244
Average per metric ton	$23.10	$26.82	$25.40	$23.98	[1]$24.03
Sold or used by producers	54,581	45,526	38,571	46,839	53,277
P_2O_5 content	16,810	13,939	11,814	14,336	16,244
Value	$1,243,297	$1,212,433	$983,465	$1,122,966	$1,278,356
Average per metric ton	$22.78	$26.63	$25.50	$23.97	[2]$23.99
Exports[3]	14,276	10,395	9,842	12,010	11,528
P_2O_5 content	4,554	3,300	3,138	3,839	3,646
Value	$431,419	$373,192	$293,626	$327,345	$324,784
Average per metric ton	$30.22	$35.90	$29.83	$27.26	$28.17
Imports for consumption[4]	486	13	31	9	9
Customs value	$12,856	$420	$1,302	r$376	$274
Average per metric ton	$26.45	$32.31	$42.00	r$42.69	$31.71
Consumption[5]	40,791	35,144	28,760	r34,838	41,758
Stocks, Dec. 31: Producer	13,709	19,619	18,287	r14,500	11,897
World: Production	r144,193	r143,087	127,335	p139,265	e150,571

eEstimated. pPreliminary. rRevised.
[1]Arithmetic average of sold or used values.
[2]Weighted average of sold or used values.
[3]Exports reported to the Bureau of Mines by companies.
[4]Bureau of the Census data, less imports indicated from Canada and Israel for 1984.
[5]Measured by sold or used plus imports minus exports.

Improvement in world phosphate rock production was principally due to an increase in world domestic deliveries. Phosphate rock exports were recovering slowly but were still below those of the record high year of 1980. The conclusions drawn are that the recession more than temporarily impacted the world industries importing phosphate rock, and the substitution of processed phosphates for phosphate rock increased in importance. Worldwide, the profitability of phosphate rock mines was depressed because surplus inventories persisted despite voluntary mine closings and production slowdowns.

Crop prices, again because of surplus production, were depressed and failed to keep pace with inflation. Although fertilizer prices in most areas of the world were relatively stable, other costs of farming increased more rapidly than agricultural product prices. The farmer was caught in a cost-price squeeze that precluded a significant increase in the use of phosphate fertilizer.

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 phosphate rock semiannual survey. Of the 25 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 98th Congress, 2d session, passed House bill 9, a bill to designate components of the National Wilderness Preservation System in the State of Florida. The bill directed the U.S. Department of the Interior not to issue phosphate leases in the Osceola National Forest, FL, until the President makes a recommendation to Congress to do so. The President signed House bill 9 on September 28, 1984. Four companies applied for phosphate rock Preference Right Mining Leases in the early and mid-1960's after discovering phosphate rock in the Osceola National Forest. Successive administrations denied issuing the leases as opposition to mining the Osceola National Forest increased from private environmental organizations, the State of Florida, and the U.S. Forest Service. Two of the four companies that applied for Preference Right Leases, as directed by the Mining Law of 1920, initiated civil suits for leases prior to the enactment of House bill 9. The District Court of the United States for the District of Columbia had not ruled for the plaintiffs or defendants by yearend.

DOMESTIC PRODUCTION

Florida and North Carolina produced 42 million metric tons of marketable phosphate rock, a substantial increase over the 36 million tons produced in 1983; the Western States produced 5.4 million tons, essentially the same quantity produced in 1983; and Tennessee produced 1.4 million tons, about the same as that of 1983.

Florida and North Carolina.—Companies that mined phosphate rock in central Florida were Agrico Chemical Co., Amax Chemical Inc., Beker Phosphate Inc., Brewster Phosphates, CF Industries Inc., Estech Inc., Gardinier Inc., W. R. Grace & Co., International Minerals & Chemical Corp. (IMC), Mobil Mining and Minerals Co., and USS Agri-Chemicals Inc. Occidental Chemical Agricultural Products Inc. produced marketable phosphate rock in Hamilton County, north Florida.

Several small companies in north-central Florida intermittently recovered soft phosphate rock from tailing ponds remaining from old inactive hard-rock phosphate mines. The companies' estimated combined annual capacity of 45,000 tons has seldom been achieved. The soft rock has a low fluorine content that permits it to be marketed 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, NC. Mining was conducted with hydraulic dredges and draglines to supply phosphate rock to a fertilizer complex adjacent to the mine.

North Carolina Phosphate Corp., an Agrico mining company, planned to open a 3.4-million-ton-per-year phosphate rock mine adjacent to and south of Texasgulf's Lee Creek Mine in North Carolina. The proposed mine was scheduled to begin producing in 1989 with bucket wheel excavators, mobile transfer conveyors, and rail-mounted tripper cars with slewing conveyors.

In central Florida, Agrico mined phosphate rock from the Payne Creek, Saddle Creek, and Fort Green Mines in Polk County. Since the Payne Creek and Saddle Creek Mines, if operated at planned production rates, were expected to deplete their respective deposits in 1987, Agrico planned to open a mine in North Carolina in 1989.

Amax Phosphate Inc. closed the Big Four phosphate rock mine in Hillsborough County, FL, in October. The mine supplied phosphate rock for phosphate fertilizer and animal feed supplements. Amax Phosphate had indicated its intentions to keep the mine closed and was attempting to sell the central Florida mine and chemical plants.

Beker operated the Wingate Creek Mine in Manatee County at a rate in excess of 1 million tons per year. Beker was permitted to truck phosphate rock from the mine, about 64 kilometers, to Port Manatee where it was transferred to a Beker-owned, self-unloading, tug-barge unit for shipment across the Gulf of Mexico to its Taft, LA, plant.

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. The Haynsworth Mine, if production plans are followed, was scheduled to gradually reduce production and deplete the deposit. The Lonesome Mine was expected to continue producing at planned production rates.

CF Industries produced phosphate rock in Hardee County from the "North Pasture" deposit but failed to restart the Bartow, FL, phosphate fertilizer plant that was closed in late 1982. Some process design work was authorized for CF Industries' proposed Hardee Complex II Mine in Hardee County.

Estech closed the Silver City Mine but continued to operate the Watson Mine as a joint venture with Zen-Noh Phosphate Corp. Estech offered to sell its Duette deposit in northeastern Manatee County, FL, after failing to obtain the necessary mining permits from the county. County residents approved a referendum in November to purchase the 4,208-hectare (10,400-acre) tract from Estech, but the issue remained unresolved at yearend.

Gardinier produced phosphate rock at its Fort Meade Mine until early November, when the mine was closed for inventory control. Low demand for phosphate rock at Gardinier's Tampa chemical plant appeared to be a problem that had existed for several years.

W. R. Grace closed the Bonny Lake Mine in February. Mining had begun in 1947 on the 4,856-hectare (12,000-acre) site and after 37 years, the Bonny Lake deposit was depleted. One of the draglines that mined Bonny Lake was walked to the Hookers Prairie Mine, and the other, to the new Four Corners Mine. The Four Corners Mine, a joint venture with IMC, was prepared in the last quarter of the year to start producing in January 1985.

Hopewell Land Corp., a Noranda Group company, planned to open a relatively small, about 450,000 tons per year, phosphate rock mine near Lithia, FL. The mine was scheduled to start producing in early 1985.

IMC operated the Clear Springs, Kingsford, and Noralyn-Phosphoria Mines in central Florida and had 50% equity in the Four Corners Mine. IMC also owned phosphate reserves in Hillsborough County. A new phosphoric acid train at IMC's chemical plant near Mulberry, FL, was capable of producing 500,000 tons per year of phosphoric acid.

Mobil operated the Nichols and Fort Meade Mines in central Florida. Plans to open a new South Fort Meade phosphate rock mine were deferred because of the difficulty in reaching agreement with the State over its reclamation plan and unfavorable economics.

USS Agri-Chemicals and Freeport Phosphate Rock Co. produced phosphate rock from the Rockland Mine. Less than 1 million tons was produced in 1983; however, production was expected to approach 2 million tons by 1985.

Occidental operated the Swift Creek and Suwannee River Mines in northern Florida. The mines supplied both a 390,000- and a 730,000-ton-per-year phosphoric acid plant. Merchant-grade acid was converted to superphosphoric acid to supply the U.S.S.R.'s liquid diammonium phosphate fertilizer plants.

Tennessee.—All of the phosphate rock mined in Tennessee by Occidental, Monsanto Co., and Stauffer Chemical Co. was beneficiated and used to produce elemental phosphorus in each company's respective electric furnaces. Stauffer acquired additional reserves from the Tennessee Valley Authority. Because both Monsanto and Stauffer also operated electric furnaces in the Western United States with lower production costs, the Tennessee furnaces were used to satisfy any differential demand above that which was met by Western production.

Western States.—Western phosphate rock was mined in two grades, 24% to 28% phosphorus pentoxide (P_2O_5) for elemental phosphorus production and 30% to 33%

P_2O_5 for wet-process phosphoric acid production. The lower grade ore was mined and used directly in electric furnaces.

The Conda Partnership, a 50-50 association between Beker and Western Cooperative Fertilizers Ltd., Canada, mined phosphate rock from the Maybie Canyon, Champ, Mountain Fuel, North Dry Ridge, and Husky Mines. Beker's share of the mined rock was used in the adjacent fertilizer complex at Conda, ID, and Western Cooperative's share was exported to plants in Alberta, Canada.

Monsanto obtained phosphate rock for its electric furnaces from the Henry Mine. The phosphate rock was trucked from the mine to electric furnaces at Soda Springs, ID. Mining capacity was about 0.9 million tons per year.

Stauffer obtained phosphate rock for a two-electric-furnace plant at Silver Bow, MT, from the Wooley Valley Mine northeast of Soda Springs, ID.

Cominco American Incorporated mined phosphate rock from an underground mine in Powell County, MT. This was the only underground phosphate rock mine operating in the United States. During the shipping season, the ore from the mine was loaded directly into railcars for delivery to Kimberley, British Columbia, Canada.

Chevron Resources Co. started construction of a 400,000-ton-per-year diammonium phosphate fertilizer plant at Rock Springs, WY; contracted to construct a 152-kilometer (95-mile) pipeline to carry phosphate rock slurry from Vernal, UT, to Rock Springs, WY; and planned to increase the mine and beneficiation plant capacity at Vernal to more than 1 million tons per year. The new fertilizer plant at Rock Springs was planned to use sulfur from Chevron U.S.A. Inc.'s Carter Creek sour gas processing plant in southwest Wyoming. All of the new facilities were planned to begin operating in 1986.

J. R. Simplot Co. operated the Gay Mine on the Fort Hall Indian Reservation to supply acid-grade phosphate rock to its fertilizer complex at Pocatello, ID, and furnace-grade phosphate rock to FMC Corp.'s electric furnaces west of Pocatello. In June, production began at Simplot's new phosphate rock mine, Smokey Canyon, in Caribou County. The beneficiated phosphate rock was pumped 43 kilometers (27 miles) through a 20-centimeter (8-inch-diameter) pipeline to the Conda, ID, plant where the concentrate was dried and calcined. The Smokey Canyon Mine replaced the nearly exhausted Woodall Peak Mine.

Table 2.—Production of phosphate rock in the United States, by region

(Thousand metric tons and thousand dollars)

Region	Mine production		Marketable production							Stocks, Dec. 31
			Used directly		Washer production		Total[1]			
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value[2]	
1983:										
Florida and North Carolina	r117,193	15,077	2,388	717	33,572	10,495	35,960	11,212	842,926	r13,065
Tennessee	2,217	898	--	--	1,193	307	1,193	307	r29,073	159
Western States[3]	6,281	1,584	2,531	665	2,888	904	5,419	1,569	149,096	1,276
Total[1]	125,691	17,559	4,920	1,382	37,653	11,706	42,573	13,088	r1,021,095	r14,500
1984:										
Florida and North Carolina	153,694	18,856	5,582	1,673	36,871	11,312	42,453	12,985	993,356	10,608
Tennessee	2,538	513	--	--	1,368	345	1,368	345	33,275	194
Western States[3]	6,780	1,649	2,522	670	2,855	888	5,376	1,558	155,613	1,096
Total[1]	163,012	21,017	8,104	2,343	41,094	12,546	49,197	14,889	1,182,244	11,897

rRevised.
[1]Data may not add to totals shown because of independent rounding.
[2]Derived from arithmetically averaging sold or used reported data.
[3]Includes Idaho, Montana, and Utah.

CONSUMPTION AND USES

The U.S. primary demand for phosphate rock recovered to the level attained in the prior record high year of 1980.

The percent distribution by grade of marketable phosphate rock sold or used in the United States or exported was somewhat distorted by the low-grade phosphate rock for electric-furnace consumption included with high-grade rock for wet-process phosphoric acid production.

Essentially all of the phosphate rock produced in Florida and North Carolina was either used in the production of phosphate fertilizers or exported for that purpose.

All of the phosphate rock produced in Tennessee was used in electric furnaces to produce elemental phosphorus. The elemental phosphorus was converted into intermediate phosphoric acid and various sodium, calcium, and potassium chemicals for nonfertilizer uses.

Of the marketable phosphate rock domestically consumed in the Western States, the consumption was approximately equally divided between electric furnaces and fertilizer. About 2% was exported.

Table 3.—U.S. phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1980	1981	1982	1983	1984
Less than 60	5.3	5.6	4.9	8.0	12.1
60 to less than 66	15.7	15.7	15.6	14.6	8.1
66 to less than 70	56.7	60.1	63.8	60.6	63.0
70 to less than 72	12.7	9.6	5.8	8.3	10.1
72 to less than 74	6.0	6.0	6.1	5.5	2.0
74 or more	3.6	3.0	3.8	3.0	4.7

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 4.—Florida and North Carolina phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1980	1981	1982	1983	1984
Less than 60	0.1	0.2	0.6	3.3	7.8
60 to less than 66	15.3	14.4	12.2	13.0	7.0
66 to less than 70	62.2	67.0	68.5	64.2	67.5
70 to less than 72	11.2	7.7	6.9	9.6	9.9
72 to less than 74	7.0	7.1	7.2	6.4	2.4
74 or more	4.2	3.6	4.5	3.5	5.4

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 5.—Tennessee phosphate rock grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1980	1981	1982	1983	1984
Less than 60	75.3	50.6	38.0	89.4	100.0
60 to less than 66	24.7	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 grade distribution pattern

Grade (percent BPL[1] content)	Distribution (percent)				
	1980	1981	1982	1983	1984
Less than 60	27.7	31.4	27.2	25.2	27.0
60 to less than 66	16.5	16.0	29.4	27.5	19.1
66 to less than 70	27.7	28.5	43.4	47.3	39.6
70 to less than 72	28.1	24.1	--	--	14.3

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Table 7.—Phosphate rock sold or used by producers in the United States, by use

(Thousand metric tons)

Use	1983 Rock	1983 P_2O_5 content	1984 Rock	1984 P_2O_5 content
Domestic:[1]				
Wet-process phosphoric acid	30,354	9,275	36,651	11,207
Normal superphosphate	194	63	103	34
Triple superphosphate	677	213	1,062	336
Defluorinated rock	68	24	68	24
Direct applications	184	62	95	33
Elemental phosphorus	3,321	851	3,722	953
Ferrophosphorus	32	9	48	12
Total[2]	34,830	10,497	41,748	12,598
Exports[3]	12,010	3,839	11,528	3,646
Grand total[2]	46,839	14,336	53,277	16,244

[1]Includes rock converted to products and exported.
[2]Data may not add to totals shown because of independent rounding.
[3]Exports reported to the Bureau of Mines by companies.

Table 8.—Phosphate rock sold or used by producers in the United States, by grade and region in 1984

(Thousand metric tons and thousand dollars)

Grade (percent BPL[1] content)	Florida and North Carolina			Tennessee		
	Rock	P_2O_5 content	Value[2]	Rock	P_2O_5 content	Value[2]
Below 60	3,628	947	91,689	1,340	338	32,590
60 to less than 66	3,245	946	67,327	--	--	--
66 to less than 70	31,389	9,714	704,693	--	--	--
70 to less than 72	4,574	1,489	117,320	--	--	--
72 to less than 74	1,092	364	30,655	--	--	--
74 or more	2,483	849	77,963	--	--	--
Total	46,411	14,309	1,089,647	1,340	338	32,590
	Western States[3]			Total		
	Rock	P_2O_5 content	Value[2]	Rock	P_2O_5 content	Value[2]
Below 60	1,494	369	22,738	6,462	1,654	147,017
60 to less than 66	1,055	292	17,231	4,300	1,238	84,558
66 to less than 70	2,186	681	78,266	33,575	10,395	782,959
70 to less than 72	791	255	37,884	5,365	1,744	155,204
72 to less than 74	--	--	--	1,092	364	30,655
74 or more	--	--	--	2,483	849	77,963
Total	5,526	1,597	156,119	53,277	16,244	1,278,356

[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.
[2]F.o.b. mine.
[3]Includes Idaho, Montana, and Utah.

Table 9.—Phosphate rock sold or used by producers, by use and region

(Thousand metric tons)

Use	Florida and North Carolina		Tennessee		Western States[1]		Total[2]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1983:								
Domestic:[3]								
Agricultural	29,178	8,918	--	--	2,297	719	31,476	9,637
Industrial	--	--	1,187	307	2,167	553	3,354	860
Total	29,178	8,918	1,187	307	4,464	1,272	34,830	10,497
Exports[4]	11,045	3,538	--	--	964	301	12,010	3,839
Total[2]	40,223	12,456	1,187	307	5,428	1,573	46,839	14,336

See footnotes at end of table.

Table 9.—Phosphate rock sold or used by producers, by use and region —Continued

(Thousand metric tons)

Use	Florida and North Carolina		Tennessee		Western States[1]		Total[2]	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1984:								
Domestic:[3]								
Agricultural	35,924	10,991	--	--	2,054	641	37,978	11,633
Industrial	61	18	1,340	338	2,369	609	3,770	965
Total	35,985	11,009	1,340	338	4,423	1,250	41,748	12,598
Exports[4]	10,425	3,298	--	--	1,104	348	11,528	3,646
Total[2]	46,411	14,309	1,340	338	5,526	1,597	53,277	16,244

[1]Includes Idaho, Montana, and Utah.
[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 10.—Florida and North Carolina phosphate rock sold or used by producers

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton
1980	47,171	14,690	$1,108,991	$23.51
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

Table 11.—Tennessee phosphate rock sold or used by producers

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton
1980	1,665	432	$13,330	$8.01
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

Table 12.—Western States phosphate rock sold or used by producers

Year	Rock (thousand metric tons)	P_2O_5 content (thousand metric tons)	Value: Total (thousands)	Value: Average per ton
1980	5,713	1,681	$120,309	$21.06
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

STOCKS

Inventories of marketable phosphate rock were reported to the Bureau of Mines by producing companies on a monthly and semiannual basis. The monthly reports enabled the Bureau to publish stock trends during the year in its monthly Phosphate Rock Mineral Industry Surveys (MIS). The semiannual reports provided the data for stock levels reported in the annual Advance Summary MIS, crop year MIS, and the Minerals Yearbook.

After inventories peaked in 1981, inventories were reduced in 1982 by closing mines for various lengths of time and were further reduced in succeeding years as demand improved for phosphate fertilizer.

Table 13.—Marketable phosphate rock yearend stocks

(Million metric tons)

Year	Quantity
1975	9.9
1976	15.2
1977	13.7
1978	15.7
1979	14.5
1980	[r]13.7
1981	[r]19.6
1982	18.3
1983	[r]14.5
1984	11.9

[r]Revised.

PRICES

Phosphate rock was sold under contracts negotiated between buyers and sellers. List prices were occasionally published by producing organizations; however, actual contract prices that are negotiated between the buyer and seller were not published.

Phosphate rock exports from Tampa, FL, included a freight, loading, and weighing cost of $5.74 per ton as of October 1, 1984, and a severance tax of $2.39 per ton; exports from Jacksonville, FL, incurred a freight and handling cost of $8.13 per ton as well as a severance tax of $2.39 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 a 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)	1981[3]	1982[4]	1983[5]	1984[6]
68	$30.00	$23.00	$27.00	$26.50
70	30.50	23.50	28.00	27.50
72	36.00	27.00	30.00	30.50
75	43.00	34.00	35.00	35.00

[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 $1.84 severance tax.
[4]Estimated selling price including $2.03 severance tax.
[5]Estimated selling price including $2.25 severance tax.
[6]Estimated selling price including $2.39 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)	1981	1982	1983	1984
Khouribga:				
70 to 71	52.00	42.00	35.00	36.00
76 to 77	58.00	50.00	45.00	47.00
Youssoufia:				
68 to 69	44.00	38.00	29.00	30.00
74 to 75	56.00	47.00	41.00	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)	1983 Domestic	1983 Export	1983 Average	1984 Domestic	1984 Export	1984 Average
Less than 60	[r]26.94	(2)	[r]26.94	25.14	25.64	25.28
60 to less than 66	[r]24.97	[r]25.19	[r]25.03	20.90	20.10	20.75
66 to less than 70	[r]21.33	[r]25.21	[r]21.95	22.19	24.51	22.45
70 to less than 72	[r]27.12	[r]23.93	[r]24.83	25.34	25.75	25.65
72 to less than 74	[r]25.59	[r]25.59	[r]25.59	24.49	32.10	28.08
74 or more	[r]35.28	[r]34.70	[r]34.92	29.31	33.01	31.40
Average	22.64	25.70	23.48	22.67	26.28	23.48

[r]Revised.
[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.
[2]Revised to zero.

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)	1983			1984		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	r13.56	(2)	r13.56	15.22	--	15.22
60 to less than 66	16.24	40.14	19.28	11.15	41.51	16.33
66 to less than 70	r36.99	r46.29	r39.80	32.14	44.81	35.80
70 to less than 72	--	--	--	45.78	51.45	47.87
Average	23.76	45.07	27.54	23.81	46.03	28.25

rRevised.
[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.
[2]Revised to zero.

Table 18.—Price or value of Tennessee phosphate rock, by grade

(Dollars per metric ton, f.o.b. mine)

Grade (percent BPL[1] content)	1983	1984
Less than 60	r24.52	24.32
60 to less than 66	r23.15	--
Average	24.37	24.32

rRevised.
[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)	1983			1984		
	Domestic	Export	Average	Domestic	Export	Average
Less than 60	r21.40	(2)	r21.40	22.25	25.64	22.75
60 to less than 66	r22.76	r26.97	r23.74	18.47	24.94	19.67
66 to less than 70	r22.53	r28.53	r23.57	22.72	27.62	23.32
70 to less than 72	r27.12	r23.93	r23.83	31.55	27.77	28.93
72 to less than 74	r25.59	r25.59	r25.59	24.49	32.10	28.08
74 or more	r35.28	r34.70	r34.92	29.31	33.01	31.40
Average	22.84	27.26	23.97	22.84	28.17	23.99

rRevised.
[1]1.0% BPL (bone phosphate of lime or tricalcium phosphate)=0.458% P_2O_5.
[2]Revised to zero.

FOREIGN TRADE

U.S. phosphate rock exports set a record high in 1980 and then abruptly declined in the early 1980's with the world recession. Exports recovered somewhat in 1983 and 1984. Increased supplies of phosphate rock from African and Mideastern phosphate rock producing countries were expected to increase competition in world markets, particularly for U.S. producers.

Free trade or exports of phosphate rock were incompletely described by the statistics. For example, several U.S. companies were partners in fertilizer plants in other countries and as such were committed to ship phosphate rock to those operations. Other organizations from foreign countries owned a percentage of U.S. phosphate mines and controlled their share of production. Further, the classification of domestic consumption or home deliveries is misleading in that frequently only a fraction of this classification stayed in the country, with the balance exported as converted phosphate fertilizer.

In Florida, rail freight, port charges, and severance taxes all increased, further reducing the competitive position of phosphate rock exporting companies.

The small quantities of phosphate rock imported into the United States in 1984, as reported by the Bureau of the Census, are shown in the following tabulation:

Country of origin	Metric tons
China	5
Japan	102
Kenya	1
Mexico	2,872
Netherlands Antilles	5,603
United Kingdom	54
Total	8,637

NOTE: Reported imports from Canada and Israel are excluded.

Table 20.—U.S. exports of phosphate rock, by country

(Thousand metric tons and thousand dollars)

Country	1983		1984	
	Quantity	Value[1]	Quantity	Value[1]
Australia	338	10,226	212	6,199
Austria	207	7,502	20	6
Belgium-Luxembourg	505	15,850	549	17,454
Brazil	--	--	12	709
Canada	2,762	101,305	2,998	106,479
Finland	106	3,520	149	4,967
France	843	26,384	702	23,856
Germany, Federal Republic of	770	24,262	541	16,770
India	305	14,755	248	9,954
Italy	224	6,766	85	2,640
Japan	1,528	63,110	1,274	50,843
Korea, Republic of	1,516	52,139	1,501	46,750
Mexico	370	11,109	429	12,861
Netherlands	974	27,915	640	18,957
New Zealand	90	3,492	51	1,578
Norway	46	1,951	--	--
Philippines	80	3,083	25	974
Poland	769	22,181	--	--
Romania	317	11,492	433	17,435
Sweden	159	6,117	187	6,797
Taiwan	29	1,022	23	854
United Kingdom	122	4,288	26	854
Other	137	4,892	1,211	45,095
Total	12,197	423,361	11,316	392,032

[1]All values f.a.s. (free alongside ship).

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)

Country	1983		1984	
	Quantity	Value[1]	Quantity	Value[1]
Argentina	6	830	9	1,107
Belgium-Luxembourg	34	4,291	78	9,208
Brazil	--	--	44	6,031
Bulgaria	90	10,612	92	11,781
Burma	--	--	15	2,840
Canada	89	14,607	204	30,867
Chile	96	11,956	182	15,660
China	281	35,175	--	--
Colombia	18	3,625	15	2,720
Costa Rica	8	1,214	8	1,035
Dominican Republic	9	1,736	8	1,490
France	30	4,037	9	1,063
Germany, Federal Republic of	100	13,830	80	9,772
Hungary	21	2,704	15	1,739
Indonesia	57	8,432	--	--
Ireland	23	2,887	38	4,887
Italy	7	955	7	924
Japan	30	4,081	30	4,286

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)

Country	1983		1984	
	Quantity	Value[1]	Quantity	Value[1]
Peru	12	1,566	14	1,987
Singapore	5	648	--	--
Uruguay	1	205	6	829
Venezuela	1	377	8	1,548
Other	276	40,902	228	39,322
Total	1,194	164,670	1,090	149,096

[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

Country	1983		1984	
	Quantity (metric tons)	Value[1] (thousands)	Quantity (metric tons)	Value[1] (thousands)
Canada	65,838	$1,445	1,097	$24
Other	2,772	62	660	30
Total	68,610	1,507	1,757	54

[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)

Country	1983		1984	
	Quantity	Value[1]	Quantity	Value[1]
Argentina	61	10,641	84	15,901
Australia	187	32,144	206	41,339
Bangladesh	100	18,106	--	--
Belgium-Luxembourg	679	114,214	748	139,672
Brazil	--	--	91	17,660
Canada	173	27,728	115	22,753
Chile	26	4,381	51	10,257
China	585	99,820	1,229	230,928
Colombia	47	8,127	61	11,920
Costa Rica	196	3,404	19	3,838
Dominican Republic	34	5,683	31	5,849
Ecuador	3	488	39	7,788
Ethiopia	22	3,826	--	--
France	61	10,908	19	3,769
Germany, Federal Republic of	32	5,869	27	5,028
Guatemala	225	4,316	13	2,962
India	141	24,560	1,189	227,337
Ireland	42	7,226	34	5,775
Italy	--	--	128	24,357
Japan	444	75,190	488	92,197
Mexico	185	31,885	267	52,049
Netherlands	--	--	19	3,394
New Zealand	56	9,646	45	8,978
Nicaragua	149	2,580	19	2,812
Pakistan	328	62,788	247	48,680
Spain	122	18,731	--	--
Thailand	46	7,684	68	12,335
Turkey	60	9,812	60	11,844
Uruguay	13	2,244	--	--
Yugoslavia	66	11,666	79	15,268
Other	675	115,566	970	175,889
Total	4,758	729,233	6,346	1,200,579

[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)

Country	1983 Quantity	1983 Value[1]	1984 Quantity	1984 Value[1]
Canada	1	124	3	520
Colombia	6	1,162	9	2,061
Germany, Federal Republic of	7	1,827	54	13,397
India	154	30,203	212	45,001
Indonesia	109	28,368	95	20,465
Mexico	(2)	2	21	4,051
Turkey	54	13,459	140	25,612
U.S.S.R	9	2,925	--	--
Venezuela	37	6,865	100	23,322
Other	(2)	44	233	46,626
Total	377	84,979	867	181,055

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.

Source: Bureau of the Census.

Table 25.—U.S. exports of phosphoric acid, more than 65% P_2O_5, by country

(Thousand metric tons and thousand dollars)

Country	1983 Quantity	1983 Value[1]	1984 Quantity	1984 Value[1]
Canada	39	8,680	62	14,633
U.S.S.R	730	214,810	719	186,400
Other	73	13,677	73	14,480
Total	842	237,167	854	215,513

[1]All values f.a.s. (free alongside ship).

Source: Bureau of the Census.

Table 26.—U.S. exports of elemental phosphorus, by country

Country	1983 Quantity (metric tons)	1983 Value[1] (thousands)	1984 Quantity (metric tons)	1984 Value[1] (thousands)
Argentina	(2)	$2	--	--
Belgium	17	53	--	--
Brazil	7,438	13,347	3,270	$5,068
Canada	1,264	1,441	1,518	1,888
China	3,000	3,798	2,300	2,816
Japan	8,985	13,926	5,776	9,647
Korea, Republic of	761	1,051	496	752
Mexico	22	47	19	78
Taiwan	168	232	793	986
Other	97	219	680	1,140
Total	21,752	34,116	14,852	22,375

[1]All values f.a.s. (free alongside ship).
[2]Less than 1/2 unit.

Source: Bureau of the Census.

Table 27.—U.S. imports for consumption of phosphate rock and phosphatic materials

(Thousand metric tons and thousand dollars)

Fertilizer	1983 Quantity	1983 Value[1]	1984 Quantity	1984 Value[1]
Phosphates, crude and apatite	9	r305	9	274
Phosphatic fertilizers and fertilizer materials	36	3,622	119	7,536
Dicalcium phosphate	r1	676	526	378
Phosphorus	r2,122	r3,362	4,222	6,482
Phosphoric acid	r9,060	2,930	10,104	4,060
Phosphoric acid, fertilizer grade	(2)	r69	1	380
Normal superphosphate	2	277	1	141
Triple superphosphate	9	1,272	9	1,029

[r]Revised.
[1]Declared customs valuation.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

World phosphate rock production increased to an estimated 151 million tons to meet an improved international market. As the world economy improved, phosphoric acid industry sales, a good indicator of the state of the market for the phosphate industry, increased in 1983 over the low level of 1982. Although less than improvement in phosphate rock production in those years, improvement in phosphoric acid deliveries continued in 1984 as the market returned to relative stability. Over the past decade, trade in phosphoric acid steadily increased as producers of phosphate rock broadened their product spectrum and upgraded the value of their raw materials.

Morocco was the world's largest supplier of merchant-grade acid (MGA), and the United States was a close second. Other countries such as Belgium, Israel, Jordan, Senegal, the Republic of South Africa, Spain, and Tunisia had established MGA industries supplying Northwestern Europe, France, India, Italy, and the U.S.S.R. Because MGA trade appeared to be advantageous to both producers and consumers, with cost savings anticipated in transportation, plant construction, sulfur acquisition, and flexibility in supply to meet demand, MGA trade was expected to increase at the expense of trade in phosphate rock.

Algeria.—Production of phosphate rock from the Djebel Onk Mine, operated by Société Nationale de Recherches et d'Exploitations Minières, was an estimated 1 million tons, or similar to production during the past 3 years. About 50% of the rock produced was exported to Eastern and Western Europe, and the balance was domestically consumed or stockpiled.

Australia.—The Duchess Mine of Queensland Phosphate Ltd. remained closed. A small quantity of phosphate rock, estimated to be about 4,000 tons, was produced in South Australia, but because of its high iron and aluminum content, it could be used only in organic fertilizers for horticultural purposes. Studies of an apatite-bearing carbonatite deposit west of Laverton, Western Australia, were continuing, but the evaluation was incomplete.

Brazil.—Phosphate rock production increased tenfold since the 1970's. During the past 5 years, Brazil had become self-sufficient in phosphate rock. The largest phosphate rock producing company in Brazil was Fertilizantes Fosfatados S.A. (FOSFÉRTIL), followed by Fosfatos de Goiás S.A. and Serrana S.A. de Mineração. These three companies combined contributed more than 3 million tons in 1984. FOSFÉRTIL had additional reserves in Paulista, Pernambuco State, northeastern Brazil. Industria de Fosfatados Catarinense was evaluating a phosphate deposit in the area of Anitapolis, Santa Catarina State.

China.—Production estimates of phosphate rock show a progressive increase over the past 5 years. Estimated production in 1984 was 11.8 million tons, and reserves were more than 200 million tons recoverable at a cost of less than $35 per ton. Recent phosphate discoveries were reported in Yunnan, Hubei, and Guizhou Provinces, where medium-sized phosphate mines were under construction.

Christmas Island.—Phosphate rock was mined by the Government-owned Phosphate Mining Co. of Christmas Island (PMIC). Demand from Australia and New Zealand for PMIC rock declined in recent years. Mining the estimated remaining 27.8 million tons of high-grade rock was expected to depend on PMIC operating profitably.

Egypt.—The Hamrawein phosphate rock mine on the Red Sea started production at a rate of 200,000 tons per year and was planned to increase production to 600,000 tons per year. The Abu Zaabal Mine at Sebaiya West, designed to produce 400,000 tons per year, was being developed to replace mines near Quseir and Safaga. Only limited progress was made at the much publicized Abu Tartur phosphate rock project in the Western Desert, where an experimental mine had been operating since 1980.

Greece.—About 8 years ago, a phosphate deposit was discovered in the Epirus region of western Greece. Exploration showed the apatite deposit to have inconsistent characteristics that made the ore difficult to beneficiate. In 1984, plans were to mine the "Drymon IV" part of the deposit to produce 200,000 tons per year of 28% P_2O_5 concentrates. If the studies continue to show economic and technical feasibility, a mine could be operating in 1986.[2]

Israel.—The Israelis planned to increase phosphate rock production by optimizing the operation of the mines at Arad, Oron, and Zin. The closed Makhtesh Mine was expected to be restarted if demand for phosphate rock warrants additional production.

Jordan.—Phosphate rock was mined at Albyadd, El Hassa, and Rusaiffa with a combined capacity of 4.6 million tons per year. A substantial increase in mining production planned for 1984 that could increase total capacity to 6 to 7 million tons per year. The feasibility of producing an additional 3 million tons of phosphate rock per year by 1988 and 10 million tons per year by 2000 from the Shiddaya phosphate rock deposits near Maan was under study.[3]

Mexico.—Roca Fosfórica Mexicana S.A. de C.V. had intended to start the San Juan de la Costa phosphate mine on the Baja California Sur and the Santo Domingo Mine in 1982 and, in so doing, attempt to make Mexico independent of phosphate rock imports by 1985. The San Juan de la Costa Mine actually started in 1981; however, the Santo Domingo Mine was delayed as the floating hydraulic-cutter dredges, with 27-inch-diameter suction heads, were unable to break the coquina formation, which is characteristic of much of the deposit. With subsequent problems at both mines, it was assumed that Mexican phosphate rock production would expand only moderately in the foreseeable future.

Morocco.—The exact startup dates for the eight planned phosphoric acid lines of 500 tons per day each at Jorf Lasfar, south of Casablanca, were not certain; however, it appeared that the first two lines would be on-stream in 1985 and the other lines would come on at intervals through 1989. In addition, two 200,000-ton-per-year triple superphosphate plants were planned to be constructed at Jorf Lasfar after 1985. Phosphate rock concentrate for the phosphoric acid and triple superphosphate plants was to be 70% to 71% bone phosphate of lime (BPL). The above planned capacity at Jorf Lasfar was in addition to existing capacity at Safi, where the combined phosphoric acid capacity of Maroc Chemie, Maroc Phosphore I, and Maroc Phosphore II had been about 1,500 tons per day P_2O_5. Maroc Chemie also had a 300-ton-per-day P_2O_5 triple superphosphate plant.

Pakistan.—A 200,000-ton-per-year phosphate rock mine was planned to start producing in 1986 from the Kakul phosphate deposit in Pakistan's Northwest Frontier Province. The mine was being developed with capital and technical assistance by the Overseas Development Administration of the British Government.[4]

Senegal.—The Taiba Mine capacity was increased to 1.2 million tons per year to supply Industries Chimiques du Senegal. A 693,000-ton-per-year sulfuric acid plant and a 264,000-ton-per-year P_2O_5 phosphoric acid plant were constructed at Darou Khoudoss near the Taiba Mine. At M'bao, near Dakar, facilities were constructed to produce 170,000 tons per year of triple superphosphate and 80,000 tons per year of monoammonium and diammonium phosphate. A deposit at Semuce near Matam in the Fleure region was under study as a potential source of phosphate rock.

Sri Lanka.—Phosphate rock production from the Eppawala deposit was planned to increase from 15,000 to 1 million tons per year to supply phosphate rock to proposed triple superphosphate and diammonium phosphate plants at East Coast Trincomalee. A joint venture partnership was formed between Agrico Chemical Co. and the State Mining and Mineral Development Corp. to accomplish the mine expansion and construct the fertilizer plant. However, the partners agreed to put the programs on hold until political differences in the country are settled.

Togo.—The Office Togolaise des Phosphates was studying the feasibility of constructing a 1,000-ton-per-day P_2O_5 phosphoric acid plant and a 1,000-ton-per-day triple superphosphate plant at K'peme adjacent to the phosphate rock beneficiation facility. To supply both export demand and that from a new fertilizer complex, a new phosphate rock mine at Dagbati would have to be developed to augment phosphate rock production from the Hahotoe-K'pogame deposit.[5]

Tunisia.—Tunisia's Industries Chimiques de Gafsa started a new phosphoric acid plant and two triple superphosphoric granulation units at M'Dilla, about 12 kilometers from the phosphate rock mines at Gafsa. Capacity of the complex was 158,000 tons per year P_2O_5 phosphoric acid, and each granulation unit's capacity was 672 tons per day.[6]

U.S.S.R.—The mines in the Kola Peninsula produced about 18 million tons of phosphate rock, or about 70% of total production, in the Soviet Union. Plans were to limit production to 19 million tons per year. Five mines in the Kara Tau Basin in southern Kazakhstan produced an estimated 10 million tons of phosphate rock. An approximate breakdown of the annual production from three of the mines was Chulak Tau, 2 to 3 million tons; and Ak Say and Kok Dzhonc combined, 1 million tons.[7]

Table 28.—Phosphate rock, basic slag, and guano: World production, by country[1]

(Thousand metric tons)

Commodity and country[2]	Gross weight					P_2O_5 content				
	1980	1981	1982	1983[p]	1984[e]	1980	1981	1982	1983[p]	1984[e]
Phosphate rock:										
Algeria	1,025	916	947	893	[3]1,000	317	262	289	276	309
Australia	7	22	211	21	[3]11	2	6	59	6	3
Brazil[4]	2,612	3,238	2,732	3,208	3,855	989	979	1,141	1,119	1,345
China[e]	10,726	11,500	11,720	12,500	11,800	2,360	2,530	2,580	[r]3,750	3,540
Christmas Island (Indian Ocean)	1,713	1,423	1,328	1,094	[3]1,259	602	499	466	385	443
Colombia	6	[r]17	20	17	28	1	4	4	4	7
Egypt	658	720	711	647	[3]1,043	184	203	200	205	253
Finland	138	201	233	381	[3]477	50	72	83	141	176
France	([5])	([5])	([5])	([5])	--	([5])	([5])	([5])	([5])	--
India	541	562	560	691	800	167	173	173	213	246
Indonesia	11	8	5	3	3	4	3	2	2	2
Iraq	--	[e]50	363	1,199	1,500	--	[r e]16	[r e]113	[r e]261	360
Israel	2,307	1,919	2,148	2,969	[3]3,312	750	624	698	892	995
Jordan	3,911	4,244	4,390	4,749	6,263	1,271	1,379	1,427	1,548	2,042
Korea, North[e]	500	500	500	500	500	150	150	150	[r]160	160
Mexico	397	[r]252	379	389	[3]375	[r]118	150	195	114	110
Morocco[6]	18,824	18,562	17,754	20,106	[3]21,245	[e]5,835	[e]5,958	[e]5,700	[r e]6,400	6,762
Nauru	2,087	1,480	1,359	1,684	[3]1,359	803	570	523	648	523
Peru	14	98	29	3	1	4	30	9	([7])	([7])
Philippines	17	8	6	10	4	4	2	2	([7])	([7])
Senegal[8]	1,632	1,699	1,182	1,521	[3]1,912	[e]497	[e]518	361	534	583
South Africa, Republic of	3,185	2,718	3,173	2,742	[3]2,585	[e]1,147	[e]942	[e]1,149	996	939
Sri Lanka	5	15	[e]20	16	16	1	4	7	6	6
Sweden	88	124	131	107	[3]128	34	48	50	41	49
Syria	1,319	1,321	1,455	1,229	[3]1,514	402	402	443	375	461
Tanzania	--	--	--	20	[3]15	--	--	--	6	7
Thailand	6	6	4	5	6	2	1	1	1	2
Togo	2,933	2,215	2,800	2,081	2,696	1,061	806	1,005	755	979
Tunisia	4,582	4,596	4,196	5,924	[3]5,346	1,283	1,287	1,213	1,700	1,554
Turkey	21	43	[9]35	50	96	6	11	9	15	29
U.S.S.R.[e]	[r]30,300	[r]30,700	[r]31,300	[r]31,600	31,900	[r]9,600	[r]9,700	[r]9,800	[r]10,000	10,100
United States	54,415	53,624	37,414	42,573	[3]49,197	16,711	16,365	11,504	13,088	14,889
Vietnam[e]	[r]83	[r]181	[r]110	[r]200	200	[r]27	[r]60	[r]36	[r]66	66
Zimbabwe	130	125	120	133	[3]125	45	44	42	47	44
Total	[r]144,193	[r]143,087	127,335	139,265	150,571	[r]44,427	[r]43,798	39,434	43,754	46,984

See footnotes at end of table.

Table 28.—Phosphate rock, basic slag, and guano: World production, by country[1] —Continued

(Thousand metric tons)

Commodity and country[2]	Gross weight					P_2O_5 content				
	1980	1981	1982	1983[p]	1984[e]	1980	1981	1982	1983[p]	1984[e]
Basic (Thomas) slag:										
Argentina	4	1	1	1	1	1	(7)	(7)	(7)	(7)
Belgium	893	496	393	250	350	161	89	71	45	63
Egypt	10	[e]10	10	10	10	2	2	2	2	2
France	1,862	1,451	1,343	1,224	1,200	335	261	242	216	170
Germany, Federal Republic of	1,103	824	502	409	400	[r]161	138	130	110	90
Luxembourg	688	595	572	[e]500	450	122	106	103	90	81
United Kingdom	[r e]150	4	4	4	4	[r e]30	1	1	1	1
Total	[r]4,710	3,381	2,825	2,398	2,415	[r]812	597	549	464	407
Guano:										
Chile	--	1	1	1	1	--	(7)	(7)	(7)	(7)
Kenya	--	--	(7)	(7)	(7)	--	--	(7)	(7)	(7)
Philippines	25	2	15	1	1	5	(7)	3	(7)	(7)
Seychelles Islands (exports)	4	[e]5	[e]5	[e]5	5	1	2	2	2	2
Total	29	8	21	7	7	6	2	5	2	2

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

[1]Table includes data available through Apr. 9, 1985. 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]Figure represents total of direct sales of run-of-mine product plus output of marketable concentrate. Direct sales of run-of-mine product were as follows, in thousand tons: 1980—50; 1981—53; 1982—45 (estimated); 1983—55 (estimated); and 1984—60 (estimated). Total output of crude ore reported in Brazilian sources is far higher than figures presented here, but such figures are not equivalent to data shown for other countries in this table.

[5]Revised to zero.

[6]Production from Western Sahara area included with Morocco.

[7]Less than 1/2 unit.

[8]Includes aluminum phosphate as follows, in thousand metric tons: 1980—224; 1981—199 (revised); 1982—279; 1983—187; and 1984—200 (estimated). Data do not include figures for output of several types of manufactured phosphate fertilizers that are produced from the reported calcic phosphate and aluminum phosphate to avoid double counting.

[9]Run-of-mine ore.

WORLD RESERVES

The Bureau of Mines published Information Circular 8989, which reports the conclusions of investigating the availability of phosphate rock from 201 phosphate mines and deposits in market economy countries and 17 mines and deposits in the U.S.S.R. and China.[8]

A study of the worldwide availability of phosphate rock was made and published in the United Nations Natural Resources Forum.[9]

An analysis of phosphate rock resources in the United States, based on past estimates and recent available information, was published in U.S. Geological Survey Circular 888.[10]

TECHNOLOGY

Continuous flotation studies of dolomitic phosphate matrix from southern Florida were made by the Bureau of Mines to produce an acceptable concentrate.[11]

Studies to develop processes to dewater slurries from processing operations were conducted by the Bureau of Mines.[12] A prototype unit using polyethylene oxide flocculant was operated at a number of phosphate mines in Florida to accelerate the dewatering of phosphatic clay wastes. In all cases, with or without additional additives to cope with various clay characteristics, initial dewatering to at least 20% solids was achieved.

The Bureau of Mines obtained high recovery of P_2O_5 from plus 37- and plus 20-micrometer-size fractions of settled phosphatic clay wastes.[13] The flotation studies showed that an 89% P_2O_5 concentrate could be recovered from the plus 37-micrometer flotation feed at a grade of 21.9% P_2O_5. A 29% P_2O_5 concentrate, which is below commercial specifications, was produced from the plus 37-micrometer feed material by eliminating sodium silicate in the rougher float; however, the P_2O_5 recovery dropped to 56.7% of the flotation feed.

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[1]Physical scientist, Division of Industrial Minerals.

[2]Industrial Minerals (London). No. 198, Mar. 1984, p. 12.

[3]European Chemical News. V. 42, No. 1124, Mar. 26, 1984, p. 21.

[4]Mining Magazine. June 1984, p. 515.

[5]European Chemical News. V. 42, No. 1132, May 21, 1984, p. 26.

[6]———. V. 43, No. 1149, Oct. 22, 1984, p. 13.

[7]Phosphorus and Potassium. No. 133, Sept.-Oct. 1984, pp. 22-25.

[8]Fantel, R. A., T. F. Anstett, G. R. Peterson, K. E. Porter, and D. E. Sullivan. Phosphate Rock Availability—World. A Minerals Availability Program Appraisal. BuMines IC 8989, 1984, 65 pp.

[9]Fantel, R. A., G. R. Peterson, and W. F. Stowasser. The Worldwide Availability of Phosphate Rock. Nat. Resour. Forum, v. 9, No. 1, Jan. 1985, 20 pp.

[10]Cathcart, J. B., R. P. Sheldon, and R. A. Gulbrandsen. Phosphate Rock Resources of the United States. U.S. Geol. Surv. Circ. 888, 1984, 48 pp.

[11]Davis, B. E., T. O. Llewellyn, and C. W. Smith. Continuous Beneficiation of Dolomitic Phosphate Ores. BuMines RI 8903, 1984, 14 pp.

[12]Scheiner, B. J., A. G. Smelley, and D. R. Brooks. Large-Scale Dewatering of Phosphatic Clay Waste From Central Florida. BuMines RI 8611, 1982, 11 pp.

[13]Jordan, C. E., C. W. Smith, G. V. Sullivan, and B. E. Davis. Recovery of Phosphate From Florida Phosphate Operations Slimes. BuMines RI 8731, 1982, 13 pp.

Platinum-Group Metals

By J. Roger Loebenstein[1]

World mine production of platinum-group metals (PGM) increased to 7.1 million troy ounces in 1984. World mine production of the principal metals of the group, platinum and palladium, increased to 2.9 million ounces and 3.5 million ounces, respectively. The Republic of South Africa remained the leading producer of platinum, and the U.S.S.R. remained the leading producer of palladium.

Demand for platinum in market economy countries increased to 2.6 million ounces, and demand for palladium in these countries increased to 3.3 million ounces.

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 48 operations to which

Table 1.—Salient platinum-group metals[1] statistics

(Thousand troy ounces unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Mine production[2]	3	7	8	6	15
Value thousand dollars	$923	$1,571	$1,278	$1,133	$2,607
Refinery production:					
Primary refined	3	7	9	9	24
Secondary:					
Nontoll-refined	331	392	344	r303	339
Toll-refined	1,079	1,191	868	995	1,157
Total refined metal	1,413	1,590	1,221	r1,307	1,520
Stocks, yearend:					
Industry (refined)	973	918	1,107	943	1,297
National Defense Stockpile:					
Platinum	453	453	453	453	453
Palladium[3]	1,255	1,255	1,255	1,255	1,262
Iridium[4]	17	17	21	r28	30
Exports:					
Refined[5]	592	651	439	446	597
Total	765	863	836	1,229	1,162
Imports for consumption:					
Refined[5]	3,109	2,611	2,150	2,790	3,928
Total	3,502	2,850	2,494	3,218	4,474
Imports, general	3,772	3,191	2,494	3,218	4,485
Consumption (reported sales to industry)	2,206	1,921	1,873	1,914	2,469
Consumption, apparent[6]	r2,640	r2,414	r1,871	r2,810	3,322
Net import reliance[7] as a percent of apparent consumption	87	83	81	89	89
Price, producer, average, per ounce:					
Platinum	$439	$475	$475	$475	$475
Palladium	$214	$130	$110	$130	$147
World: Mine production	6,848	6,931	6,424	p6,524	e7,053

eEstimated. pPreliminary. rRevised.
[1]The platinum group comprises six metals: platinum, palladium, iridium, osmium, rhodium, and ruthenium.
[2]Byproduct of copper refining.
[3]Includes 7,200 ounces purchased in 1984, but not added to inventory in that year.
[4]Includes 2,400 ounces purchased in 1983 and 1,800 ounces purchased in 1984, but not added to inventory in those years.
[5]Includes both unwrought and semimanufactured.
[6]Mine production plus nontoll-refined production plus refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks.
[7]Refined imports for consumption minus refined exports plus or minus changes in Government and industry stocks.

a survey request was sent, 69% responded, representing an estimated 97% of the total refined metal production shown in tables 1, 2, and 9. Production of refined metal for the 15 nonrespondents was estimated using reported prior year production levels.

Legislation and Government Programs.—The General Services Administration purchased 1,800 ounces of iridium and 7,200 ounces of palladium for the National Defense Stockpile in the fourth quarter of 1984.

DOMESTIC PRODUCTION

ASARCO Incorporated, Kennecott, and U.S. Metals Refining Co. produced platinum and palladium as byproducts of copper refining. Secondary metal was refined by about 20 firms, mostly on the east and west coasts. Most PGM scrap was refined on a toll basis. The largest scrap processors in the United States were the Specialty Metals Div. of Engelhard Corp. (formerly Engelhard Minerals and Chemicals Corp.), Johnson Matthey Inc., and U.S. Metals.

Texasgulf Minerals and Metals Corp. announced plans to extract PGM from spent automobile catalytic converters and petroleum reforming catalysts. The company's new plasma arc smelting plant, located in Anniston, AL, will process about 7 million pounds of catalyst per year at full capacity.[2]

A leading fabricator and refiner of precious metals, Engelhard, was reorganized into Specialty Chemicals Div., for catalyst production, and Specialty Metals Div., for refining and fabricating of precious metals. Refining operations at Engelhard's Delancy Street refinery, which has been curtailed since mid-1982, were resumed.[3]

Nassau Recycle Corp., Gaston, SC, a subsidiary of AT&T Technologies Inc. was renamed AT&T Nassau Metals Corp. The company owns a precious metals refinery on Staten Island, NY.[4]

Table 2.—Platinum-group metals refined in the United States

(Troy ounces)

	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
PRIMARY METAL							
Nontoll-refined:							
1980	535	1,765	--	--	--	--	2,300
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
Toll-refined:							
1980	128	673	--	--	--	--	801
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
SECONDARY METAL							
Nontoll-refined:							
1980	154,075	162,408	3,186	13	10,106	1,135	330,923
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	r177,816	r2,357	--	3,663	750	r303,165
1984	89,660	243,324	735	27	3,568	2,047	339,361
Toll-refined:							
1980	533,101	498,905	4,933	1,371	33,362	7,340	1,079,012
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

See footnote at end of table.

Table 2.—Platinum-group metals refined in the United States —Continued

(Troy ounces)

	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1983 TOTALS							
Total primary	2,029	7,031	--	--	--	--	9,060
Total secondary	552,279	[r]634,548	[r]8,177	925	45,287	56,538	[r]1,297,754
Grand total	554,308	[r]641,579	[r]8,177	925	45,287	56,538	[r]1,306,814
1984 TOTALS							
Total primary	2,583	17,898	1,000	250	--	2,000	23,731
Total secondary	613,818	811,813	8,561	76	41,152	21,335	1,496,755
Grand total	616,401	829,711	9,561	326	41,152	23,335	1,520,486

[r]Revised.

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 electrical contacts; in capacitors; in conductive and resistive films used in electronic circuits; and in dental alloys used for making crowns and bridges.

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
1980	1,118,231	911,967	23,584	819	73,528	77,781	2,205,910
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:							
Automotive	508,499	172,050	43	--	19,734	--	700,326
Chemical	65,369	39,892	[r]592	356	[r]3,985	[r]54,968	[r]165,162
Dental and medical	[r]16,744	[r]343,519	134	1,033	173	237	[r]361,840
Electrical	[r]74,716	[r]250,059	1,014	--	[r]8,471	[r]71,249	[r]405,509
Glass	14,903	146	35	--	2,033	--	17,117
Jewelry and decorative	10,327	6,711	787	--	2,248	892	20,965
Petroleum	38,030	49,870	1,040	--	--	180	89,120
Miscellaneous	68,128	59,582	1,378	--	7,581	17,251	153,920
Total	[r]796,716	[r]921,829	[r]5,023	1,389	44,225	[r]144,777	[r]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	98,925	389,070	1,514	--	9,023	54,114	552,646
Glass	12,184	10	106	--	2,941	--	15,241
Jewelry and decorative	9,280	5,884	1,173	--	1,238	765	18,340
Petroleum	28,045	92,134	--	--	11	600	120,790
Miscellaneous	66,154	57,134	2,991	--	6,666	7,211	140,156
Total	1,028,728	1,255,875	7,117	1,072	87,937	88,530	2,469,259

[r]Revised.

[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.

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
1980	502,185	353,002	15,032	200	46,105	56,737	973,261
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	r433,457	r412,178	r16,944	489	r51,107	r28,973	r943,148
1984	647,875	505,237	19,603	1,302	51,889	71,506	1,297,412

r Revised.
[1] Includes metal in depositories of the New York Mercantile Exchange (NYMEX); on Dec. 28, 1984, this comprised 285,800 troy ounces of platinum and 66,900 troy ounces of palladium.

PRICES

Whereas dealer prices for both platinum and palladium changed little, dealer prices for other PGM increased sharply. Rhodium prices increased reportedly because of higher demand for automobile catalysts.

In January, the Tokyo Gold Exchange introduced trading of platinum and silver futures contracts. The contract size for platinum was 500 grams (16 troy ounces).[5]

Similarly, in July, the U.S. Commodity Futures Trading Commission approved trading of 25-troy-ounce platinum futures contracts. Trading began in August on the MidAmerica Commodity Exchange in Chicago. Contract specifications called for plate or ingot containing at least 99.9%-pure platinum. Smaller firms, including merchants and scrap dealers, used the MidAmerica Exchange, and industrial users continued to dominate trading on the New York Mercantile Exchange (NYMEX).[6]

In June, the NYMEX increased the minimum purity requirement for palladium contracts from 99.8% to 99.9%. The minimum purity requirement for platinum contracts remained 99.9%.[7] NYMEX trading volume in futures contracts for 1982 through 1984 is shown in the following tabulation:

	Platinum[1]	Palladium[2]
1982	669,024	63,829
1983	1,053,282	241,224
1984	571,127	159,019

[1] 50 troy ounces per contract.
[2] 100 troy ounces per contract.

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
1980	439	677	214	201	766	729	505	666	45	35	150	130
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:												
January	475	461	130	125	600	266	600	285	45	25	110	130
February	475	465	130	125	600	283	600	285	45	25	110	130
March	475	402	130	102	600	294	600	316	45	26	110	130
April	475	414	130	120	600	295	600	300	45	26	110	130
May	475	447	130	131	600	304	600	300	45	26	110	130
June	475	423	130	133	600	323	600	304	45	26	110	130
July	475	435	130	146	600	319	600	305	45	26	110	130
August	475	435	130	148	600	334	600	317	45	29	110	135
September	475	429	130	151	600	311	600	323	45	29	110	135
October	475	394	130	142	600	337	600	325	45	32	110	135
November	475	385	130	146	600	334	600	325	45	34	110	136
December	475	393	130	164	600	339	600	325	45	37	110	136
Average	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

[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.

FOREIGN TRADE

The major sources for imports of PGM, in declining order, were the Republic of South Africa, the United Kingdom, and the U.S.S.R. The major recipients of exports, in declining order, were the United Kingdom, Japan, and Belgium-Luxembourg.

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)			Metal rolled (troy ounces)		Total	
			Platinum	Palladium	Other platinum group	Platinum	Other platinum group	Troy ounces	Value (thousands)
1980	2,797	170,256	254,495	179,686	109,511	34,959	13,260	764,964	$341,206
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:									
Australia	--	3	757	1,406	816	--	65	3,047	787
Belgium-Luxembourg	--	150,868	--	93	475	--	12	151,448	25,737
Brazil	108	1,100	--	860	1,833	--	--	3,901	1,065
Canada	425	66,531	5,585	18,759	26,561	275	2,039	120,175	33,625
China	--	--	1,291	--	1,601	--	--	2,892	895
Colombia	--	--	128	--	367	--	100	595	202
Cyprus	--	--	1	645	200	--	--	846	100
France	60	237	2,557	11,931	659	34	1,209	16,687	3,538
German Democratic Republic	--	--	--	--	5,862	--	--	5,862	2,208
Germany, Federal Republic of	35,310	26,373	31,372	17,818	11,945	3,426	368	126,612	23,623
Greece	--	15	--	1,278	882	--	41	2,216	340
Hong Kong	--	31	7,432	418	400	--	--	8,281	2,708
Israel	--	--	8	64	1,030	--	60	1,162	233
Italy	--	14,601	1,830	445	2,175	24	84	19,159	6,779
Japan	5,269	4,791	116,650	64,994	16,154	31,862	5,106	244,826	68,518
Korea, Republic of	--	--	80	2,599	56	128	5	2,868	283
Mexico	--	--	286	--	178	--	515	979	288
Netherlands	325	327	510	9,322	13,547	--	12,028	36,059	6,153
Singapore	--	21	--	61	461	--	3	546	121
South Africa, Republic of	--	--	303	23	256	--	--	582	223
Spain	94	--	3	655	936	--	16	1,704	600
Sweden	--	2,711	--	775	3,364	2	--	6,852	2,136
Switzerland	193	--	6,303	3,434	12,545	--	225	22,700	6,242
Taiwan	--	--	--	15,432	124	482	350	16,388	2,853
U.S.S.R	--	--	--	--	3,215	--	--	3,215	1,127
United Kingdom	1,326	254,800	2,269	30,240	58,061	7,195	4,909	358,800	83,491
Venezuela	--	--	--	312	107	--	100	519	69
Other	8	16	36	1,128	1,825	56	240	3,309	902
Total	43,118	522,425	177,401	182,692	165,635	43,484	27,475	1,162,230	274,846

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
1980	15,427	1,191,803	1,202,342	26,090	440	10,388	109,591	98,488	110,951	675	376,500
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:											
Australia	263	1,082	10,338	--	--	--	--	--	--	--	8,038
Belgium-Luxembourg	--	43,253	153,646	--	--	--	2,955	--	--	--	46,245
Canada	2,692	37,050	85,367	--	--	--	1,254	--	325	--	242,857
Chile	--	1,608	252	--	--	--	--	--	--	--	333
China	--	--	1,814	--	--	--	579	--	--	--	--
Colombia	9,900	2,492	--	--	--	--	13	--	1,200	--	10,266
Costa Rica	--	--	--	--	--	--	--	--	--	--	3,570
El Salvador	--	--	--	--	--	--	--	--	--	--	1,928
Finland	--	1,800	--	--	--	--	--	--	--	--	5,321
France	--	1,608	--	--	--	--	--	--	--	--	297
Germany, Federal Republic of	3,728	44,785	76,216	7,609	177	--	3,174	4,689	2,426	--	479
Hong Kong	--	--	--	--	--	--	--	--	--	--	1,695
Italy	--	41,042	15,584	--	--	--	1,628	--	--	--	7,298
Japan	--	943	11	--	50	--	257	535	--	--	158
Korea, Republic of	--	2,250	1,955	--	--	--	400	--	--	--	--
Mexico	--	--	--	--	801	--	--	--	--	--	105,242
Netherlands	--	790	48,870	427	100	--	4,608	--	--	--	324
Norway	--	7,500	12,422	--	--	--	1,770	600	--	--	5,745
Panama	--	--	--	--	--	--	--	--	--	--	1,438
South Africa, Republic of	500	1,038,332	584,685	8,369	67	--	97,133	146,268	2,000	--	6,543
Spain	--	168	2,700	--	--	--	643	--	--	--	--
Sweden	--	--	--	--	--	--	--	--	--	--	12,745
Switzerland	--	21,300	60,798	250	--	--	1,191	3,500	--	--	8
Taiwan	--	--	749	--	--	--	--	--	--	--	56,376
U.S.S.R.	971	10,269	393,509	150	50	--	6,716	4,121	328	--	--
United Kingdom	1,635	267,086	347,023	1,420	385	150	33,350	38,544	2,543	--	6,734
Venezuela	--	--	--	--	--	--	--	--	--	--	779
Zaire	--	4,000	--	--	--	--	--	--	--	--	--
Other	97	483	--	--	--	--	--	--	--	--	2,319
Total	19,786	1,527,841	1,795,939	18,225	1,630	150	155,671	198,257	8,822	--	526,738

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)
1980	230,344	114,246	73	686	744	12,994	3,501,782	$1,176,747
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:								
Australia	--	--	--	--	--	--	19,721	4,979
Belgium-Luxembourg	--	482	--	--	--	267	246,848	60,684
Canada	24,728	--	--	--	--	--	394,273	51,401
Chile	--	--	--	--	--	--	2,193	833
China	--	--	--	--	--	--	2,393	662
Colombia	--	--	--	221	--	--	24,092	7,722
Costa Rica	--	--	--	--	--	--	3,570	272
El Salvador	--	--	--	--	--	--	1,928	291
Finland	--	--	--	--	--	--	7,121	2,614
France	--	--	--	--	--	--	1,905	734
Germany, Federal Republic of	11	3,956	--	--	--	--	147,250	38,739
Hong Kong	--	--	--	--	--	--	1,695	196
Italy	50	487	--	--	--	--	66,089	20,591
Japan	--	59	--	--	--	--	2,013	560
Korea, Republic of	--	--	--	--	--	--	4,605	1,388
Mexico	--	--	136	--	--	--	106,179	4,066
Netherlands	351	10,677	--	--	--	--	66,147	12,391
Norway	--	--	--	--	--	--	28,037	8,222
Panama	--	--	--	--	--	--	1,438	379
South Africa, Republic of	--	--	--	--	--	65	1,883,962	589,955
Spain	--	--	--	--	--	--	3,511	671
Sweden	--	--	--	--	--	--	12,745	5,461
Switzerland	--	952	--	--	10	--	88,009	19,157
Taiwan	--	90	--	--	--	--	57,215	3,760
U.S.S.R.	8,635	101,387	--	1,927	--	--	528,063	85,342
United Kingdom	25,978	39,922	26	241	--	--	765,037	194,504
Venezuela	--	--	--	--	--	--	779	9
Zaire	--	--	--	--	--	--	4,000	1,900
Other	387	--	2	--	--	--	3,288	605
Total	60,140	158,012	164	2,389	10	332	4,474,106	1,118,088

Table 8.—Estimated U.S. imports of platinum and palladium, by country[1]

(Thousand troy ounces)

Country	Platinum		Palladium	
	1983	1984	1983	1984
South Africa, Republic of	626	1,043	409	587
U.S.S.R	23	20	392	495
United Kingdom	308	300	242	391
Other	305	411	568	824
Total	1,262	1,774	1,611	[2]2,296

[1]This table is based on the figures shown in table 7. Estimates are based on the explicit categories of platinum and palladium plus estimates of the metal content in the following categories: unspecified combinations, ores, sweepings, waste and scrap, and materials not elsewhere specified.
[2]Data do not add to total shown because of independent rounding.

WORLD REVIEW

PGM were mined in 10 countries in 1984. 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; the U.S.S.R. and two companies in Canada produced PGM from nickel-copper deposits.

Germany, Federal Republic of.—Degussa AG, a large refiner and producer of precious metal chemicals, increased production of automobile catalytic converters at its plant in Rheinfelden from several hundred thousand to 3 million per year. With each converter containing 0.03 to 0.05 troy ounce of platinum, the expansion reportedly increased Degussa's consumption of platinum by between 100,000 and 130,000 ounces per year. The company's decision to expand production followed the Federal Republic of Germany's decision to require catalysts in new larger cars by January 1, 1988, and in all new cars by January 1, 1989, and to offer financial incentives to purchasers of new catalyst-equipped cars after July 1, 1985.[8]

Japan.—Imports totaled about 1.2 million ounces of platinum, primarily from the Republic of South Africa, and about 1.3 million ounces of palladium, primarily from the U.S.S.R. Imports of both metals increased sharply from the amounts reported in 1983.[9]

Consumption of platinum in jewelry uses and consumption of palladium in electrical uses increased in 1984. Estimated consumption of platinum and palladium in Japan, in thousand troy ounces, was reported as follows:[10]

	Platinum	Palladium
Automotive	160	100
Chemical	120	400
Dental	--	210
Electrical	160	650
Jewelry	580	60
Miscellaneous[1]	170	10
Total[2]	1,180	1,420

[1]Glass is included with "Miscellaneous" category for platinum.
[2]Data do not add to totals shown because of independent rounding.

Source: Sumitomo Corp.

South Africa, Republic of.—Western Platinum Ltd. (Wesplat), the third largest platinum producer in the Republic of South Africa, announced that it was planning to complete construction in 1986 of a base metals refinery at a cost of $13 million. Currently, Wesplat ships matte to Norway for toll refining at Falconbridge Ltd.'s Kristiansand plant, where residues containing precious metals are returned for refining at Wesplat's Lonrho Brakpan refinery. The new base metals refinery is to be located at Wesplat's mine, near Rustenburg, Transvaal. Because shipping of mattes would no longer be necessary, the refinery was expected to save both time and money in refining copper, nickel, cobalt, and precious metals.[11]

Impala Platinum Holding (Pty.) Ltd. increased production of platinum during the second half of 1984, in response to improvements in U.S. demand for platinum, primarily from the automotive industry.[12]

United Kingdom.—Matthey Rustenburg Refiners Ltd.'s PGM refinery in Royston, owned by Johnson Matthey PLC and Rustenburg Platinum Mines Ltd., was damaged in a fire in April. Shipments from the plant were halted but resumed later in the year. The fire was partially responsible for causing the price of rhodium to increase and temporarily disrupting supply.[13]

Table 9.—Platinum-group metals: World production, by country[1]

(Troy ounces)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Australia, metal content, from domestic nickel ore:[3]					
Palladium	10,545	12,896	13,379	[e]12,000	12,000
Platinum	2,058	2,093	2,388	[e]1,900	2,000
Canada: Platinum-group metals from nickel ore	410,757	382,658	228,425	223,925	[4]348,216
Colombia: Placer platinum	14,345	[r]14,804	11,886	10,303	10,000
Ethiopia: Placer platinum[e]	[4]113	125	125	125	125
Finland:					
Palladium	675	1,993	4,662	2,283	2,200
Platinum	225	1,608	4,147	2,186	2,000
Japan, metal from nickel-copper ores:[5]					
Palladium	28,968	25,748	27,862	37,122	35,000
Platinum	12,366	10,521	15,411	21,460	20,300
South Africa, Republic of: Platinum-group metals from platinum ore[e] [6]	3,100,000	3,110,000	2,600,000	2,600,000	2,900,000
U.S.S.R.: Placer platinum and platinum-group metals recovered fom nickel-copper ores[e]	3,250,000	3,350,000	3,500,000	3,600,000	3,700,000
United States: Placer platinum and platinum-group metals from gold-copper ores	3,348	7,318	8,033	6,257	[4]14,635
Yugoslavia:					
Palladium	4,501	3,119	[e]3,000	[e]2,900	3,000
Platinum	418	482	[e]480	[e]400	350
Zimbabwe:					
Palladium	6,784	5,200	2,765	[r] [e]2,000	2,000
Platinum	2,990	2,300	1,704	[r] [e]1,200	1,200
Total	6,848,093	[r]6,930,865	6,424,267	6,524,061	7,053,026

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

[1]Table includes data available through May 14, 1985. 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 5.)

[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 5.)

[4]Reported figure.

[5]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 Philippine origin are not duplicative, but output from Canadian material might duplicate a part of reported Canadian production.

[6]Includes osmiridium produced in gold mines.

TECHNOLOGY

Johnson Matthey Chemicals Ltd., a division of Johnson Matthey PLC, of the United Kingdom, tested the durability of a three-way PGM catalyst on a vehicle traveling 50,000 miles at high speeds. The test was conducted in preparation for the introduction of catalysts in 1989 on all new automobiles produced in the Federal Republic of Germany. Since speed limits are higher in Europe than in the United States, the new European catalysts must be designed to withstand temperatures of 950° C to 1,000° C for prolonged periods. The test catalyst used was specifically designed for high-temperature operation and contained platinum and rhodium in the ratio of 5 to 1, deposited on a ceramic monolith support. The results ot the test showed that emissions could be reduced below U.S. 1983 model year limits.[14]

The technology used for controlling automobile emissions of hydrocarbons and carbon monoxide was applied to reducing pollution from woodburning stoves. A catalyst consisting of platinum metal dispersed on a ceramic honeycomb support was used to reduce the temperature at which combustion of the smoke components inside the stove occurred, thus allowing them to be burned. The use of a catalyst in woodburning stoves was claimed to reduce the amount of wood consumed by 30%, as well as lessen the possibility of a chimney fire caused by the accumulation of creosote.[15]

Workers at the Ibaraki Electrical Communication Laboratory in Japan reported improvement in the magnetic properties of sputtered iron oxide used in magnetic recording tapes when osmium was used as an additive.[16]

A process that employs vacuum technology to apply thin coatings, called sputtering, has reportedly overcome many of the previous difficulties in working ruthenium. The process is particularly useful for electric and electronic applications. Elec-Trol Corp. reported that sputtered ruthenium functioned better than rhodium in dry-reed relays. Elec-Trol stated that ruthenium contacts do not stick and that ruthenium offers stable contact resistance, in addition to being far cheaper than rhodium.[17]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]International Precious Metals Institute. Precious Metals News and Review. Texasgulf Minerals and Metals To Recover Platinum From Automotive Catalysts. V. 8, No. 10, Oct. 1984, p. 6.

[3]Metal Bulletin Monthly. Engelhard's New Approach. No. 162, June 1984, pp. 65-69.

[4]American Metal Market. Nassau Recycle Renamed AT&T Nassau Metals with Lewallen New President. V. 92, No. 66, Apr. 4, 1984, p. 2.

[5]Furukawa, T. Tokyo Exchange Pioneers 3 Precious Metals Trade. Am. Met. Mark., v. 92, No. 23, Feb. 2, 1984, p. 6.

[6]Burgert, P. Success Seen for MidAm's Half-Sized Platinum Pact. Am. Met. Mark., v. 92, No. 189, Sept. 27, 1984, p. 5.

[7]International Precious Metals Institute. Precious Metals News and Review. V. 8, No. 6, June 1984, p. 6.

[8]Chemical Week. A German Expansion in Catalytic Converters. V. 135, No. 14, Oct. 3, 1984, p. 18.

[9]Endo, Y. (Sumitomo Corp., NY). Private communication, 1985; available upon request from J. R. Loebenstein, BuMines, Washington DC.

[10]Sumitomo Corp. Precious Metals Market in Japan. 15th ed., Feb. 1985, 18 pp.

[11]Engineering and Mining Journal. South Africa—Construction of a $13.1 Million Base Metal Refinery. Aug. 23, 1984, p. 107.

[12]Salk, J. Impala Lifts Platinum Production. Am. Met. Mark., v. 92, No. 184, Sept. 20, 1984, pp. 1, 8.

[13]Metals Week. Platinum Refining Halted at Royston Refinery. V. 55, No. 17, Apr. 23, 1984, p. 2.

[14]Wilkins, A. J. J. High Temperature Durability Trial—Three-Way Platinum Metals Catalyst Completes 50,000 Miles At Maximum Vehicle Speed. Platinum Met. Rev., v. 28, No. 4, Oct. 1984, pp. 174-176.

[15]Platinum Metals Review. Combustion in Wood-Burning Stove—Platinum Catalyst Increases Thermal Efficiency and Greatly Reduces Pollution. V. 28, No. 3, July 1984, pp. 115-116.

[16]———. Osmium Doping Improves Recording Media—Thin Films Have High Coercivity And Coercive Squareness. V. 28, No. 3, July 1984, p. 116.

[17]International Precious Metals Institute. Precious Metals News and Review. The Low Cost and Non-Stick Properties of Ruthenium Make It a Substitute for Rhodium in Dry-Reed Relays. V. 8, No. 4, Apr. 1984, p. 9.

Potash

By James P. Searls[1]

U.S. potash production and apparent consumption in terms of potassium oxide (K_2O) equivalent increased in 1984. Production during the second half of 1984 was less than that of the first half, because a mine was closed for a month, but was more than in the second half of 1983, when three mines had been closed for extended periods. Sales and prices increased in comparison with those of 1983, and yearend stocks decreased. The United States continued to be a net importer of potash; net import reliance as a percentage of apparent consumption was 74%. Canada provided an amount equal to 73% of the domestic apparent consumption. U.S. exports increased substantially, particularly to Brazil and Mexico, both of which had received credit guarantees by the U.S. Department of Commerce.

The domestic potash producer at the Great Salt Lake in Utah ceased production for an indefinite period when the rising lake breached the main dike and flooded many of the solar evaporation ponds. One Carlsbad, NM, firm was closed temporarily during the year to decrease inventories. Two New Mexico producers petitioned the U.S. Government to levy import duties on potash imports from four countries.

Table 1.—Salient potash[1] statistics

(Thousand metric tons and thousand dollars unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production	4,315	4,153	3,366	2,770	3,039
K_2O equivalent	2,239	2,156	1,784	1,429	1,564
Sales by producers	4,265	3,670	3,387	2,950	3,184
K_2O equivalent	2,217	1,908	1,784	1,513	1,639
Value[2]	$353,900	$328,900	$265,600	$220,800	$241,800
Average value per ton of product dollars	$82.98	$89.62	$78.42	$74.85	$75.95
Average value per ton of K_2O equivalent do	$159.63	$172.40	$148.87	$145.97	$147.55
Exports[3]	1,584	887	952	564	836
K_2O equivalent	840	491	519	300	446
Value[4]	$179,830	$107,950	$93,200	$55,760	$85,660
Imports for consumption[3] [5]	8,193	7,903	6,338	7,322	7,948
K_2O equivalent	4,972	4,796	3,858	4,440	4,829
Customs value	$648,000	$750,400	$575,400	$600,600	$658,100
Apparent consumption[6]	10,874	10,686	8,773	9,708	10,296
K_2O equivalent	6,349	6,213	5,123	5,653	6,022
Yearend producers' stocks, K_2O equivalent	273	520	520	r 7391	8312
World: Production, marketable K_2O equivalent	27,857	r27,079	24,665	p27,426	e28,638

eEstimated. pPreliminary. rRevised.

[1]Includes muriate and sulfate of potash, potassium magnesium sulfate, 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 sales plus imports minus exports.

[7]Inventory adjustment of minus 46,000 tons.

[8]Inventory adjustment of minus 4,000 tons.

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.

DOMESTIC PRODUCTION

Domestic K_2O production rose 9% in 1984, for a recovery with a very small price rise following 2 dismal years. In 1982, an unprofitable potash mine had been closed permanently, and in 1983, a second mine had closed for an extended period. In addition, a small brine operation had closed temporarily for weather-related reasons in 1983, as did a second larger brine operation in 1984. In 1984, three operating mines and the closed mine were known to be for sale. Of the total production for the year, 79% was standard, coarse, or granular muriate of potash, also known as potassium chloride, and 7% was sulfate of potash, also known as potassium sulfate. The remaining production comprised manure salts, soluble and chemical grades of muriate of potash, and sulfate of potash-magnesia or potassium-magnesium sulfate. The New Mexico producers accounted for 89% of the total marketable salts production. New Mexico crude salt mine production was 13.1 million metric tons with an average K_2O content of 13.0%, a slight rise from that of 1983.

Five companies produced potash in New Mexico from underground, bedded sylvinite and langbeinite deposits east of Carlsbad. The companies were AMAX Chemical Corp. of AMAX Inc.; Duval Corp. of Pennzoil Co. Inc.; 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 companies produced at reduced levels but were on normal schedules for the year until December when AMAX Chemical temporarily closed in response to low prices. At yearend, the Mississippi Chemical Corp. sylvinite mine and mill, which had been closed since January 1983, the AMAX Chemical sylvinite mine and mill, the Kerr-McGee Chemical sylvinite mine and mill, and the Duval langbeinite mine and mill were for sale. Sylvinite ore was used for muriate of potash production and langbeinite, for sulfate of potash-magnesia. IMC mined both ores and reacted muriate of potash with sulfate of potash-magnesia to produce sulfate of potash.

Sulfate of potash was produced at two Texas plants, one operated by Permian Chemical Corp. and one by PCA. Permian reported production of about 16,000 tons,[2] K_2O equivalent, from its Mannheim furnaces using muriate of potash and sulfuric acid, but this datum was not included in Bureau of Mines statistics because Permian was not a mining firm. The PCA plant produced sulfate of potash from Hargreaves furnaces using muriate of potash and sulfur dioxide; that production was reported and treated as if it were in New Mexico because PCA had mined the potash feed in New Mexico. Both firms sold the byproduct hydrochloric acid to the Texas petroleum industry for well acidification.

Two companies were producing potash in Utah at the beginning of the year. Texasgulf Chemical Co. of Texasgulf Inc. and 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. The brine-gathering canals of Kaiser Chemicals of Kaiser Aluminum & Chemical Corp. continued to be flooded at the beginning of the year, but some crude salts had been harvested for production of potash. By summer, the gathering canals had dried out, and the company was able to harvest some crude salts for potash production at yearend. Great Salt Lake Minerals & Chemicals Corp., a subsidiary of Gulf Resources & Chemicals Corp., apparently did not harvest enough crude salts from its solar evaporation ponds in 1983 to produce sulfate of potash in the first months of 1984, and on May 5, the lake breached the outer dike of the ponds and flooded many of the harvesting ponds, thereby precluding further production for the year.

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	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
January-June:														
Muriate of potash, 60% K_2O minimum:														
Standard	346	368	211	226	468	467	286	286	26,800	30,500	274	133	166	82
Coarse	137	149	84	92	142	196	84	121	9,000	13,900	98	46	60	28
Granular	464	543	282	331	452	529	274	322	28,700	37,200	176	149	107	91
Chemical	25	31	15	20	27	32	17	20	W	W	2	(2)	1	(2)
Potassium sulfate	158	100	81	51	169	145	86	74	30,500	27,600	59	49	31	25
Other potassium salts[3]	298	381	75	94	361	426	92	104	W	W	277	228	62	51
Total[4]	1,428	1,573	749	813	1,619	1,794	839	927	122,400	139,300	887	607	428	278
July-December:														
Muriate of potash, 60% K_2O minimum:														
Standard	292	418	180	256	288	406	176	249	17,300	26,400	232	140	r143	85
Coarse	99	157	61	97	96	142	59	88	6,200	9,100	92	61	r57	38
Granular	393	385	239	233	419	373	254	227	25,300	23,600	135	160	r82	97
Chemical	24	19	15	12	25	15	16	9	W	W	1	4	(2)	3
Potassium sulfate	r170	112	r87	57	r137	101	r69	52	r24,900	19,600	r94	60	r48	31
Other potassium salts[3]	r346	375	r97	95	r367	352	r99	88	W	W	r273	251	r61	58
Total[4]	1,324	1,466	679	751	1,331	1,389	673	712	98,400	102,500	827	677	r391	312
Grand total[4]	2,770	3,039	1,429	1,564	2,950	3,184	1,513	1,639	220,800	241,800	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, 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]
1983:							
January-June	6,562	851	1,251	653	1,395	717	96,900
July-December	5,878	748	1,129	561	1,129	560	77,800
Total[3]	12,440	1,600	2,380	1,214	2,525	1,278	174,700
1984:							
January-June	7,209	973	1,434	733	1,575	801	118,000
July-December	5,884	725	1,302	655	1,225	618	86,100
Total[3]	13,093	1,697	2,735	1,388	2,799	1,418	204,100

[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)

	1980	1981	1982	1983	1984
Production	203	200	166	r168	109
Sales by producers	201	178	176	r156	126
Value[2]	$61,080	$61,993	$61,934	r$55,453	$47,197
Exports[3]	70	40	71	44	34
Value[4]	$23,113	$16,095	$27,648	$16,390	$13,940
Imports[3]	22	18	6	29	29
Value[5]	$7,111	$7,380	$2,409	$12,300	$12,600
Apparent consumption[6]	153	156	111	141	121
Yearend producers' stocks	24	46	36	44	31

rRevised.
[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]Sales plus imports minus exports.

CONSUMPTION AND USES

Apparent domestic consumption of all forms of potash increased about 7% from that of 1983. After the "payment-in-kind" (PIK) program ended, farmers planted large acreages and had money available to purchase fertilizer as a result of the PIK program. The PIK program was a U.S. Department of Agriculture program to reduce farm crop surpluses by paying the farmer from the stocks of surplus crops for not planting that same crop during 1983. Farmers expected a strong export market and bought more fertilizer for the larger acreages. Downward pressure on demand for fertilizers came from continuing high interest rates, the generally declining value of agricultural land as collateral for loans, and the continuing problem of the high relative value of the U.S. dollar that restricted exports. Corn production increased by 80% from that of 1983, and soybean production increased by 21%.

According to the Potash & Phosphate Institute, which reported sales of U.S. and Canadian producers, domestic sales of muriate of potash for agricultural uses changed as follows: Standard grade rose 12% to 446,000 tons, K_2O equivalent; coarse grade fell 8% to 2.2 million tons; granular grade fell 1% to 1.5 million tons; and sulfate of potash and sulfate of potash-magnesia combined fell 8% to 169,000 tons. The percentage breakdown by grade and type was 46% coarse muriate, 31% granular muriate, 10%

standard muriate, 10% soluble muriate, and 3% sulfates of both types and all sizes. Potash sales from U.S. mines as a percentage of total domestic sales represented 8% of the coarse muriate, 26% of the granular muriate, 3% of the soluble muriate, 37% of the standard muriate, and 100% of both types and all sizes of sulfates.

The Potash & Phosphate Institute also reported that 351,000 tons of potash was sold for nonagricultural uses. Of this, standard muriate was 65%, soluble muriate was 34%, and sulfates of both types and of all sizes was 1%. Nonagricultural use of potash was 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. Late in the year, a new caustic potash plant opened in New Jersey, but the byproduct chlorine was considered to be in long-term oversupply. Some muriate of potash was also used by the petroleum well-drilling industry in drilling muds for shale stabilization and in well stimulation by massive fracturing, in which the potassium ion inhibits clay particle swelling.

Table 5.—Sales of North American potash, by State of destination

(Metric tons of K_2O equivalent)

State	Agricultural potash		Nonagricultural potash	
	1983	1984	1983	1984
Alabama	67,906	78,041	52,298	61,940
Alaska	167	257	--	--
Arizona	513	438	43	22
Arkansas	44,421	44,179	476	140
California	53,657	62,054	9,672	10,992
Colorado	18,705	13,051	163	6,083
Connecticut	5,513	4,282	47	52
Delaware	23,503	27,694	32,082	35,755
Florida	112,475	148,230	821	865
Georgia	109,014	162,351	422	957
Hawaii	11,650	16,056	--	--
Idaho	18,192	19,008	55	--
Illinois	829,863	717,548	24,526	32,942
Indiana	429,723	362,757	3,533	2,352
Iowa	551,731	493,110	350	1,226
Kansas	31,944	33,653	2,614	2,549
Kentucky	148,205	149,555	369	364
Louisiana	42,517	49,783	1,881	1,775
Maine	4,979	7,160	25	114
Maryland	26,960	24,088	476	509
Massachusetts	3,831	5,015	584	534
Michigan	227,179	204,048	2,693	1,702
Minnesota	391,068	360,667	30	36
Mississippi	89,248	49,804	2,094	3,165
Missouri	265,801	247,720	2,806	3,458
Montana	12,530	13,029	172	135
Nebraska	42,972	39,180	530	113
Nevada	--	12	320	249
New Hampshire	457	553	--	--
New Jersey	6,426	6,819	920	11,463
New Mexico	1,516	6,831	31,575	29,685
New York	71,341	78,520	42,429	976
North Carolina	86,610	103,421	12	46
North Dakota	23,450	22,099	--	104
Ohio	406,765	396,761	43,097	60,423
Oklahoma	22,680	41,778	7,038	7,796
Oregon	22,124	26,154	1,168	1,485
Pennsylvania	49,748	48,601	3,394	4,036
Rhode Island	2,231	2,258	132	110
South Carolina	54,535	65,909	120	117
South Dakota	11,946	11,769	--	7
Tennessee	109,582	131,052	143	423
Texas	141,526	140,996	34,202	47,317
Utah	2,839	4,254	2,074	13,563
Vermont	3,450	3,712	--	--
Virginia	45,731	65,384	316	331
Washington	36,039	40,241	2,980	2,905
West Virginia	5,786	4,150	898	1,280
Wisconsin	297,844	280,336	311	201
Wyoming	2,181	1,854	1,940	824
Total	4,969,074	4,816,222	311,831	351,121

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	1981	1982	1983	1984
Agricultural:				
Standard	873	563	399	446
Coarse	2,070	1,750	2,402	2,219
Granular	1,549	1,237	1,533	1,511
Soluble	435	357	451	471
Total	4,927	3,907	4,785	4,647
Nonagricultural:				
Soluble	118	106	114	120
Other	260	210	195	227
Total	378	316	309	347
Grand total	5,305	4,223	5,094	4,994

Source: Potash & Phosphate Institute.

According to the Potash & Phosphate Institute, the major consuming States of agricultural potash from Canadian and U.S. potash producers, in decreasing order, were Illinois, Iowa, Ohio, Indiana, Minnesota, and Wisconsin. These six States consumed 54% of the total from Canadian and U.S. producers. According to testimony before the International Trade Commission (ITC) on potash imports from the U.S.S.R., about one-half of these imports reached the Midwest by barging up the Mississippi River, implying that sales data from Canadian and U.S. potash producers may not supply complete information on potash sales to the Midwest or the Southeast. According to the Potash & Phosphate Institute, the major agricultural consumers of domestically produced potash, in decreasing order, were Texas, Missouri, Illinois, California, Florida, and Louisiana. These six States accounted for 53% of the total. The major agricultural consumers of domestically produced sulfates of potash, in decreasing order, were Florida, California, Georgia, Kentucky, Texas, and North Carolina, which together consumed 60% of the total.

STOCKS

Yearend producers' stocks of potash decreased 20% from that of 1983. Yearend stocks were 20% of annual production or 10.5 weeks of production. Yearend 1983 stocks were revised owing to a stock adjustment of 46,000 tons between June and July 1983. A stock adjustment is a producer's correction of the quantities on the books to agree with actual quantities of material in the warehouses.

TRANSPORTATION

Ocean freight rates fell in January, but returned to early January levels by midsummer. Rail tariffs rose slightly in January and struggled to maintain the higher level. Unpublished, i.e., Staggers Act, contracts make determination of rail freight costs difficult. Construction of a new warehouse and terminal was commenced in Texas City, TX, for exporting potash and other bulk commodities. The Houston potash dock was closed for improvements on October 15 and reopened November 10. Port Arthur and Beaumont were the alternative ports.

About 1 million tons of Canadian muriate of potash passed through Thunder Bay, Ontario, for lake freightage to U.S. Great Lakes ports. About 750,000 tons of Canadian muriate of potash was shipped to Minneapolis or St. Louis for transfer to barges. About 120,000 tons of Canadian muriate of potash moved by unit trains to Florida, Georgia, and Tennessee. Potash was shipped by sea from the new PCA mine in Sussex, New Brunswick, Canada, to the U.S. east coast for the first time.

PRICES

The average value, f.o.b. mine, of U.S. potash sales of all types and grades was $147.55 per ton, an increase of less than $2 per ton. The average value was $150.34 in the first half of 1984 and $143.91 in the second half.

The average annual price for the three grades of muriate rose to $109 per ton. Standard-grade muriate of potash averaged $106 per ton, coarse-grade averaged $110 per ton, and granular averaged $111 per ton.

The average annual price for sulfate of potash increased to $375. Prices were apparently unaffected when the sulfate of potash producer on the Great Salt Lake was flooded, idling nearly one-half of U.S. capacity. It appears that this price was near the backstop price of this product.

Table 7.—Prices[1] of U.S. potash, by type and grade

(Dollars per metric ton of K_2O equivalent)

Type and grade	1982		1983		1984	
	January-June	July-December	January-June	July-December	January-June	July-December
Muriate, 60% K_2O minimum:						
Standard	114.76	97.59	93.56	98.52	106.44	106.20
Coarse	125.76	105.25	108.13	104.73	115.23	103.33
Granular	115.81	103.30	104.46	99.44	115.68	103.97
All muriate[2]	117.16	100.71	100.10	99.75	111.98	104.86
Sulfate, 50% K_2O minimum	362.85	341.91	353.19	[r]359.03	374.22	377.21

[r]Revised.
[1]Average prices, f.o.b. mine, based on sales.
[2]Excluding soluble and chemical muriates.

FOREIGN TRADE

U.S. potash exports rose 48%, by ton product, with a strong increase of about 177% by product ton in exports to Latin America. Brazil, Colombia, Peru, Venezuela, and to a lesser extent, Mexico, increased their imports of potash. The increases to Brazil and Mexico were brought about by credit guarantees from the U.S. Department of Commerce. Exports to Japan fell by 39% and exports to India fell to zero. The high relative value of the U.S. dollar to many foreign currencies continued to be a problem, along with aggressive marketing by the Canadian exporter to the Pacific Basin.

A 9% increase in total U.S. imports of potash represented primarily an increase in muriate from Canada. However, imports of sulfate of potash and potassium nitrate decreased. Imports of muriate of potash from Canada increased 13% over the 1983 level and amounted to 92% of all muriate imports and 91%, by K_2O equivalent, of all potash imports. Israel was the second largest source of imports, with 5% of muriate of potash imports and 5% of total potash imports.

Two New Mexico potash producers, AMAX Chemical and Kerr-McGee Chemical, filed petitions against the potash producers from the German Democratic Republic, Israel, Spain, and the U.S.S.R. before the ITC and the International Trade Administration (ITA) of the U.S. Department of Commerce. PCA and IMC provided proprietary data to the petitioners but did not join the actual petitions. The petitions charged (1) dumping, the sale of potash in the United States at prices less than those charged in their home market, and requested antidumping duties, and (2) material injury from subsidies and requested countervailing duties.

The ITC found a likelihood of injury and sent the petitions to the ITA for actual duty determination. By November, the antidumping petition against Spain had been withdrawn by the petitioners and the dumping allegations against Israel had not been proven. The duties from the material-injury-from-subsidies petition against Spain and Israel were put at 7.88% and 3.64% ad valorem, respectively, but the ITC ruled that because these were relatively low duties and they concerned a relatively low percentage of the total U.S. market, these duties should not be collected. The ITA had decided in an earlier case, on Polish carbon steel wire rod, that it was impossible for ordinary analysis to determine the internal subsidy that is given to a state-owned industry in a nonmarket economy, so the material-injury-from-subsidies investigation against the German Democratic Republic and the U.S.S.R. was dropped by both the ITA and the ITC. Preliminary findings concerning dumping against both countries had called for duties of 112% ex-factory value for East German imports and 187% for Soviet imports; only the final determination of dumping duties against the two countries remained to be resolved at yearend.

Table 8.—U.S. exports of potash

	Approximate average K_2O content (percent)	Quantity (metric tons)		Value[1] (thousands)
		Product	K_2O equivalent	
1983				
Potassium chloride, all grades	61	385,980	235,450	$30,700
Potassium sulfate	51	86,320	44,020	16,390
Potassium magnesium sulfate	22	91,440	20,120	8,670
Total[2]	XX	563,730	299,580	55,760
1984				
Potassium chloride, all grades	61	621,820	379,300	$57,200
Potassium sulfate	51	67,320	34,340	13,940
Potassium magnesium sulfate	22	147,160	32,380	14,550
Total[2]	XX	836,300	446,020	85,660

XX Not applicable.
[1]F.a.s. U.S. port.
[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. exports of potash, by country

Country	Metric tons of product						Total value[3] (thousands)	
	Potassium chloride		Potassium sulfates, all grades[1]		Total[2]			
	1983	1984	1983	1984	1983	1984	1983	1984
Argentina	--	2,000	6,850	--	6,850	2,000	$750	$200
Australia	--	11,520	7,010	9,050	7,010	20,570	1,770	2,940
Bahamas	20	--	1,710	1,790	1,720	1,790	340	380
Belgium	7,600	--	--	3,000	7,600	3,000	580	270
Brazil	11,970	289,930	9,210	4,000	21,180	293,930	1,790	28,200
Canada	4,710	1,590	18,830	73,440	23,540	75,030	2,760	9,500
Chile	--	--	10,020	12,350	10,020	12,350	1,940	2,560
Colombia	6,720	43,480	6,060	16,130	12,770	59,610	1,170	5,940
Costa Rica	16,000	6,450	3,760	14,690	19,760	21,140	1,660	2,340
Denmark	23,790	--	--	--	23,790	--	1,830	--
Dominican Republic	19,850	26,770	1,520	1,740	21,370	28,500	1,890	2,860
Ecuador	5,440	14,980	--	5,110	5,440	20,090	420	1,810
Egypt	--	--	10,120	--	10,120	--	1,920	--
French West Indies	14,690	--	--	3,150	14,690	3,150	1,290	340
Guatemala	1,680	3,160	200	420	1,880	3,580	220	400
Haiti	--	600	110	10	110	611	10	67
Honduras	1,150	620	70	90	1,220	710	150	67
India	30,430	--	--	--	30,430	--	2,040	--
Italy	1,600	--	--	7	1,600	7	120	2
Jamaica	--	--	120	--	120	--	10	--
Japan	85,590	74,910	53,920	10,220	139,510	85,130	14,120	6,830
Korea, Republic of	180	--	110	46	290	46	30	5
Leeward and Windward Islands	1,100	1,550	350	64	1,450	1,610	130	170
Malaysia	--	--	--	23,800	--	23,800	--	1,900
Mexico	36,100	42,190	18,720	26,310	54,820	68,500	6,170	8,530
New Zealand	94,190	59,090	420	370	94,620	59,460	7,710	5,260
Nicaragua	--	--	5,900	--	5,900	--	530	--
Norway	r6,200	--	--	--	r6,200	--	r420	--
Panama	2,820	4,250	1,470	150	4,290	4,400	360	440
Peru	5,430	19,160	4,750	1,210	10,180	20,380	760	1,840
Philippines	10	35	430	2,130	440	2,160	90	420
Saudi Arabia	90	7	100	180	190	180	20	20
Sweden	6,600	--	--	640	6,600	640	450	150
Switzerland	r1,410	--	--	--	r1,410	--	r100	--
Taiwan	20	400	--	--	20	400	1	30
Thailand	--	--	6,000	4,000	6,000	4,000	500	360
Venezuela	60	19,040	9,150	34	9,210	19,080	1,560	1,760
Other	530	101	850	350	1,380	460	140	54
Total[2]	385,980	621,820	177,760	214,480	563,730	836,300	55,760	85,660

rRevised.
[1]Includes potassium magnesium sulfate.
[2]Data may not add to totals shown because of independent rounding.
[3]F.a.s. U.S. port.

Sources: Bureau of the Census and Bureau of Mines.

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.	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
Belgium-Luxembourg	--	--	--	27,600	--	--	--	--	--	27,600	--	$5,500	--	$5,900
Canada	6,371,200	7,188,400	100	--	860	--	60	--	6,372,200	7,188,400	$485,380	578,000	$507,410	607,300
Chile	1,300	--	--	--	900	--	19,500	22,000	21,700	22,000	26,300	2,900	29,270	3,200
China	--	--	--	--	--	1	--	--	--	1	--	(2)	--	(2)
France	--	14	--	--	--	--	--	--	--	14	--	20	--	24
German Democratic Republic	136,100	100,900	20	--	--	--	--	--	136,100	100,900	9,510	7,900	10,980	9,700
Germany, Federal Republic of	29,900	5,500	58,600	29,000	--	--	--	--	88,500	34,500	11,230	7,100	12,600	7,800
Israel	509,500	412,800	--	--	64,400	20,500	--	--	573,900	433,300	59,790	45,800	66,770	50,900
Japan	4	--	--	--	--	--	r190	380	200	380	r54	100	r75	140
Netherlands	--	4,100	--	200	--	1	--	--	--	4,300	--	540	--	650
Spain	53,100	10,500	--	--	--	--	--	--	53,100	10,500	3,050	900	4,110	1,000
U.S.S.R	76,000	125,200	--	--	--	--	--	--	76,000	125,200	5,100	9,000	5,700	10,300
United Kingdom	300	650	--	--	--	--	--	--	300	650	200	300	230	400
Total[1]	7,177,400	7,848,100	58,700	56,800	66,200	20,500	19,800	22,300	7,322,100	7,947,700	600,600	658,100	637,100	697,400

rRevised.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

Sources: Bureau of the Census and 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.
1983					
Potassium chloride	61	7,177,400	4,378,200	$570,000	$602,800
Potassium sulfate	50	58,700	29,400	11,300	12,300
Potassium nitrate	45	66,200	29,800	16,600	18,600
Potassium sodium nitrate mixtures	14	19,800	2,800	2,700	3,400
Total	XX	7,322,100	4,440,200	600,600	637,100
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

[e]Estimated. XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.

Sources: Bureau of the Census and Bureau of Mines.

WORLD REVIEW

World production in 1984 increased to above 1980 levels as recent Canadian, Israeli, Jordanian, and Soviet capacity expansions were used to greater extent. World prices, as measured f.o.b. Vancouver, Canada, rose gradually throughout the year, but did not quite reach 1981 levels. The demand for potash has been price-inelastic; therefore, future supply capacity expansions beyond demand expansions were considered likely to confine prices to relatively low, "market oversupplied" levels indefinitely.

Limited information was available about several tentative potash projects. The Argentine Government has released a study for developing some potash deposits in the Mendosa and Neuquen Provinces that would supply about 100,000 tons of product for internal consumption and the export of up to 900,000 tons onto the world market by 1990.[3] Some developers in Australia are reinvestigating a potash showing in southwest Australia near Perth. In Botswana, the Sua Pan deposit of Lake Makgadikgadi may produce some potash along with the small amount of planned soda ash production. The Government of Bolivia has continued its studies of the development of the Salar de Uyuni as a source of several products that would include boron, lithium, and potash. In Chile, the development of the Salar de Atacama has progressed to the point of the Government's awarding development rights for the potash and boric acid to AMAX Inc. and a Chilean partner; no capacity forecasts were available at yearend. In Egypt, there was continued exploratory drilling of a potash showing near the upper end of the Red Sea.

Brazil.—Petrobrás Mineração S.A. (PETROMISA), the developer of the new potash mine scheduled to start up in December at Taquari-Vassouras (T-V) in the Sergipe, reported the discovery of another potash deposit 15 kilometers away. The new deposit, named Santa Rosa de Lima, was being considered to supply crude ore to the T-V mill. PETROMISA mine engineers also claimed a solution to the tachyhydrite problem under the two T-V potash zones that will allow the mining of the lower zone. These two developments have increased company potash reserves from 7.3 to 17.3 million tons. In the Amazon Basin, the Fazendinha deposit, sometimes called Nova Olinda do Norte, was estimated to contain reserves of 22 million tons.

Canada.—Potash Corp. of Saskatchewan (PCS) was considering an overture from the Chinese International Technical Import Co. to purchase a minority position in the Lanigan Mine, which was being expanded to 1.7 million tons per year, making it the largest single-shaft potash mine in the world. Miners in the southern part of PCS's Rocanville Mine struck water in mid-November, and underground work was halted temporarily. PCA's new mine near Sussex, New Brunswick, shipped its first product in late January to Denmark. PCA formed a subsidiary firm to own all of its Canadian properties and offered 20% ownership of these properties through the stock market to Canadian citizens. Kalium Chemicals, PPG Industries Inc., planned to expand its Belle Plaine solution mine and crystallization facility by 25% to about 1.1 million tons per year.

The Canadian Pacific Railroad chose the contractors for a new tunnel to be built by 1988 at Rogers Pass through the Selkirk Mountains in southeastern British Columbia. The 9-mile-long tunnel was designed to lie below an existing tunnel to permit more loaded, westward bound trains to pass through than a simple double tracking of the first, higher tunnel would provide. Empty eastbound returns would use the higher tunnel. This roadbed improvement was considered important to overseas potash exports from Vancouver, British Columbia.

Table 12.—Salient Canadian potash statistics

(Thousand metric tons of K_2O equivalent)

	1981	1982	1983	1984
Production[1]	7,175	5,208	5,928	7,749
Domestic sales by domestic producers[1]	332	273	385	436
Exports:				
United States[1]	4,182	3,202	3,965	3,892
Overseas[1]	1,823	1,576	2,026	2,544
Imports for consumption[2]	11	13	17	20
Domestic consumption[3]	343	286	402	456
Yearend producers' stocks[1]	1,308	1,486	862	1,543

[1]Data supplied by the Potash & Phosphate Institute.
[2]From Bureau of the Census export data. Sulfate of potash was probably landed on the Canadian east coast from European sources.
[3]Domestic sales by domestic producers plus imports.

China.—The first sizable potash plant in China was under construction at the Qaidam Basin, Lake Chaerhan, and a second large ore zone was discovered. The Chinese requested Jacobs International Group Inc. to leave the project and took over the development using their own technicians. Later in the year, the Chinese offered their potash expertise to the Thais.

France.—The Theodore Mine of Mines de Potasse d'Alsace was scheduled for closure in 1985 owing to declining ore reserves.

Israel.—The antidumping petition testimony in the United States revealed that the Israeli Government provided grants for capital investment and the Bank of Israel provided low-cost loans for production, exports, and imports to be used for exports. The second stage of the Makleff expansion at the Dead Sea Works was completed, raising capacity by 0.3 million tons to 1.3 million tons. The firm decided to consider producing sulfate of potash. The Dead Sea Works had chosen an 18-kilometer conveyor belt to replace the trucks carrying potash from the plant to the railhead at Tsefa, near Dimona. Israel was increasing warehouse capacity at the Ashdod port facility to 160,000 tons of product to better serve the 60,000-ton Panamax ships. Israel hired the Canadian Pacific Railroad to help increase Israeli rail capacity to the port of Eilat on the Red Sea for improved shipping to the Far East.

Jordan.—The Arab Potash Co. brought a third carnallite pond into production in July. For easier shipment to eastern markets, the rail line to Aqaba, locomotive maintenance facilities, and rolling stock were to be improved with a $133 million investment.

Spain.—Unión Explosivos Río Tinto S.A. sold the Llobregat Mine to Empresa Nacional de Fertilizantes S.A. of Instituto Nacional de Industria (INI) to help pay off its debt. Potasas de Navarra S.A., owned by INI, was scheduled to close its mine near Pamplona at yearend 1985.

The potash antidumping testimony revealed that Minas de Potasas de Suria S.A. was the only Spanish company exporting potash to the United States. The net subsidy for exports was estimated at 7.88% prior to July 11, 1984, and 6.9% on or after July 11, 1984, by the ITA.

Thailand.—The Government signed agreements with Duval and Agrico Chemical Co. of The Williams Companies, to permit development of two potash leases, but Amax Exploration Inc. failed to sign its agreement. Duval, CRA Exploration Pty. Ltd. of Australia, Siam Cement Co., and the Government of Thailand were to conduct additional exploration at the Khon Kaen location. Agrico, Thai Central Chemical Co., and the Government were to conduct additional exploration at the Udon Thani location. Amax Exploration, Siam Cement, and the Government were to explore at the Sakon Nakhon location. The Government's development project at the large carnallitic zone at Bamnet Narong was flooded during the year.

Tunisia.—The International Bank for Reconstruction and Development made a loan of $13.6 million for the study of potential potash production from the Chott al-Jerid and Adibate Sabkha deposits. The study of the Sebkha al Melah deposit was already in progress. A contractor was chosen for constructing new port facilities at the Tunisian port of Zarzis to handle future potash exports.

[1]Physical scientist, Division of Industrial Minerals.
[2]All tonnages reported in metric tons, K_2O equivalent, unless otherwise specified.
[3]Industrial Minerals (London). No. 204, Sept. 1984, p. 123.

Table 13.—Marketable potash: World production, by country[1]

(Thousand metric tons of K_2O equivalent)

Country	1980	1981	1982	1983[p]	1984[e]
Canada (sales)[2]	7,532	6,549	5,309	6,938	7,685
Chile[3]	25	21	21	21	22
China[4]	12	20	26	29	40
France	1,894	1,831	1,704	1,536	1,500
German Democratic Republic	3,422	3,460	3,434	3,431	3,450
Germany, Federal Republic of	2,737	[r]2,591	2,056	2,419	2,280
Israel	797	839	1,004	[e]1,000	1,100
Italy	156	146	146	[r e]200	180
Jordan	--	--	9	[e]170	280
Spain	658	732	692	657	677
U.S.S.R	8,064	8,449	8,079	9,294	9,500
United Kingdom	321	285	401	302	360
United States	2,239	2,156	1,784	1,429	[5]1,564
Total	27,857	[r]27,079	24,665	27,426	28,638

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Apr. 23, 1985.
[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 domestic producers in 1984 increased 12% to 502,000 short tons and 10% in value to \$4.9 million. Pumice imported for consumption increased 59% to 293,000 tons, of which Greece supplied 96%. U.S. apparent consumption increased 26% over that in 1983. Estimated world production increased 8% to 13.4 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 75% 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)

	1980	1981	1982	1983	1984
United States: Sold and used by producers:					
Pumice and pumicite	543	499	416	449	502
Value (f.o.b. mine and/or mill)	\$4,267	\$4,311	\$3,750	\$4,486	\$4,929
Average value per ton	\$7.86	\$8.64	\$9.01	\$9.99	\$9.82
Exports[e]	1	1	1	1	1
Imports for consumption	194	92	121	184	293
Apparent consumption[1]	736	590	536	632	794
World: Production, pumice and related volcanic materials	[r]13,702	[r]13,456	13,662	[p]12,404	[e]13,365

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Quantity sold and used, plus imports, minus exports.

DOMESTIC PRODUCTION

Pumice and pumicite production by domestic producers increased 12% in quantity and 10% in value. Twenty-one companies operated twenty-two mines in eight States, of which four States—California, Idaho, New Mexico, and Oregon—accounted for 97% 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; General Pumice Corp., Espanola, NM; Copar Pumice Co. Inc., Santa Fe, NM; Central Oregon Pumice Co., Bend, OR; and Cascade Pumice Co., Bend, OR. Together, these eight companies accounted for 89% of the tonnage and 69% of the value of total U.S. production of pumice and pumicite.

Table 2.—Pumice and pumicite sold and used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1983		1984	
	Quantity	Value	Quantity	Value
Arizona	2	15	2	21
California	65	1,582	80	1,600
New Mexico	110	1,070	132	1,269
Oklahoma	1	W	W	W
Other[1]	271	1,819	288	2,039
Total	449	4,486	502	4,929

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Hawaii, Idaho, Kansas, Oregon, and State indicated by symbol W.

CONSUMPTION AND USES

U.S. apparent consumption was 794,000 tons, an increase of 26% over that of 1983. Pumice and pumicite produced for domestic use as concrete aggregate and admixture declined 11%. Decorative building block use increased 36%, and abrasive use increased 67% to 25,000 tons.

Table 3.—Pumice and pumicite sold and used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1983		1984	
	Quantity	Value	Quantity	Value
Abrasives (includes cleaning and scouring compounds)	15	446	25	810
Concrete admixture and aggregate	189	1,195	169	876
Decorative building block	200	2,131	272	2,801
Landscaping	9	84	15	129
Other[1]	36	630	21	313
Total	449	4,486	502	4,929

[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 pumice and pumicite sold and used by domestic producers was $9.82 per ton compared with $9.99 per ton in 1983.

Prices quoted in Chemical Marketing Reporter at yearend, for domestic grades of pumice bagged in 1-ton lots, increased to $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, increased to $280 per ton for fine and $350 per ton for medium. Coarse material was quoted at $300 per ton, which equaled the 1983 yearend high price for this grade.

The average declared customs value of pumice imported from Greece for use in concrete masonry products increased from $6.35 per ton to $6.82 per ton.

FOREIGN TRADE

Pumice imported for consumption, 96% of which was received from Greece, increased by 59%. Imports from Greece totaled 281,000 tons, of which 98% 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)
1983:							
Greece	2,262	$31	--	--	181,475	$1,150	--
Iceland	158	27	--	--	--	--	$27
Italy	271	45	2	$2	--	--	--
Mexico	--	--	--	--	123	4	--
Other[1]	8	10	6	10	--	--	79
Total	2,699	113	8	12	181,598	1,154	106
1984:							
Greece	5,167	75	--	--	275,756	1,880	--
Iceland	8,228	153	--	--	--	--	23
Italy	3,297	156	172	36	--	--	1
Mexico	--	--	--	--	72	2	--
Other[2]	11	18	20	12	3	3	124
Total	16,703	402	192	48	275,831	1,885	148

[1]Includes Austria, Canada, Denmark, France, the Federal Republic of Germany, Japan, the Republic of Korea, Switzerland, Taiwan, and the United Kingdom.
[2]Includes Austria, Canada, China, Denmark, France, the Federal Republic of Germany, Hong Kong, Japan, Nigeria, Spain, Switzerland, Taiwan, and the United Kingdom.

WORLD REVIEW

World production of pumice and related volcanic materials increased 8% to an estimated 13.4 million tons. The combined output of Greece and Italy accounted for 69% of the world's total production.

[1]Industry economist, Division of Industrial Minerals.

Table 5.—Pumice and related volcanic materials: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina[3]	40	56	59	76	72
Austria: Trass	9	9	12	3	3
Cameroon: Pozzolan	NA	58	89	NA	NA
Cape Verde Islands: Pozzolan[e]	17	11	11	11	11
Chile: Pozzolan	275	306	190	192	190
Costa Rica[e]	1	1	2	2	2
Dominica: Pumice and volcanic ash[e]	120	120	120	120	120
France: Pozzolan and lapilli	513	[r]518	790	699	660
Germany, Federal Republic of:					
Pumice (marketable)	890	440	243	220	290
Pozzolan[e]	220	220	220	NA	NA
Greece:					
Pumice	[r]1,024	[r]684	[r e]690	551	660
Pozzolan	[r]1,609	[r]1,634	1,653	[r e]1,650	1,710
Guadeloupe: Pozzolan[e]	275	265	265	265	265
Guatemala:					
Pumice[e]	20	17	13	[4]17	18
Volcanic ash	14	6	[e]4	([5])	([5])
Iceland	40	37	96	50	55
Italy:					
Pumice and pumiceous lapilli	629	[r]671	[e]825	[e]770	720
Pozzolan	5,684	[r]6,073	[e]6,100	[e]5,500	6,100
Martinique: Pumice	169	172	[e]170	[e]165	165
New Zealand	15	37	55	19	22
Spain[6]	1,198	1,034	1,070	1,100	1,200
United States (pumice and pumicite, sold and used by producers)	543	499	416	449	[4]502
Yugoslavia: Volcanic tuff	397	588	569	[e]545	600
Total	[r]13,702	[r]13,456	13,662	12,404	13,365

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 7, 1985.
[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 achieved a record-high level in 1984. Molycorp Inc., a wholly owned subsidiary of Unocal Corp., and Associated Minerals Ltd. Inc., a subsidiary of Renison Goldfields Consolidated Ltd., were the only domestic mine producers of rare-earth minerals. Mine production by both companies was significantly higher than in 1983. Molycorp, Rhône-Poulenc Inc., W. R. Grace & Co.'s Davison Chemical Div., and Research Chemicals Div. of NUCOR Corp. were the principal processors of rare earths in the United States. Major end uses were in petroleum catalysis, 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. This is the "Rare Earths and Thorium" survey. Both of the mines to which a survey request was sent responded, representing 100% of total production. Production data are withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—On October 30, Public Law 98-573, the Trade and Tariff Act of 1984, was enacted. Under section 151 of this law, the import duty on yttrium-bearing materials and compounds containing by weight more than 19% but less than 85% yttrium oxide equivalent was suspended until December 31, 1988. The duty-free status was designed

Table 1.—Salient U.S. rare earth statistics

(Metric tons of rare-earth oxides (REO) unless otherwise specified)

	1980	1981	1982	1983	1984
Production of rare-earth concentrates[1]	15,986	17,082	17,501	17,083	25,311
Exports:[e]					
Ore and concentrate	4,741	5,056	2,565	2,684	4,304
Ferrocerium and pyrophoric alloys	14	9	22	59	27
Imports for consumption:[e]					
Monazite	2,831	4,108	3,962	2,215	3,114
Metals, alloys, oxides, compounds	1,624	1,631	1,695	1,857	2,926
Shipments from Government stockpile	1,257	802	364	--	--
Stocks, producers and processors, yearend	W	W	W	W	W
Consumption, apparent[e]	18,100	20,000	17,100	19,600	21,400
Prices, yearend, dollars per kilogram:					
Bastnasite concentrate, REO basis	$1.98	$2.14	$2.31	$2.14	$2.14
Monazite concentrate, REO basis	$0.81	$0.83	$0.75	$0.71	$0.64
Mischmetal, metal basis	$12.35	$12.35	$12.35	$12.35	$12.35
Employment, mine and mill[e 2]	250	275	303	266	321
Net import reliance[e 3] as a percent of apparent consumption	11	14	([4])	12	([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.

to help the domestic processing industry compete with foreign yttrium materials imported under TSUS No. 423.00 (Other inorganic compounds: Other, Rare-earth oxides except cerium oxide) or 423.96, part 2C, schedule 4 (Mixtures of two or more inorganic compounds: Other), or item 603.70 (Other metal bearing materials, etc: Other, other), part 1, schedule 6.

DOMESTIC PRODUCTION

Domestic production improved significantly in 1984, with mine output increasing 52%. Bastnasite was the major domestic ore of rare earths and accounted for the majority of increased production. Production of monazite, the only other rare-earth ore produced domestically, also increased. Molycorp, the only U.S. producer of bastnasite, operated a mine at Mountain Pass, CA. Associated Minerals, the only domestic producer of monazite, operated a mine at Green Cove Springs, FL, to recover monazite as a byproduct of processing minerals sands for titanium and zirconium minerals.

Molycorp's sales of rare earths increased 38% during 1984 compared with those of 1983. Sales of high-purity, separated rare-earth products reportedly increased 75% and accounted for 40% of Molycorp's rare-earth revenues.[2]

Associated Minerals relocated its wet-processing plant at Green Cove Springs, FL, to a nearby higher grade ore body, and resultant minerals sands production increased 25% over that of 1983. Spiral concentrators installed at the mine increased recovery and concentrate grades and reportedly resulted in significant reductions in costs and improvement in plant throughput.[3]

Marathon Gold Corp., in a joint venture with Centennial Gold Corp., a 54% owner of Marathon, and Hampton Gold Mining Areas PLC, continued exploration work at its rare earth-gold deposit near Craig, CO. Rhône-Poulenc has reportedly agreed to purchase, from the joint venture, 4,000 to 8,000 metric tons of monazite and xenotime per year that could be processed at either its Freeport, TX, plant or its La Rochelle facilities in France.

Union Carbide Corp. purchased Katalistics International BV of the Netherlands, a producer of petroleum cracking catalysts. Katalistics manufactured fluid cracking catalysts at plants in Savannah, GA, and in Delfzijl, Netherlands. Union Carbide, already a producer of molecular sieves, reportedly hopes to commercialize the use of a new generation of zeolite-based molecular sieves for use in fluid cracking catalysts, some of which utilize rare earths.[4]

Williams Strategic Metals Inc. (WSM) continued development and processing research to recover rare earths and magnetite from iron ore tailings near Mineville, NY. Recovery of magnetite was scheduled to begin in the summer of 1985, with recovery of rare earths, including yttrium, from apatite to begin at an undisclosed future date.[5] WSM expected to produce magnetite and yttrium, including the other rare earths as principal products, and phosphoric acid, derived from the apatite, as a byproduct.

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 24,800 tons of equivalent rare-earth oxides (REO) in various forms in 1984, 29% more than was consumed in 1983. Bastnasite consumption was 39% more than in 1983, but consumption of monazite decreased 23% in 1984.

Shipments of rare-earth products from domestic processors amounted to 20,400 tons of contained REO, an increase from the 16,900 tons of contained REO shipped in 1983.

The approximate distribution of rare earths by end use, based on information supplied by primary processors and some consumers, was as follows: petroleum catalysts, 59%; metallurgical uses (including iron and steel additives, alloys, and misch-metal), 23%; ceramics and glass (including polishing compounds and glass additives), 15%; and miscellaneous (including phosphors, electronics, permanent magnets, lighting, and research), 3%.

Consumption of mixed rare-earth compounds was 31% more than the 1983 level, while consumption of purified rare-earth compounds was 22% higher. Higher consumption of purified materials was the result of strong demand for samarium and neodymium oxides and metals for use in permanent magnets, for europium and yttrium oxides for use in phosphors, and for yttrium oxides for use in high-temperature ceramics. This trend toward higher consumption of neodymium was expected to continue as its use in high-strength neodymium-iron-boron magnets develops.

The producers of mischmetal, rare-earth silicide, and other rare-earth alloys consumed 37% more contained REO than in 1983. Shipments of rare-earth alloys and high-purity rare-earth metals increased 66% and 78%, respectively.

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, tableware, crystal and leaded stemware, opthalmic lenses, welder's safety lenses, decorative glass, 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, stereo-viewing systems, data printers, welder's electronic safety goggles, image storage devices, and as principal constituents and stabilizers in high-temperature ceramics (e.g., yttria-stabilized zirconia), glazes, and paint.

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 control rods, 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, magnetic chucks, eddy current brakes, ferrofluidic exclusion seals, microwave focusing, wristwatches, magnetrons, klystrons, medical and dental applications, traveling wave tubes, drill bit salvage, 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; low-temperature refrigerants; hydrogen storage alloys; 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 1984. All rare-earth stocks held in the NDS were contained in sodium sulfate and were inventoried on a contained-REO basis. Effective October 1, 1984, section 902 of the Department of Defense Authorization Act, 1985, canceled authorization to dispose of the excess rare earths in the NDS. Stocks of yttrium oxide held in non-NDS Government inventories totaled 108 kilograms, all declared excess and authorized for disposal.

Industry stocks of rare earths held by 22 producing, processing, and consuming companies increased 56%. Bastnasite concentrate stocks held by the principal producer and four other processors increased 36% over the 1983 level. Yearend 1984 inventories of monazite and other rare-earth concentrates increased.

Stocks of mixed rare-earth compounds increased, while stocks of purified compounds decreased during the year. Yearend stocks of contained REO equivalent in mischmetal, rare-earth silicide, and other alloys containing rare earths increased 28% as a result of continued low demand for iron and steel products. Inventories of high-purity rare-earth metals decreased.

PRICES

The price range of Australian monazite (minimum 55% rare-earth oxide including thoria, f.o.b./f.i.d.),[6] as quoted in Metal Bulletin (London), decreased from $A410-$A450 per ton at yearend 1983 to $A410-$A440 per ton by yearend 1984. Changes in the foreign exchange rate, resulting from the economic strength of the U.S. dollar, caused the corresponding domestic price range to decrease further from US$369-US$405 per ton in 1983[7] to US$340-US$365 per ton in 1984.[8]

The yearend price quoted in Industrial Minerals (London) for yttrium concentrate (60% Y_2O_3, f.o.b. Malaysia) was $46 per kilogram.

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 1984, unchanged from that of yearend 1983.

The price of cerium concentrate quoted by American Metal Market was $1.32 per pound of contained cerium oxide at yearend 1984, the same level as at the end of 1983. The price of lanthanum concentrate at yearend 1984 was also unchanged from that of yearend 1983 at $1.32 per pound of REO contained.

The mischmetal (99.8%, lots over 100 pounds, f.o.b. shipping point) price, quoted in American Metal Market, remained at the yearend 1980 level of $5.60 per pound throughout the 1981-84 period; however, prior to 1984, the rare-earth alloy price was based on 50- to 100-pound lots, f.o.b. Newark, NJ.

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, 1984, as follows:

Product (oxide)	Percent[1] purity	Quantity (pounds)	Price per pound
Cerium	99.0	200	$8.00
Europium	99.99	25	650.00
Gadolinium	99.99	40	60.00
Lanthanum	99.99	300	7.00
Neodymium	96.0	300	4.00
Do	99.99	50	55.00
Praseodymium	96.0	300	16.80
Samarium	96.0	110	25.00
Terbium	99.9	110	450.00
Yttrium	99.99	50	42.00

[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 August 1, 1984, 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	.92
Lanthanum-lanthanide carbonate	60.0	200	2.45
Lanthanum nitrate	39.0	250	1.70
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 August 15, 1984, as follows:

Product[1] (oxide)	Percent purity	Quantity (kilograms)	Price per kilogram
Cerium	99.5	20	$20.35
Erbium	96.0	50	170.00
Europium	99.99	20	1,575.00
Gadolinium	99.99	50	136.50
Lanthanum	99.99	25	16.20
Praseodymium	96.0	20	38.85
Samarium	96.0	25	63.50
Terbium	99.9	20	820.00
Yttrium	99.99	50	99.80

[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 August 15, 1984, as follows:

Product (compound)	Percent[1] purity	Quantity (kilograms)	Price 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	16.65
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.

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 and 1984 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	98	430

[1]Minimum 99.9% purity, 1- to 20-kilogram quantities.
[2]Ingot form, 1 to 5 kilograms, from 99.9% grade oxides.

FOREIGN TRADE

Domestic 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, excluding monazite, which includes bastnasite concentrates, increased 57% above the 1983 total of 5.1 million kilograms to 8.0 million kilograms in 1984. Exports of rare-earth metal ores were valued at about $16.3 million. Major destinations were Japan, 60%; Austria, 19%; and the United Kingdom, 7%.

Exports of ferrocerium and other pyrophoric alloys containing rare earths totaled 30,869 kilograms, 53% less than the 1983 level. Major destinations in 1984 were Japan, 28%; the Dominican Republic, 27%; and Venezuela, 14%.

Exports of thorium ore, including monazite, increased threefold, compared with those of 1983. France was the destination of the reported total of 229,983 kilograms valued at $157,608.

Lower U.S. import duties on rare-earth materials, resulting from the 1979 Tokyo Round of tariff negotiations, continued for nations having most-favored-nation status. The import duties for these countries are scheduled to decline annually at staged rates through January 1, 1987.

The import tariff for yttrium-bearing ores, materials, and compounds was suspended in 1984. The suspension was to remain in effect until July 1, 1988, and should allow domestic processors to better compete with foreign-produced yttrium products.

Table 2.—U.S. import duties on rare earths

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1984	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1984
Ore and concentrate[1]	601.12, 601.45	Free	Free	Free.
Cerium chloride, oxide, compounds	418.40, 418.42, 418.44	10.1% ad valorem.	7.2% ad valorem.	35% ad valorem.
Rare-earth oxides except cerium oxide	423.0030	4.2% 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	31 cents per pound plus 3.8% 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	32 cents per pound plus 3.9% ad valorem.	22 cents per pound plus 2.6% ad valorem.	Do.
Inorganic chemicals (includes yttrium concentrates[2]).	603.70	5.9% ad valorem.	5% ad valorem.	30% ad valorem.

[1]Crude or concentrated by crushing, flotation, washing, or by other physical or mechanical processes that do not involve substantial chemical change.

[2]Includes materials concentrated by chemical processes that involve substantial chemical change.

Table 3.—U.S. imports for consumption of monazite, by country

Country	1980 Quantity (metric tons)	1980 Value (thousands)	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)
Australia	4,933	$1,749	7,469	$3,158	6,600	$2,830	3,726	$1,395	5,610	$2,156
Malaysia	215	101	--	--	603	240	302	122	--	--
South Africa, Republic of	--	--	--	--	--	--	--	--	51	46
Total	5,148	1,850	7,469	3,158	7,203	3,070	4,028	1,517	5,661	2,202
REO content[e]	2,831	XX	4,108	XX	3,962	XX	2,215	XX	3,114	XX

[e]Estimated. XX Not applicable.

Table 4.—U.S. imports for consumption of rare earths, by country

Country	1982 Quantity (kilograms)	1982 Value	1983 Quantity (kilograms)	1983 Value	1984 Quantity (kilograms)	1984 Value
Cerium chloride:						
Germany, Federal Republic of	1,096	$18,334	--	--	--	--
Malaysia	--	--	--	--	701,092	$754,588
Netherlands	--	--	227	$5,136	--	--
Total	1,096	18,334	227	5,136	701,092	754,588
Cerium compounds:						
France	5,700	61,616	3,500	13,505	1,000	4,778
Germany, Federal Republic of	18	7,410	25	9,433	42	10,373
Japan	--	--	800	1,038	207	9,226
South Africa, Republic of	--	--	2	791	--	--
Switzerland	--	--	2	670	1	266
United Kingdom	6	2,302	--	--	5	783
Total	5,724	71,328	4,329	25,437	1,255	25,426
Cerium oxide:						
Austria	--	--	68	674	68	738
Belgium	--	--	18,120	6,504	--	--
France	26,239	72,912	6,239	78,136	3,790	53,891
Germany, Federal Republic of	7	1,727	2	381	12	1,457
Japan	--	--	835	7,692	3,357	30,522

Table 4.—U.S. imports for consumption of rare earths, by country —Continued

Country	1982 Quantity (kilograms)	1982 Value	1983 Quantity (kilograms)	1983 Value	1984 Quantity (kilograms)	1984 Value
Cerium oxide —Continued						
Switzerland	--	--	3	$335	6	$1,207
United Kingdom	--	--	50	536	40	287
Total	26,246	$74,639	25,317	94,258	7,273	88,102
Cerium salts:						
Finland	15,300	18,339	--	--	--	--
France	--	--	1,760	6,580	--	--
United Kingdom	120	1,012	--	--	--	--
Total	15,420	19,351	1,760	6,580	--	--
Rare-earth oxide excluding cerium oxide:						
Austria	--	--	--	--	50	2,646
Belgium	--	--	55	25,906	16,803	42,856
Brazil	300	27,235	54,999	575,850	--	--
Canada	--	--	100	128,611	83,815	23,264
China	1,300	71,168	19,575	450,033	4,058	263,084
France	140,020	7,141,420	206,345	9,393,632	271,555	13,880,011
Germany, Federal Republic of	17,116	2,258,877	702	191,953	1,078	284,165
Guyana	38	19,543	--	--	--	--
India	--	--	--	--	199,998	192,500
Italy	--	--	22,640	10,466	--	--
Japan	10,292	1,221,724	10,983	585,262	14,311	1,034,997
Korea, Republic of	--	--	--	--	68	5,087
Malaysia	--	--	273,597	251,022	274,592	295,907
Mexico	--	--	--	--	50,499	2,222
Netherlands	50	26,269	--	--	54	23,459
Norway	4,770	517,124	7,128	778,743	6,168	659,184
Switzerland	6	3,180	5	4,790	--	--
Taiwan	--	--	500	31,184	--	--
U.S.S.R.	10,746	1,143,593	12,657	1,237,136	11,984	747,572
United Kingdom	8,316	79,889	31	6,196	225	28,541
Total	192,954	12,510,022	609,317	13,670,784	935,258	17,485,495
Rare-earth alloys:[1]						
Austria	17,500	161,506	--	--	52,463	444,685
Brazil	40,000	312,758	65,147	457,419	79,993	526,031
Germany, Federal Republic of	4,858	44,531	9,870	143,328	11,276	100,653
United Kingdom	769	139,542	237	41,038	5	485
Total	63,127	658,337	75,254	641,785	143,737	1,071,854
Rare-earth metals including scandium and yttrium:						
China	2,100	52,068	--	--	1,573	59,526
France	500	14,984	50	1,805	--	--
Japan	550	47,483	81	12,679	--	--
Malaysia	--	--	--	--	40	644
U.S.S.R.	--	--	300	70,500	700	164,735
United Kingdom	68	24,394	370	97,258	2,003	394,484
Total	3,218	138,929	801	182,242	4,316	619,389
Other rare-earth metals:						
China	--	--	--	--	1,000	1,181
France	--	--	--	--	135	3,979
Germany, Federal Republic of	6	928	46	5,524	77	7,514
Japan	45	2,233	422	8,237	--	--
United Kingdom	--	--	5	359	--	--
Total	51	3,161	473	14,120	1,212	12,674
Ferrocerium and other pyrophoric alloys:						
Austria	2,367	33,340	953	13,430	937	12,875
Brazil	14,954	212,450	28,839	396,715	47,388	685,088
France	47,968	571,079	54,321	576,549	72,470	695,395
German Democratic Republic	--	--	--	--	170	1,589
Germany, Federal Republic of	462	7,266	--	--	459	5,340
Italy	6	286	--	--	--	--
Japan	19,375	257,589	13,190	176,108	15,537	204,308
Sweden	--	--	6,694	7,816	--	--
Taiwan	--	--	91	410	--	--
United Kingdom	606	10,163	608	14,288	1,167	45,965
Total	85,738	1,092,173	104,696	1,185,316	138,128	1,650,560

[1]Essentially all mischmetal.

WORLD REVIEW

Bastnasite was the world's principal source of rare earths. It 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, a byproduct of minerals sands mined for titanium and zirconium in several countries and for tin in Malaysia and Thailand. 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. China, with 80%, had the largest share of world reserves.

Australia.—Allied Eneabba Ltd. reportedly produced 9,843 tons of monazite in 1984, a 6% decrease from the 10,429 tons produced in 1983. The decrease was attributed to the breakdown of an overland conveyor system and was reportedly responsible for an overall 3% decrease in the company's minerals sands production. However, sales of monazite increased 21% compared with 1983 levels, and monazite accounted for 12% of the minerals sands revenues generated at Allied. During the year, Allied acquired minerals sands leases by purchasing 1,123 hectares of land at Eneabba, Western Australia. Total proven and probable ore reserves for Allied at yearend were 10.8 million tons of heavy minerals. The 7% reduction from 1983 reserves included 6% that was mined in 1984 and 1% reclassified out of reserve status.[9]

Allied, in cooperation with a Japanese company, was reportedly studying a plan to build a US$50 ($A60) million processing plant to treat monazite and produce rare-earth compounds. The plant reportedly would also treat monazite from other producers in Western Australia that, combined, supplied nearly one-half of the world's supply of monazite.[10]

Associated Minerals Consolidated Ltd. (AMC), a wholly owned subsidiary of Renison Goldfields, improved monazite recovery rates at its Eneabba, Western Australia, processing plant. The relocation of a bucket wheel excavator from AMC's east coast operations to Capel, Western Australia, reportedly reduced minerals sands mining costs by 40%.[11]

An agreement was reached between Consolidated Rutile Ltd. (CRL) and AMC for the acquisition of assets on North Stradbroke Island owned by AMC and its subsidiary, Titanium and Zirconium Industries Pty. Ltd. The assets CRL was to acquire, in the first quarter of 1985, included housing, heavy minerals sands processing plants, stocks of ilmenite, and a 1,400-ton-per-hour dredge that was already operating on CRL's leases near Amity on the north side of North Stradbroke Island. The agreement may have been prompted by AMC's failure to receive Government approval to export products derived from its leases on Moreton Island. AMC's leases on Moreton Island will reportedly not be relinquished because the heavy mineral reserves are the last known extensive deposit on the east coast.[12]

CRL announced that it would commit US$26 ($A31) million to the development of its Gordon heavy minerals leases on the southern end of North Stradbroke Island. A new dredge and plant there reportedly will have a capacity of 2,700 tons per hour, similar to the capacity of CRL's mine at Bayside on the western side of the island. Mining was scheduled to begin at the Gordon leases in the first half of 1985.[13]

In 1984, Rutile & Zircon Mines (Newcastle) Ltd. (R & Z Mines) reportedly planned to move over the next 2 years to new minerals sands leases located 4 to 5 kilometers north of the current Hunter River, New South Wales, workings. R & Z Mines operated two dredge-concentrator units, one at Tomago and the other at a site north of the Hunter River; both mines supplied the R & Z Mines dry processing plant in Tomago, near Newcastle, New South Wales.[14]

In return for surrender of heavy minerals sands leases on Moreton Island, Bribie Island, Curtis Island, and along the central coast of Queensland, the State government reportedly offered the two companies involved development leases at Inskip Point, Queensland. The companies, Murphyores Holdings Ltd. and Mineral Deposits Ltd., were prohibited from mining along the coastal areas of Queensland to allow for the expansion of national park, port, and industrial sites.[15]

In Western Australia, Cable Sands Pty. Ltd. reported that 1983 had been a record-high year for production. About 600 tons of monazite and 30 tons of xenotime were produced at Cable's Bunbury plant in 1983. In 1984, the company was in the process of moving its mining and wet-processing operations from Capel, Western Australia, to an area 4 kilometers north of Capel. A second, smaller plant was planned to start production at yearend at a site 40 miles north of Bunbury. Cable planned to make a more substantial move in a few years from its new Capel location to a coastal site, where it was expected to switch to a dredge-type operation.[16]

Westralian Sands Ltd. at Yoganup, Western Australia, installed new gravity concentrator equipment at its Yoganup Extended Mine, increasing minerals sands throughput from 320 to 400 tons per hour. The higher capacity was reportedly necessary to offset a decline in ore grades. Monazite production was about 2,100 tons, 600 tons more than in 1983.[17]

Brazil.—Production of various rare-earth compounds, in kilograms, was as follows:

Year	Carbonate	Chloride	Oxide
1979	14,000	2,725,000	16,000
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

Production of crude monazite ore in 1983 was 915 tons from the State of Espírito Santo and 5,015 tons from the State of Rio de Janeiro.

According to Anuário Mineral Brasileiro 1984, measured reserves of monazite were 17,839 tons with an REO content of 10,668 tons. Monazite reserves were located in the States of Espírito Santo, Paraná, and Rio de Janeiro.[18] Rare-earth resources of 50,000 tons of REO were contained in clayey ore in the Poços de Caldas region.

Canada.—Highwood Resources Ltd. announced the discovery of a beryllium-yttrium deposit at Thor Lake, 65 miles southwest of Yellowknife, Northwest Territories. Reserves delineated in two zones amounted to 479,000 tons at a grade of 1.4% beryllium oxide in the North (T) Zone and 1.3 million tons of 0.66% beryllium oxide in the South Zone. Initial testing of drill cores indicated that 1.8 to 2.3 kilograms of yttrium oxide per ton was contained in the beryllium ore.[19]

China.—Mitsui Mining & Smelting Co. Ltd., a producer of REO's in Japan, reportedly signed a 5-year contract to import 200 tons of rare earths per year from China. The rare-earth material is to be supplied from the Xun Wu Mine in Jiangxi Province, China. The mine and plant at Xun Wu recover rare-earth concentrates from a residual clay deposit containing high-grade samarium and europium.[20]

Principal destinations of exports of rare earths in 1983 were the Federal Republic of Germany and Japan. Products that were exported included rare-earth chloride, rare-earth metals including yttrium and samarium, ferrocerium, and yttrium oxide.[21]

India.—Monazite and other heavy minerals have been identified in beach sands on the Thanjavur coast in the State of Tamil Nadu. The deposit's monazite content is reportedly at least equal to Indian Rare Earths Ltd.'s (IRE) Manavalakurichi deposit in Tamil Nadu. India's Department of Geology & Mining is scheduled to conduct a detailed geological investigation to determine reserves and study minerals sands deposition rates in the area.[22]

Production by IRE in 1983-84[23] declined for the second year in a row. Rare-earth chloride production decreased from 3,464 tons in the 1982-83 financial year to 2,879 tons in 1983-84. IRE's rare-earth division processed 2,903 tons of monazite during the 12-month period.

Construction work at IRE's Orissa Sands Complex in Orissa was in its final stage. The dredge and wet concentrator plant was commissioned and trial runs at the dry mill were reportedly in progress. It was expected that the complex will be partially commissioned during 1984-85.[24]

Japan.—Demand for rare earths in 1983 was reported as follows:[25] Catalysts, 250 tons; cerium oxide, 1,600 tons; europium oxide, 7 tons; lanthanum oxide, 200 tons; mischmetal, 280 tons; rare-earth fluoride, 40 tons; samarium oxide, 180 tons; yttrium oxide, 170 tons; and other REO's, 120 tons.

Imports of rare earths in 1984 were reported in the Japan Metal Journal, as follows:

Product	Quantity (kilograms)
Cerium fluoride	274
Cerium oxide	57,088
Ferrocerium and other pyrophoric alloys	20,909
Lanthanum oxide	226,036
Rare-earth chloride	3,745,521
Rare-earth metals including yttrium and scandium	131,279
Yttrium oxide	263,335

Principal sources of imported compounds were Brazil, China, France, India, and the United States. Leading sources of rare-earth metals and alloys were Brazil, China, France, and the United States.

Mitsubishi Metal & Mining Co. reportedly concluded a 5-year contract to purchase ore from the Xin Wu Mine in Kiangsi Province, China. Mitsui Mining & Smelting carried out preliminary separation of the Chinese ore at its Miike factory in Japan. Final separation of the concentrate was completed by Mitsui Mining & Smelting and Nippon Yttrium K.K., on a 50:50 joint venture with Tohuku Kinzoku Kagaku.[26]

Demand for samarium oxide and samarium metal was strong in 1983, and production of rare-earth magnets, primarily samarium-cobalt magnets, increased to 270 tons, 50% more than in 1982. Mitsubishi Kasei Kogyo, one of the Japanese producers of REO's, expected to produce about 30 tons of samarium oxide per year from their Kurozaki plant.[27]

Sri Lanka.—The mineral composition of the heavy minerals sands mined at Pulmoddai, on the northeastern coast, contained 70% to 72% ilmenite, 8% to 10% zircon, 8% rutile, and 0.3% monazite. Production of monazite from the island was about 70 tons per year. Ceylon Mineral Sands Corp., a wholly owned Government corporation, remained the sole mining and processing operation.[28]

Thailand.—Monazite and xenotime were produced as byproducts of processing minerals sands for tin. Production of xenotime concentrates was as follows:[29]

Year	Quantity (metric tons)
1979	6
1980	52
1981	45
1982	46
1983	38

Table 5.—Monazite concentrate: World production, by country[1]

(Metric tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Australia	14,079	[r]13,282	9,562	[r e]15,000	15,000
Brazil	2,532	2,100	1,768	5,256	6,000
India[3]	3,395	3,704	[e]4,000	[e]4,000	4,000
Malaysia (exports)	347	320	582	1,051	1,000
Sri Lanka	63	60	304	[e]300	300
Thailand	152	107	162	277	250
United States	W	W	W	W	W
Zaire	51	[r]35	32	8	5
Total	20,619	[r]19,608	16,410	25,892	26,555

[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. 23, 1985.
[2]In addition to the countries listed, China, Indonesia, North Korea, the Republic of Korea, and Nigeria 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.

TECHNOLOGY

In 1984, the Crucible Magnetics Div. of Colt Industries announced the development of an improved neodymium-iron-boron magnet having the highest magnetic energy product ever achieved with a permanent magnet, 42.9 megagauss oersteds (MGOe). The company expects production magnets to have strengths in the range of 30 MGOe to 40 MGOe. The higher strength neodymium-iron-boron magnets are expected to be used in high-torque miniaturized motors in a wide variety of applications. These new magnets may partially replace the best previously available magnets, samarium-cobalt, which have magnetic energy products in the range of 16 MGOe to 25 MGOe.[30]

A new nickel-base, high-temperature alloy, containing 16% chromium, 2.5% iron, 4.5% aluminum, and a small amount of yttrium, was developed by Cabot Corp. The alloy, No. 214, reportedly has outstanding resistance to oxidation through 2,200° F, as well as good resistance to carburization and chlorine attack. Potential applications for the alloy are in support systems for ceramic firing kilns, in roller hearth and muffle furnace components, as electric heating elements, as tubing in strand annealing furnaces, in high-temperature test racks, and in gas turbine engine hot spots.[31]

Researchers at Ford Motor Corp. developed an oxygen analyzer to accurately and rapidly measure the air-to-fuel ratio of any combustion process. The device is also capable of measuring oxygen concentrations. Oxygen concentration is determined by utilizing an yttria-doped zirconia sensor. The analyzer was designed to determine the oxygen equivalence and air-to-fuel ratios of diesel and spark-ignited internal combustion engines burning conventional or nonconventional fuels and may also be used to analyze combustion in oil and coal power production processes in the home and in commercial heating and cooling systems.[32]

Mitsui & Co. and Japan Metals and Chemicals Co. Ltd. jointly developed a hydrogen absorbing-desorbing battery that uses lanthanum-mischmetal nickel dihydride. Containing 300 kilograms of lanthanum-rich mischmetal, the battery will reportedly absorb 60 cubic meters of hydrogen gas when fueled at a pressure of 9.8 kilograms per square centimeter and desorb the gas at a pressure of 6 kilograms per square centimeter. An experimental model of a hydrogen-powered car employing this system was successfully tested on the Fuji Speedway in Japan. The battery can reportedly power a hydrogen combustion car for 200 kilometers on a single charge.[33]

Gadolinium-153 has become the most used radioisotope for pharmaceutical applications. The isotope is a key component in a scanning device for detection and therapeutic followup of bone mineral loss. Gadolinium's two characteristic radiations, a 100-kiloelectron-volt gamma ray and a 43-kiloelectron-volt X-ray, are compared after passing through bone to determine bone density using absorption ratios. The rare-earth isotope is produced at Oak Ridge National Laboratory's high-flux isotope reactor by irradiating europium.[34]

An optically transparent lead-lanthanum-zirconate-titanate (PLZT) ceramic developed in 1969 by Sandia National Laboratories to protect vision from thermonuclear flashblindness will reportedly be used in cockpit window panels in Rockwell International's B-1B bomber. The open and closed states of the PLZT is typically 20% and 0.006% light transmission, respectively. When a light hazard is detected by the sensor, closure time is less than 150 microseconds. Sandia designed and developed PLZT flyers' goggles in 1975 that unfortunately blacked out not only visual contact with flight hazards outside the aircraft but the cockpit instrumentation as well. The new window panels will allow pilots to maintain visual contact with cockpit instrumentation during a nuclear blast. The PLZT material will reportedly provide sufficient visibility in the open state for taxi, takeoff, and all mission phases except during nuclear flare. The panels reportedly must be removed before touchdown to provide sufficient visibility.[35]

A magneto-optical recorder that stores information on a thin amorphous layer of gadolinium-terbium-iron was built by scientists at Philips Forschungs Laboratory in Hamburg, Federal Republic of Germany. Other storage layer materials that were successfully tested were mixtures of gadolinium, iron, terbium, tin, and bismuth. Information was written to and read out by a low power semiconductor laser. Data are recorded thermomagnetically by applying light impulses and magnetic field pulses simultaneously to the rare-earth-containing disk using heat from laser light pulses to reverse the magnetic domains on the disk. For readout, less light is focused on the disk and stored data are detected by a photodiode array. Potential applications of the recorder lie with small personal computers or minicomputers, with each 5-centimeter disk having a 10-megabyte capacity.[36]

A laser system being developed for laser-induced fusion by the U.S. Department of Energy at Lawrence Livermore National Laboratory set a new record for energy and power production. Using 8 of the 10 neodymium-glass solid-state lasers that are part of the Nova system, 57 trillion watts of infrared laser light was delivered in a single pulse of one-billionth of a second. Advancements in laser-induced fusion could result in low-cost nonradioactive electrical power generation if an element such as hydrogen can be fused successfully. Hydrogen fusion is the process that generates most of the Sun's energy.[37]

The strongest ceramic material yet to be developed was produced using yttria-densified beta sialon (Si-Al-O-N). Using mixed aluminum oxide and silicon nitride powders, corresponding to various sialon compositions, researchers were able to produce larger volumes of lower viscosity liquids by using additives as magnesia and yttria. This allows the beta form to be sintered to theoretical density without the application of pressure. With proper heat treatment or controlled cooling, beta sialon with grain boundaries of yttrium sialon (Y-Si-Al-O-N) glass are produced with intragranular crystalline yttrium-aluminum garnet (YAG). The extremely strong ceramic material is reportedly easier to manufacture and shape than ordinary silicon nitride, and by changing the powder composition and heat treatment, a variety of mechanical and physical properties may be produced. Cutting tools from a glassy version of the ceramic are said to be superior to hard metal or alumina. Other applications under consideration include metal tube and wire drawing dies, ball and journal bearings, and welding shields and nozzles.[38]

The progress of research into the development of a new class of high-performance permanent magnets prepared from neodymium-iron-boron and praseodymium-iron-boron alloys was published by researchers at General Motors Corp.[39] Using rapid quench-techniques, high-coercivity (resistance to demagnetization) unachievable by conventional powder metallurgy methods has been obtained by crystallization of an amorphous precursor or by direct quenching from a melt. A maximum energy product of 14.1 MGOe, the largest value ever reported for a light rare earth-iron magnet, was attained.

Researchers at Sumitomo Special Metals Co. Ltd. in Japan published a paper on the synthesis of a neodymium-boron-iron permanent magnet by powder metallurgical processes. A record high-energy product of 36.4 MGOe was obtained. It was noted that additions of cobalt or small additions of "heavy group" rare earths improved the relatively low-curie temperature of the high-magnetic-strength alloy.[40]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Unocal Corp. 1984 Annual Report. 48 pp.

[3]Renison Goldfield Consolidated Ltd. Annual Report 1984. 39 pp.

[4]Industrial Minerals (London). Carbide Buys Cracking Catalysts. No. 200, May 1984, p. 23.

[5]Engineering and Mining Journal. New York—Recovery of Rare Earths. V. 185, No. 1, Jan. 1984, pp. 76-77.

[6]Free on board/free into container depot.

[7]Values have been converted from Australian dollars ($A) to U.S. dollars (US$) at the rate of $A1.1117=US$1.00 based on yearend 1983 foreign exchange rates from the Wall Street Journal.

[8]Values have been converted from Australian dollars ($A) to U.S. dollars (US$) at the rate of $A1.2070=US$1.00 based on yearend 1984 foreign exchange rates from the Wall Street Journal.

[9]Allied Eneabba Ltd. Annual Report 1984. 36 pp.

[10]Industrial Minerals (London). Annual Report Highlights. Allied Eneabba Limited. No. 200, May 1984, p. 27.

[11]Work cited in footnote 3.

[12]Industrial Minerals (London). World of Minerals. Agreement on Stradbroke Reached. No. 205, Oct. 1984, pp. 9-10.

[13]Coope, B. M. Developments in Australia's Industrial Minerals. Ind. Miner. (London), No. 206, Nov. 1984, pp. 61-67.

Mining Journal (London). Consolidated Rutile: Island Mining. V. 303, No. 7782, Oct. 12, 1984, p. 262.

[14]Works cited in footnote 13.

[15]Mining Journal (London). Industry in Action. Leases for Murphyores. V. 303, No. 7757, Apr. 20, 1984, pp. 270-271.

[16]Works cited in footnote 13.

[17]Industrial Minerals (London). Westralian Sands Ltd. Annual Report Highlights. No. 212, May 1985, p. 19.

[18]Anuário Mineral Brasileiro 1984. Monazita. Pp. 289-290.

[19]Industrial Minerals (London). Canada-Progress at Thor Lake. No. 208, Jan. 1985, p. 10.

The Northern Miner (Toronto, Ontario, Canada). Highwood Ups Reserves on Beryllium-Yttrium Bet. Nov. 29, 1984, p. A12.

[20]Mining Journal (London). Sales & Contracts—Rare Earths for Mitsui. V. 303, No. 7790, Dec. 7, 1984, p. 401.

[21]Roskill's Letter From Japan. Trade Statistics. Table 11: China: Exports of Rare Earths. No. 13, Spring 1984, p. 23.

[22]Industrial Minerals (London). India—New Rare Earths Find. No. 210, Mar. 1985, p. 10.

[23]Data are for Apr. 1 to Mar. 31 of the years stated.

[24]Indian Rare Earths Ltd. 34th Annual Report 1983-84. Pp. 19-22.

[25]Roskill's Letter From Japan. Rare Earths: Demand Firm on Most Fronts. No. 108, Apr. 1985, pp. 1-12.

[26]Work cited in footnote 25.

[27]Roskill's Letter From Japan. Samarium Cobalt: Magnet Production Up 50%. No. 98, June 1984, pp. 12-13.

[28]U.S. Embassy, Colombo, Sri Lanka. State Dep. Airgram A-38, Aug. 22, 1984, pp. 4-5.

[29]U.S. Embassy, Bangkok, Thailand. State Dep. Airgram A-26, Apr. 23, 1984, 14 pp.

[30]Colt Industries. News Release. Available from Colt Industries, Crucible Magnetics Div., RFD 2, Elizabethtown, KY 42701.

[31]Research & Development. Special Report 1984 IR 100 Competition Winners, Cabot Alloy No. 214. Oct. 1984, p. 117.

[32]———. Special Report 1984 IR 100 Competition Winners, Ford Lambda Oxygen Analyzer. Oct. 1984, p. 87.

[33]Furukawa, T. Japan Battery Uses Lanthanum, Nickel Metals. Am. Met. Mark., June 4, 1984, p. 19.

[34]Chemical & Engineering News. Science/Technology Concentrates. Gadolinium-153 a Top Seller. May 7, 1984, p. 28.

[35]Aviation Week & Space Technology. B-1B Cockpit To Be Fitted With Nuclear Flash Shield. Feb. 27, 1984, pp. 56-61.

[36]Sanders, I., and M. Urnerwille. Digital Magneto-Optical Recorder. Paper in SPIE-Proceedings. (Incline Village, NV, Jan. 17-20, 1983). Soc. Photo-Opt. Instrum. Eng., v. 382, 1983, pp. 240-244.

[37]Rare-Earth Information Center News. RE's in the News: Light Record. V. 19, No. 3, Sept. 1, 1984, p. 4.

[38]Jack, K. H. Met. Tech., v. 9, July 1982, pp. 297-301.

[39]Croat, J. J., J. F. Herbst, R. W. Lee, and F. E. Pinkerton. Pr-Fe and Nd-Fe-Based Materials: A New Class of High-Performance Permanent Magnets. J. Appl. Phys., v. 55, No. 6, Mar. 15, 1984, pp. 2078-2082.

[40]Sagawa, M., S. Fujimura, N. Togawa, H. Yamamoto, and Y. Matsuura. New Material for Permanent Magnets on a Base of Nd and Fe. J. Appl. Phys., v. 55, No. 6, Mar. 15, 1984, pp. 2083-2087.

Salt

By David E. Morse[1]

Total production of all types of salt increased 19% in 1984 reversing the downward trend of the previous 4 years. Salt sold or used by producers increased 4.65 million short tons; imports for consumption were up more than 1.5 million tons; and apparent consumption of salt increased by over 5.8 million tons. Salt used for deicing purposes from domestically produced rock salt and bulk salt imports, was responsible for the greatest share of increased consumption. Salt sold for animal feed uses declined by about 100,000 tons.

Salt consumption by food-related industries was virtually unchanged despite increased consumer awareness of the allegedly harmful effects of excess salt in the diet. Vacuum pan salt sold to grocery stores declined, however, by over 100,000 tons indicating that consumers had become more salt conscious and were restricting their intake.

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 44 companies to which a survey request was sent, 39 responded, representing 96% of the total production shown in table 1. Production for the five nonrespondents was estimated using reported 1983 production levels adjusted by trends in employment and other guidelines. One producer reported no production.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1980	1981	1982	1983	1984
United States:					
Production[1]	41,483	38,899	37,665	32,973	39,181
Sold or used by producers[1]	40,352	38,907	37,894	34,573	39,225
Value	$656,164	$637,568	$671,424	$597,081	$675,099
Exports	831	1,046	1,001	517	820
Value	$12,829	$17,429	$16,647	$12,368	$15,299
Imports for consumption	5,263	4,319	5,451	5,997	7,545
Value	$44,071	$44,523	$56,184	$60,194	$74,100
Consumption, apparent[2]	44,784	42,180	42,344	40,053	45,950
World: Production	r186,156	r189,198	179,923	p175,563	e185,132

eEstimated. pPreliminary. rRevised.
1Excludes Puerto Rico.
2Sold or used plus imports minus exports.

DOMESTIC PRODUCTION

The total quantities of salt produced and salt sold or used by domestic producers increased 19% and 13%, respectively, compared with the depressed levels of 1983. In 1984, 43 companies operated 81 salt-producing plants in 15 States. Nine of the companies sold or used over 1 million tons each, accounting for 77% of the U.S. total.

The six leading States in quantity of salt sold or used were Louisiana, 34%; Texas, 21%; New York, 15%; Ohio, percentage withheld to avoid disclosing proprietary data; Kansas, 4%; and Michigan, 4%. A significant quantity of the salt produced in

Louisiana, New York, Texas, and West Virgina was produced as brine and was sold or used as such.

The most significant increase in 1984 was in rock salt production. Large quantities of rock salt were purchased by State and municipal governments in 1982. These large quantities and the relatively mild winter of 1982-83 caused a drop in salt demand for deicing in 1983. The excess salt inventories were used during the winter of 1983-84 and resulted in a more normal demand in 1984, which, in turn, required an increase in rock salt production.

The proportion of salt sold or used by domestic producers, by type, was as follows, in percent:

	1983	1984
Salt in brine	55	50
Mined rock salt	29	35
Vacuum pan salt and grainer or open pan salt	10	9
Solar-evaporated salt	6	6
Total	100	100

International Salt Co. Inc. was in the process of improving efficiency at its Avery Island, LA, rock salt mine. Deepening of the production shaft would allow skip loading at the 900 foot level and would replace an underground conveyor system that carried salt to the 500 foot level for hoisting to the surface. New scaling and drilling machinery were purchased and underground storage was expanded. International's Retsof Mine in Livingston County, NY, celebrated its centennial year by becoming the first North American mine to hoist its 100 millionth ton of salt.

Morton Thiokol Inc. planned to increase production capacity at its Weeks Island, LA, rock salt mine. Underground improvements, increased hoisting capacity, and expansion of surface facilities for handling and transfer to barge, truck, and rail were designed to increase capacity by 300,000 tons per year. Morton closed its Marysville, MI, evaporated salt plant in November, citing a decline in table salt use.

Cargill Inc. began constructing a solar evaporation facility near Freedom, OK. The planned capacity was 200,000 tons per year with construction projected for completion in 1985. Planned salt products were compressed pellets for water softening, blocks for livestock nutrition, and bulk and packaged salt for chemical and other commercial uses. Cargill permanently shut down its Belle Isle, LA, rock salt operation in February after engineering studies revealed that the mine could be in danger of collapsing.

High water levels, as a result of spring runoff into Great Salt Lake, adversely affected the solar salt facilities that used lake water as a brine source. The outer dike of Great Salt Lake Minerals & Chemicals Corp. was breached, which allowed the flooding of about 85% of the company's evaporation ponds, diluting brine and seriously affecting salt production for several years. In addition to damage caused by the high water level, fresh water had diluted the average sodium chloride content in the lake by nearly 35%.

Table 2.—Salt sold or used by producers in the United States,[1] by recovery method

(Thousand short tons and thousand dollars)

Recovery method	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Evaporated:				
Bulk:				
Open pan or grainer and vacuum pan	3,309	289,165	3,322	307,690
Solar	1,962	42,117	2,345	46,120
Pressed blocks	408	28,755	542	33,424
Total[2]	5,680	360,037	6,209	387,234
Rock:				
Bulk	9,867	132,537	13,276	182,905
Pressed blocks	73	5,644	71	5,697
Total[2]	9,941	138,180	13,348	188,602
Salt in brine (sold or used as such)	18,952	98,864	19,669	99,263
Grand total[2]	34,573	597,081	39,225	675,099

[1]Excludes Puerto Rico.
[2]Data may not add to totals shown because of independent rounding.

Table 3.—Salt sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Colorado	--	--	W	W
Kansas[1]	1,719	67,195	1,712	71,558
Louisiana	11,544	100,936	13,101	112,142
Michigan	1,355	93,306	1,491	93,860
New York	4,859	100,119	5,644	123,755
Ohio	2,565	85,988	W	W
Texas	8,028	65,670	8,184	69,672
Utah	936	23,184	1,246	28,651
West Virginia	1,026	W	1,004	W
Other[2]	2,541	60,683	6,844	175,461
Total	34,573	597,081	[3]39,225	675,099
Puerto Rico[e]	32	670	30	630

[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, Arizona, California, Kansas (brine only), Nevada, New Mexico, North Dakota, Oklahoma, and items indicated by symbol W.
[3]Data do not add to total shown because of independent rounding.

Table 4.—Evaporated salt sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Kansas	928	59,402	906	62,505
Louisiana	219	18,868	203	18,510
Michigan	1,006	87,893	960	88,048
New York	627	55,531	661	60,631
Utah	893	22,692	1,173	27,752
Other[1]	2,006	115,651	2,306	129,789
Total[2]	5,680	360,037	6,209	387,234
Puerto Rico[e]	32	670	30	630

[e]Estimated.
[1]Includes Arizona, California, New Mexico, North Dakota, Ohio, Oklahoma, and Texas.
[2]Data may not add to totals shown because of independent rounding.

Table 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1980	11,806	176,541
1981	11,871	167,179
1982	13,503	192,202
1983	9,941	138,180
1984	13,348	188,602

Table 6.—Pressed salt blocks sold by original producers of salt in the United States

(Thousand short tons and thousand dollars)

Year	From evaporated salt		From rock salt		Total[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1980	393	24,412	65	4,502	458	28,914
1981	404	26,099	62	4,723	466	30,822
1982	447	29,614	72	5,592	519	35,207
1983	408	28,755	73	5,644	482	34,398
1984	542	33,424	71	5,697	614	39,121

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

Table 7.—Distribution of salt sold or used by producers in the United States, by consumer or use

(Thousand short tons)

Consumer or use	Evaporated: Vacuum pans and open pans	Evaporated: Solar	Rock	Brine	Total[1]
1983:					
Chlorine, caustic soda, soda ash	75	302	1,453	18,119	19,950
All other chemicals	256	111	398	187	952
Textile and dyeing	105	W	49	W	171
Meatpackers, tanners, casing manufacturers	174	51	307	--	531
Dairy	88	4	8	--	101
Canning	110	W	76	W	211
Baking	104	3	8	--	114
Flour processors (including cereal)	61	1	24	--	86
Other food processing	184	37	41	--	262
Feed dealers	403	171	403	--	977
Feed mixers	215	105	308	--	628
Metals	35	W	189	W	242
Rubber	W	W	5	36	45
Oil	90	326	70	433	918
Paper and pulp	W	96	157	W	274
Water softener manufacturers and service companies	279	210	207	12	707
Grocery stores	738	93	156	--	987
Highway use	W	183	4,848	W	5,041
U.S. Government	19	W	525	W	563
Distributors (brokers, wholesalers, etc.)	594	W	617	W	1,332
Miscellaneous and undistributed[2]	229	432	538	463	1,426
Total[1]	[3]3,760	[3]2,124	[3]10,386	[3]19,249	[4]35,519
1984:					
Chlorine, caustic soda, soda ash	24	226	1,365	18,086	19,701
All other chemicals	306	114	684	100	1,203
Textile and dyeing	77	W	47	W	135
Meatpackers, tanners, casing manufacturers	173	46	318	--	537
Dairy	91	4	8	--	102
Canning	125	W	78	W	242
Baking	113	3	8	--	124
Flour processors (including cereal)	54	1	24	--	79
Other food processing	130	14	43	--	188
Feed dealers	371	161	391	--	923
Feed mixers	174	127	288	--	590
Metals	32	W	259	W	309
Rubber	W	W	5	32	41
Oil	86	273	74	427	860
Paper and pulp	W	170	117	W	307
Water softener manufacturers and service companies	266	293	321	11	892
Grocery stores	618	88	152	--	859
Highway use	W	482	7,121	W	7,610
U.S. Government	89	W	754	W	1,131
Distributors (brokers, wholesalers, etc.)	643	W	737	W	1,466
Miscellaneous and undistributed[2]	238	518	768	1,029	2,078
Total[1]	[3]3,609	[3]2,520	[3]13,562	[3]19,685	[4]39,376

W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and undistributed" and in total by use.

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

[2]Includes some exports and consumption in overseas areas administered by the United States and items indicated by symbol W.

[3]Differs from totals shown in tables 2, 4, and 5 because of changes in inventory and/or incomplete data reporting.

[4]Differs from totals shown in tables 1, 2, and 3 because of changes in inventory and/or incomplete data reporting.

NOTE: Additional imported salt distributed by end use shown in table 14.

Table 8.—Distribution (shipments) of evaporated and rock salt[1] in the United States, by destination

(Thousand short tons)

Destination	1983 Evaporated: Vacuum pans and open pans	1983 Evaporated: Solar	1983 Rock	1984 Evaporated: Vacuum pans and open pans	1984 Evaporated: Solar	1984 Rock
Alabama	50	W	612	49	W	705
Alaska	W	10	--	W	W	--
Arizona	11	52	4	5	46	W
Arkansas	30	--	52	29	W	81
California	144	794	W	136	795	7
Colorado	23	100	47	18	124	70
Connecticut	12	20	125	11	23	W
Delaware	3	129	2	3	177	W
District of Columbia	W	W	W	1	4	W
Florida	76	49	39	77	55	37
Georgia	59	W	86	64	W	85
Hawaii	W	W	W	W	W	W
Idaho	5	58	W	5	75	W
Illinois	379	25	1,018	351	51	1,595
Indiana	157	20	383	152	22	856
Iowa	182	39	381	167	43	341
Kansas	106	8	265	95	W	260
Kentucky	39	1	262	35	W	428
Louisiana	51	W	344	56	W	365
Maine	7	1	137	7	12	219
Maryland	43	107	71	43	229	142
Massachusetts	38	75	W	35	74	442
Michigan	224	12	799	221	W	1,371
Minnesota	146	73	333	148	95	439
Mississippi	22	W	102	23	W	125
Missouri	108	8	305	103	17	434
Montana	W	46	W	W	39	W
Nebraska	97	34	120	89	27	115
Nevada	W	W	W	W	167	W
New Hampshire	2	W	W	2	W	W
New Jersey	124	111	209	124	131	291
New Mexico	7	96	5	8	124	2
New York	246	59	1,654	242	63	2,304
North Carolina	134	91	100	123	78	86
North Dakota	49	26	6	45	37	3
Ohio	314	11	1,031	309	11	1,760
Oklahoma	72	W	66	55	9	72
Oregon	11	43	W	10	33	W
Pennsylvania	163	88	664	162	100	1,190
Rhode Island	5	43	W	5	43	39
South Carolina	35	11	16	34	W	14
South Dakota	45	25	35	42	34	42
Tennessee	63	W	518	63	W	547
Texas	156	76	236	154	76	265
Utah	6	175	W	4	368	W
Vermont	6	1	145	5	1	204
Virginia	66	61	106	62	103	105
Washington	17	414	W	18	517	W
West Virginia	15	W	65	16	W	138
Wisconsin	210	28	521	215	35	917
Wyoming	2	30	W	W	33	W
Other[2]	25	317	1,150	50	234	700
Total[3]	3,780	3,366	12,012	3,672	4,105	16,796

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Each salt type includes domestic and imported quantities.
[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 not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Apparent consumption of all forms of salt increased more than 13% or nearly 5.9 million tons compared with that of 1983. The major areas of increased consumption were by State and municipal governments for highway deicing and by producers of chlorine, caustic soda, and synthetic soda ash.

The general improvement in the domestic economy and especially in the construction industry resulted in the increase in demand for chloralkalis. Production of chlorine gas, sodium hydroxide, and metallic sodium, as reported by the Bureau of the Census, was as follows, in thousand short tons:

	1983	1984
Chlorine gas (100%)	9,960	10,724
Sodium hydroxide, liquid (100%)	10,230	11,224
Sodium, metallic	84	92

The voluntary sodium labeling campaign conducted by the food-processing industry since 1981 continued, as more sodium-modified foods were introduced to the market. The voluntary campaign was a successful attempt to prevent the proposal of new labeling regulations by the Food and Drug Administration in response to public concern that sodium ingestion, primarily in the form of salt, or sodium chloride, caused hypertension. Results by researchers at the Oregon Health Sciences University using a U.S. Government data base, however, suggested that diets with reduced levels of calcium and potassium were the primary indicators of hypertension. Study results also indicated that reduced consumption of dairy products and diets low in sodium were associated with higher blood pressure.[2]

STOCKS

Total yearend salt stocks reported by producers increased from 2.4 million tons in 1983 to 2.7 million tons. Most stocks were rock salt and solar salt. An unknown, but significant, quantity of salt for road and highway deicing was held by States, municipalities, distributors, and road deicing contractors at yearend 1984.

PRICES

The average values of different classes of salt, f.o.b. works, based on actual sales as reported by producers, were as follows, per short ton:

	1983	1984
Evaporated:		
Open pan or grainer and vacuum pan	$87.39	$92.62
Solar	21.47	19.67
Pressed blocks, all sources	71.52	63.82
Rock salt, bulk	13.43	13.78
Salt in brine	5.22	5.05

The following yearend salt prices were quoted in Chemical Marketing reporter:[3]

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

Price 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 guide to yearend price levels.

FOREIGN TRADE

The quantity of salt exported increased significantly, but did not return to the levels of 1981 and 1982. The bulk of the exports went to Canada with the balance distributed among 50 other countries.

Salt imports for consumption continued to increase despite the increase in U.S. production. The majority of imports were either bulk rock salt or solar salt. The Bahamas, Canada, and Mexico supplied more than 75% of the salt imports. Imports of vacuum pan salt in bags, sacks, barrels, or other packages continued to represent a small percentage of the total.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and the Virgin Islands

Area	1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Puerto Rico	30,000	$4,100	18,000	$2,300
Virgin Islands	1	1	1	1

Table 10.—U.S. exports of salt, by country

(Thousand short tons and thousand dollars)

Country	1983		1984	
	Quantity	Value	Quantity	Value
Australia	1	20	(1)	25
Bahamas	2	170	2	235
Canada	475	7,398	792	11,534
Costa Rica	(1)	10	(1)	27
Denmark	(1)	61	3	46
Honduras	(1)	178	(1)	21
Hong Kong	(1)	2	(1)	3
Iraq	2	394	--	--
Malaysia	(1)	2	(1)	1
Mexico	9	329	7	382
Netherlands Antilles	1	107	1	98
Saudi Arabia	14	2,806	10	1,970
South Africa, Republic of	(1)	1	(1)	1
Trinidad and Tobago	(1)	66	(1)	66
United Arab Emirates	(1)	39	(1)	49
United Kingdom	1	36	1	152
Venezuela	1	11	(1)	10
Other	11	738	4	679
Total	517	12,368	820	15,299

[1]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 salt

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels, or other packages (dutiable)		Bulk (dutiable)	
	Quantity	Value	Quantity	Value
1981	27	1,483	[1]4,292	[1]43,040
1982	47	1,613	[2]5,404	[2]54,571
1983	30	1,826	[3]5,967	[3]58,368
1984	71	2,386	[4]7,474	[4]71,714

[1]Includes salt brine from Canada through Portland, ME, and Detroit customs districts, 25 short tons ($372) and 710 short tons ($11,452), respectively; from Denmark through Cleveland customs district, 72 short tons ($1,437); from the United Kingdom through Boston customs district, 500 pounds ($791); and from France through Los Angeles customs district, 2,012 short tons ($40,234).

[2]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).

[3]Includes salt brine from Canada through Buffalo customs district, 400 pounds ($610); from Mexico through Laredo customs district, 18 short tons ($1,126); from Denmark through Cleveland customs district, 100 pounds ($269); from the United Kingdom through Baltimore customs district, 100 pounds ($1,209); from Ireland through New York customs district, 15 short tons ($300); and from Japan through Seattle customs district, 1,300 pounds ($392).

[4]Includes salt brine from Iceland, the United Kingdom and Hong Kong through New York customs district, 500 pounds ($940); from Norway and the Federal Republic of Germany, through Chicago customs district, 110 short tons ($3,299); from Denmark through Detroit customs district, 2,345 short tons ($187,238); and from Japan through Charleston customs district, 110 short tons ($527).

Source: Bureau of the Census as adjusted by the Bureau of Mines.

Table 12.—U.S. imports for consumption of salt, by country

(Thousand short tons and thousand dollars)

Country	1983		1984	
	Quantity	Value	Quantity	Value
Bahamas	933	8,854	902	9,163
Brazil	133	1,247	304	2,567
Canada[1]	2,161	20,915	3,279	27,511
Chile	341	2,772	479	4,089
France[2]	133	987	114	896
Germany, Federal Republic of[3]	1	49	1	70
Italy[4]	32	610	--	--
Mexico[5]	1,669	18,520	1,519	22,794
Netherlands	114	1,956	236	2,535
Netherlands Antilles	184	1,750	275	2,527
Spain[6]	261	1,984	418	1,503
Other	35	549	16	444
Total[7]	5,997	60,194	7,545	74,100

[1]In 1983, includes salt in sacks, bags, and barrels through eight customs districts, 26,413 short tons ($1,529,809); and salt in brine through one customs district, 400 pounds ($610).

[2]Includes salt in sacks, bags, and barrels through six customs districts, 612 short tons ($18,801) in 1983; and four customs districts, 567 short tons ($13,263) in 1984.

[3]Includes salt in sacks, bags, and barrels through four customs districts, 609 short tons ($48,736) in 1983.

[4]Includes salt in sacks, bags, and barrels through two customs district, 111 short tons ($4,674) in 1983.

[5]Includes salt in sacks, bags, and barrels through four customs districts, 190 short tons ($17,072); and salt in brine, 18 short tons ($1,126) in 1983; and three customs districts, 29,218 short tons ($306,502) in 1984.

[6]Includes salt in sacks, bags, and barrels through one customs district, 1,500 pounds ($1,318) in 1983; one customs district, 5,800 pounds ($3,933) in 1984.

[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 13.—U.S. imports for consumption of salt, by customs district

(Thousand short tons and thousand dollars)

Customs district	1983		1984	
	Quantity	Value	Quantity	Value
Anchorage, AK	1	103	(1)	36
Baltimore, MD	237	1,903	573	2,587
Boston, MA	128	707	167	1,167
Buffalo, NY	50	599	66	552
Chicago, IL	258	2,374	787	5,938
Cleveland, OH	112	1,011	25	298
Detroit, MI	645	6,434	921	9,219
Duluth, MN	147	1,364	155	1,433
Los Angeles, CA	227	3,075	121	2,173
Milwaukee, WI	565	5,103	616	4,386
New Orleans, LA	248	1,576	237	1,865
New York, NY	462	5,006	645	6,760
Norfolk, VA	124	1,152	46	501
Ogdensburg, NY	34	423	24	542
Philadelphia, PA	233	2,434	182	2,567
Portland, ME	428	4,001	571	5,378
Portland, OR	511	6,135	589	7,648
Providence, RI	129	1,220	94	959
St. Albans, VT	43	803	75	841
San Juan, PR	9	139	7	189
Savannah, GA	344	3,364	467	4,559
Seattle, WA	814	7,626	658	6,165
Tampa, FL	46	620	86	902
Wilmington, NC	201	2,987	165	2,779
Other	1	35	268	4,656
Total	5,997	60,194	7,545	74,100

[1]Less than 1/2 unit.

Source: Bureau of the Census as adjusted by the Bureau of Mines.

Table 14.—U.S. imports for consumption of salt, by use as reported by salt producers

(Thousand short tons)

Use	1983	1984
Government (highway use)	1,848	2,875
Chemical industry	290	545
Water-conditioning service companies	88	189
Other	683	951
Total[1] [2]	2,910	4,561

[1]Salt imported by companies not producing salt (distributors, direct consumers, etc.) accounts for the difference between the totals shown in this table and the totals shown in tables 1, 11, 12, and 13.
[2]Data do not add to totals shown because of independent rounding.

WORLD REVIEW

Canada.—Production increased mainly as a result of the expansion in capacity that was realized at Domtar Chemicals Ltd.'s Goderich, Ontario, mine. The company had invested $40 million to expand capacity from 2.2 to 3.5 million tons.

Mexico.—Salt production increased from the depressed levels of 1982-83 because of the strength of the export market. Mexico was one of the world's largest exporters of solar salt supplying significant quantities of salt to Japan, the United States, and Canada.

Fertilizantes Mexicanas S.A. planned to complete construction of a potash fertilizer facility at Cerro Prieto in 1986. In addition to potash, the facility was to have salt capacity of about 135,000 tons per year.

Pakistan.—The Pakistan Mineral Development Corp. announced that it had delineated an additional 30 million tons of high-quality rock salt at its Khewra Mine in Punjab. The Khewra salt mining area in the Salt Range has been a source of salt for centuries dating back to the time of the Moghul Emperors.

Yugoslavia.—Production of rock salt commenced at the Tusanji Mine in Bosnia. Production capacity at the mine was about 10,000 tons per year and would reduce the nation's import requirements.

[1]Physical scientist, Division of Industrial Minerals.

[2]McCarron, D. A., C. D. Morris, H. J. Henry, and J. L. Stanton. Blood Pressure and Nutrient Intake in the United States. Sci., v. 224, June 29, 1984, pp. 1392-1398.

[3]Chemical Marketing Reporter. Current Prices of Chemicals and Related Materials. V. 226, No. 27, Dec. 31, 1984, p. 27.

Table 15.—Salt: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Afghanistan[e]	6	7	11	11	11
Albania[e]	75	75	75	80	80
Algeria	[r] [3]155	141	154	[e]165	165
Angola[e]	55	55	[r]65	[r]60	55
Argentina:					
Rock salt	1	1	1	1	1
Other salt	1,106	1,033	655	746	720
Australia (marine salt and brine salt)	6,245	[r]7,403	5,303	[r] [e]5,510	5,500
Austria:					
Rock salt	1	1	1	1	1
Evaporated salt	452	509	478	396	440
Salt in brine	[r]288	291	236	155	160
Bahamas	754	1,069	899	950	960
Bangladesh[4]	510	304	634	268	[5]741
Benin	([6])	([6])	([6])	([6])	([6])
Brazil:					
Rock salt	877	925	922	[3]1,023	1,050
Marine salt	3,354	3,049	3,183	[3]3,592	3,640
Bulgaria[e]	95	95	95	95	95
Burma[7]	295	298	297	317	[5]309
Canada	7,748	7,981	8,752	9,482	[5]11,347
Chile	486	320	743	788	770
China	19,048	20,194	18,060	[r] [e]17,780	17,600
Colombia:					
Rock salt	[r]383	[r]349	331	293	300
Marine salt	541	440	223	321	330
Costa Rica (marine salt)[e]	44	43	[5]121	120	120
Cuba	144	177	218	222	220
Cyprus	8	10	11	([8])	--
Czechoslovakia	305	343	360	265	265
Denmark[3]	[e]420	439	440	498	500
Dominican Republic[e]	[5]61	70	70	70	70
Egypt	701	748	913	1,012	1,100
El Salvador[e]	[r]2	[r]2	[r]2	[r]2	2
Ethiopia:[4]					
Rock salt[e]	17	17	17	17	17
Marine salt	110	121	[r] [e]121	[r] [e]121	121
France:					
Rock salt	332	328	421	311	320
Brine salt	1,227	1,204	1,181	1,184	1,200
Marine salt	1,405	1,517	1,696	1,494	1,600
Salt in solution	4,867	4,266	4,091	4,673	4,740
German Democratic Republic:					
Rock salt	3,391	3,369	[r] [e]3,370	[r] [e]3,380	3,360
Marine salt	57	62	61	62	60
Germany, Federal Republic of: Marketable:					
Rock salt	7,451	9,223	7,754	6,906	7,700
Marine salt and other salt	5,111	4,601	4,348	4,560	4,600
Ghana[e]	55	55	55	55	55
Greece	133	145	[e]145	[r] [e]147	147
Guatemala	[r]11	15	[e]15	17	17
Honduras[e]	35	35	35	35	35
Iceland	([6])	([6])	([6])	1	1
India:					
Rock salt	5	[e]4	5	5	6
Marine salt	8,823	9,841	7,758	7,725	8,300
Indonesia	761	315	881	683	770
Iran[e] [9]	660	660	770	830	830
Iraq	99	88	[e]90	[r] [e]90	90
Israel	130	146	163	[e]160	160
Italy:					
Rock salt and brine salt	4,406	3,979	3,974	3,807	[5]3,588
Marine salt[e]	1,400	1,060	1,100	1,200	1,100
Japan[10]	1,226	[r]1,105	1,065	1,323	1,300
Jordan[e]	33	33	55	90	90
Kampuchea	[e]33	27	42	[r] [e]45	45

See footnotes at end of table.

Table 15.—Salt: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Kenya:					
Crude	30	30	NA	NA	NA
Refined	22	23	27	92	95
Korea, North[e]	630	630	630	630	630
Korea, Republic of	502	664	952	530	550
Kuwait	23	21	21	[e]22	22
Laos[e]	22	22	[5]10	11	11
Lebanon[e]	13	17	11	6	6
Leeward and Windward Islands[e]	55	55	55	55	55
Libya[e]	11	11	11	[r]13	13
Madagascar[e]	33	33	33	33	33
Mali[e]	5	5	5	[r]5	5
Malta	1	[r](6)	(6)	(6)	(6)
Mauritania[e]	1	--	[5]8	6	6
Mauritius	7	7	[e]7	[e]7	7
Mexico	7,248	8,767	6,130	6,287	6,600
Mongolia[e]	17	17	17	18	18
Morocco	74	52	70	77	77
Mozambique[e]	30	30	30	30	30
Namibia (marine salt)	[e]250	213	203	151	140
Netherlands	3,818	3,944	3,517	3,444	4,000
Netherlands Antilles[e]	440	440	440	[r]220	230
New Zealand	6	61	77	89	95
Nicaragua[e]	22	20	20	20	17
Niger[e]	3	3	[5]3	3	3
Pakistan:[4]					
Rock salt	546	567	589	628	660
Other salt	220	241	247	193	220
Panama[11]	20	[r]35	27	94	100
Peru	504	558	535	[e]540	550
Philippines	382	392	402	421	400
Poland:					
Rock salt	1,614	1,447	1,475	1,247	1,250
Other salt	3,383	3,261	2,776	[r e]2,750	2,750
Portugal:					
Rock salt	442	450	448	467	500
Marine salt[e]	140	130	110	120	110
Romania	5,573	5,548	5,243	5,066	5,000
Senegal[e]	[r]155	[r]155	[4]176	[r]190	190
Sierra Leone[e]	220	220	220	220	220
Somalia[e]	33	33	33	33	33
South Africa, Republic of	625	595	646	801	640
Spain:					
Rock salt	2,623	2,536	2,439	2,214	2,200
Marine salt and other evaporated salt	1,245	1,536	1,187	1,267	1,200
Sri Lanka	126	115	194	142	145
Sudan	88	71	31	[e]80	80
Switzerland	416	475	399	338	330
Syria	[e]100	[e]100	112	96	100
Taiwan	796	387	289	87	[5]241
Tanzania	40	41	41	31	35
Thailand:					
Rock salt	18	12	12	6	[5]11
Other salt[e]	180	180	180	180	180
Togo[e]	1	1	[r](6)	(8)	--
Tunisia	482	515	464	413	440
Turkey	1,299	1,539	1,448	[e]1,540	1,540
Uganda[e]	1	[r]6	[r]6	[r]6	6
U.S.S.R	16,094	16,755	17,416	17,857	18,200
United Kingdom:					
Rock salt	1,925	1,488	2,435	1,451	1,650
Brine salt[12]	1,773	1,603	1,713	1,537	1,540
Other salt[12]	4,189	4,317	4,270	3,969	3,970
United States including Puerto Rico (sold or used by producers):					
Rock salt	11,806	11,871	13,503	9,941	[5]13,348
Other salt:					
United States	28,545	27,036	24,391	24,632	[5]25,877
Puerto Rico[e]	27	8	16	32	30
Venezuela	268	[e]275	375	[r e]398	400
Vietnam[e]	480	445	720	980	880
Yemen (Aden)[e]	90	80	80	80	80
Yemen (Sanaa)[e]	70	60	60	[r]155	160

See footnotes at end of table.

Table 15.—Salt: World production, by country[1] —Continued

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Yugoslavia:					
Rock salt	186	212	219		
Marine salt	24	40	42	468	[5]419
Salt from brine	206	209	211		
Total	[r]186,156	[r]189,198	179,923	175,563	185,132

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

[1]Table includes data available through June 11, 1985.

[2]Salt is produced in many other countries, but quantities are relatively insignificant and reliable production data are not available.

[3]Data represent sales.

[4]Year ending June 30 of that stated.

[5]Reported figure.

[6]Less than 1/2 unit.

[7]Brine salt production as reported by the Burmese Government was as follows, in short tons: 1980—88,958; 1981—92,368; 1982—81,462; 1983—110,000 (estimated); and 1984—110,000 (estimated).

[8]Revised to zero.

[9]Year beginning Mar. 21 of that stated.

[10]Fiscal year ending Mar. 31 of that stated.

[11]Data for 1980 represent refined salt and subsequent years represent crude.

[12]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 Lawrence L. Davis[1] and Valentin V. Tepordei[1]

A total of 774 million short tons of construction sand and gravel valued at $2.2 billion, f.o.b. plant, was produced in the United States in 1984. This tonnage is the highest production reported since 1979, and 20% below the record high production of 1978, but 30% higher than that of 1982, when the last full annual survey was conducted.

Production of industrial sand and gravel in 1984 totaled 29.4 million tons valued at $377 million, f.o.b. plant, an increase of 10% over the total of 1983, and 12% below the record high production of 1979.

Exports of construction sand and gravel in 1984 increased 42% to 1.8 million tons valued at $10.3 million, while imports increased 23% to 151,000 tons valued at $1.6 million. Apparent consumption of construction sand and gravel in 1984 was 771 million tons.

Table 1.—Salient U.S. sand and gravel statistics[1]

(Thousand short tons and thousand dollars)

	1980	1981	1982	1983	1984
Sold or used:					
Construction sand and gravel:					
Quantity	763,100	[e]690,000	594,000	[e]655,100	773,900
Value	$1,996,000	[e]$1,928,000	$1,674,000	[e]$1,935,000	$2,244,000
Industrial:					
Sand:					
Quantity	28,711	29,250	26,350	26,080	28,680
Value	$286,500	$326,300	$316,900	$329,500	$370,370
Gravel:					
Quantity	865	728	1,024	537	705
Value	$6,458	$5,997	$6,846	$5,667	$6,844
Total industrial:[2]					
Quantity	29,600	29,980	27,400	26,620	29,380
Value	$293,100	$332,300	$323,800	$335,200	$377,200
Exports:					
Quantity	2,451	2,397	1,946	2,350	3,038
Value	$40,660	$36,736	$34,397	$32,487	$37,981
Imports for consumption:					
Quantity	541	337	275	181	177
Value	$2,718	$2,608	$4,002	$2,666	$2,529

[e]Estimated.
[1]Puerto Rico excluded from all sand and gravel statistics.
[2]Data may not add to totals shown because of independent rounding.

Exports of industrial sand increased 14% to 1.2 million tons valued at $27.7 million, while imports decreased 55% to 26,000 tons valued at $926,000. Apparent consumption of industrial sand and gravel was 28.2 million tons.

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 7,534 construction sand and gravel operations surveyed, 4,848, or 64%, responded. Their combined production represented 75% of the U.S. total shown in the tables. Of the 191 industrial sand and gravel operations surveyed, 160, or 84%, reported to the Bureau of Mines. Of these, 155 operations were active and 5 idle. Their total production was 27.4 million tons or 93% of the U.S. total industrial sand and gravel produced. The nonrespondents' production was estimated using preliminary production reports, adjusted prior years' production, and/or employment data. Of the reporting operations, 22 did not indicate a breakdown by end uses. Their total production of 1.9 million tons, as well as that of 22 estimated operations, was included in other unspecified uses. In 1984, 14 industrial sand and gravel operations were idle.

Legislation and Government Programs.—In March, the U.S. Congress approved a 6-month Interstate Cost Estimate (ICE) legislation that gives the U.S. Department of Transportation authority to disburse to the States construction funds collected into the Federal Highway Trust Fund. The action was 6 months late and released only one-half of the funds already available in the trust fund. Most of these funds are being used for highway construction and repair work, and therefore their late release impacted to some extent on the demand for construction sand and gravel.

CONSTRUCTION SAND AND GRAVEL

DOMESTIC PRODUCTION

U.S. production of construction sand and gravel increased 30% in 1984 compared with that in 1982. Of the four major geographical areas, the West again led the Nation in production with 277 million tons or 36% of the U.S. total, followed by the North Central with 208 million tons or 27% of the total, and the South with 199 million tons or 26%. Production increased 29% in the Northeast, 19% in the North Central and the South, and 14% in the West.

At the regional level, the Pacific again led the Nation with 170 million tons or 22% of the U.S. total. Next was the East North Central with 128 million tons or 17% of the total, followed by the Mountain with 107 million tons or 14% of the total.

Based on 1980 census data on population, 1984 U.S. per capita construction sand and gravel production was 3.4 tons. On a regional basis, per capita production was 6.4 tons in the West, followed by the North Central with 3.5 tons, the South with 2.6 tons, and the Northeast with 1.8 tons.

Construction sand and gravel was produced in every State, and the 10 leading States were, in descending order of tonnage, California, Texas, Michigan, Ohio, Alaska, Arizona, Colorado, Illinois, New York, and Washington. Their combined production represented 51% of the national total.

Production in 1984, compared with that of 1982, increased in every State except Alaska, Delaware, and Hawaii. The largest increases in the top 10 producing States were 75% in Michigan, 59% in Arizona, 54% in Washington, 51% in Colorado, and 50% in New York. The two States with the largest production, California and Texas, had increases of 26% and 37%, respectively.

A total of 4,331 companies produced construction sand and gravel at 5,929 operations. Operations larger than 200,000 tons per year produced 65% of the total U.S. tonnage while representing only 17% of the total number of operations. The trend toward larger operations with a higher degree of mechanization and automation continued.

The top 10 producers of construction sand and gravel were, in descending order of tonnage, Koppers Co. Inc., Lone Star Industries Inc., CalMat Corp., American Aggregates Corp., Dravo Corp., Texas Industries Inc., Tanner Co., Owl Rock Products Co., General Development Corp., and A. Teichert & Son. Combined production of the 164 operations owned by the top 10 producers was 13% of the national total.

Lone Star sold its sand and gravel facilities at Steilacoom, WA, and at Maury Island, in Puget Sound, to Reidel International Inc., a Portland, OR, firm. The facilities were renamed Pioneer Construction Materials Co. by Reidel.

Conrock Co., the Nation's third largest construction sand and gravel producer in 1982, merged with California Portland Cement Co. in 1984. The new company name is CalMat Corp.

CONSUMPTION AND USES

Sand and gravel production reported by producers to the Bureau of Mines is actually material that is "sold or used" by the companies and is defined as such. Stockpiled production is not reported until it is sold or consumed. Therefore, the sold or used tonnage represents the amount produced for domestic consumption and export.

Of the 774 million tons produced, 25% was used as concrete aggregate (including concrete sand) for buildings, highways, dams, and airports; 14% in road base and coverings; 9% as asphaltic concrete aggregates and other bituminous mixtures; 7% as construction fill; 1% each in concrete products (such as blocks, bricks, pipe, decorative, etc., and in plaster and gunite sands; and the remainder for railroad ballast, snow and ice control, roofing granules, and other unspecified uses.

Most of the sand and gravel for concrete aggregates and concrete products combined was used in the South, 41%, and the West, 31%, regions with high levels of construction activity. Most of the sand and gravel for asphaltic concrete aggregates and road base and coverings combined was used in the West, 42%, and the North Central, 34%.

PRICES

Prices in this chapter are f.o.b. plant, usually the first point of sale or captive use. This value does not include transportation from the plant or yard to the consumer. It does, however, include all costs of mining, processing, and in-plant transportation.

Compared with that of 1982, the 1984 average unit price increased 3% to $2.90 per ton, with the largest increases in concrete products and fill, 12% each; snow and ice control, 10%; plaster and gunite sands, 9%; and concrete aggregates, 8%. Average unit prices for railroad ballast and road base and coverings decreased slightly.

TRANSPORTATION

Eighty-nine percent of the construction sand and gravel produced was transported from the plant to the consumer by truck, 8% was used at the plant site, and the remainder was shipped by rail or waterway. Because most producers either did not keep records or did not report shipping distances or cost per ton per mile, no transportation cost data were available.

FOREIGN TRADE

Exports.—Exports of construction sand increased 30% to 1.2 million tons. Canada was the major destination, receiving 83% of the total, while Mexico received 15%. Exports of construction gravel increased 72% to 635,000 tons, 97% of which went to Canada.

Imports.—Imports of construction sand and gravel increased 23% to 151,000 tons, 80% of which came from Canada.

TECHNOLOGY

An optical system that measures particle size distribution of material on a moving conveyor belt was tested by Flatiron Sand and Gravel Co. As a result of the tests, the company was planning to install the system at its Arapahoe plant near Boulder, CO. The system allows the amount of sand and gravel entering the circuit on the plant feed conveyor to be regulated quickly and automatically.[2]

Table 2.—Construction sand and gravel sold or used in the United States, by geographic region

Geographic region	1983				1984			
	Quantity[e] (thousand short tons)	Percent of total	Value[e] (thousands)	Percent of total	Quantity (thousand short tons)	Percent of total	Value (thousands)	Percent of total
Northeast:								
New England	28,200	4	$86,900	4	39,694	5	$113,590	5
Middle Atlantic	41,300	6	140,500	7	49,985	6	177,028	8
North Central:								
East North Central	99,900	15	262,000	14	127,643	17	336,715	15
West North Central	75,500	12	181,600	9	80,307	10	183,146	8
South:								
South Atlantic	49,400	8	148,000	8	63,609	8	187,397	8
East South Central	31,200	5	89,800	5	36,697	5	99,225	4
West South Central	87,100	13	291,500	15	98,748	13	304,493	14
West:								
Mountain	79,100	12	240,600	12	107,332	14	314,833	14
Pacific	163,440	25	494,200	26	169,861	22	527,528	24
Total[1]	655,100	100	1,935,000	100	773,900	100	2,244,000	100

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

Krebs Engineers introduced a wet sizing machine, the C-H Whirl Sizer, that reportedly gives a sharper size separation than do conventional hydrosizers. The machine uses a gentle swirl action that provides time to separate particles close to the cut size.[3]

Concrete recycling continued to increase according to an article that reviewed recycling activity.[4] Aggregate produced from recycled concrete is a suitable substitute for virgin sand and gravel for many construction uses and is economically advantageous in areas lacking nearby resources and in urban areas where rubble disposal is expensive. Widespread use of recycled concrete in the future would reduce demand for virgin materials.

A Michigan producer installed an airlift dredge, the first of its type in North America, and realized increased productivity and reduced power consumption compared with the ladderhead dredge previously used.[5]

The National Sand and Gravel Association, the American Society of Landscape Architects, and the National Stone Association cosponsored the Ninth Annual Landscape Architecture Student Competition. First place in the sand and gravel category was awarded to students from Kansas State University for their beautification and reclamation plan for Martin Marietta Corp.'s Kentucky Avenue Mine in Indianapolis.[6]

Table 3.—Construction sand and gravel sold or used in the United States, by State

(Thousand short tons and thousand dollars)

State	1983[e]		1984	
	Quantity	Value	Quantity	Value
Alabama	8,600	23,500	10,348	26,188
Alaska	45,200	97,200	30,861	66,883
Arizona	23,200	75,000	30,439	101,959
Arkansas	6,900	19,600	8,334	23,786
California	91,000	308,700	102,420	360,427
Colorado	21,200	81,600	28,024	87,324
Connecticut	5,000	17,900	6,718	22,817
Delaware	1,400	3,200	1,003	2,795
Florida	14,900	31,500	21,032	48,494
Georgia	3,800	9,400	5,347	13,623
Hawaii	440	1,000	436	2,031
Idaho	3,000	9,800	4,725	13,509
Illinois	21,100	58,400	25,969	72,477
Indiana	14,400	37,900	16,071	44,744
Iowa	11,800	32,800	13,882	37,027
Kansas	12,400	26,600	11,796	26,358
Kentucky	5,500	13,000	7,839	18,252
Louisiana	14,200	46,600	17,040	54,664
Maine	4,800	12,100	7,885	19,228
Maryland	10,600	37,800	14,234	46,671
Massachusetts	10,400	36,200	14,168	42,139
Michigan	23,000	52,300	36,071	76,540
Minnesota	24,600	53,000	22,612	49,087
Mississippi	11,000	34,600	12,205	34,955
Missouri	7,700	17,700	7,967	19,364
Montana	5,000	10,200	7,776	21,269
Nebraska	10,100	25,000	11,839	27,791
Nevada	7,500	16,200	8,202	20,505
New Hampshire	4,000	12,100	5,637	16,054
New Jersey	10,800	34,300	9,545	31,878
New Mexico	7,000	20,000	8,363	22,389
New York	18,700	54,200	25,968	80,866
North Carolina	5,600	16,900	6,312	18,159
North Dakota	3,800	15,000	6,426	11,351
Ohio	27,200	84,600	31,748	104,709
Oklahoma	7,500	17,300	10,984	26,582
Oregon	11,000	37,000	12,776	37,117
Pennsylvania	11,800	52,000	14,472	64,285
Rhode Island	1,000	2,400	1,483	5,282
South Carolina	5,200	15,000	5,845	17,097
South Dakota	5,100	11,500	5,786	12,168
Tennessee	6,100	18,700	6,304	19,830
Texas	58,500	208,000	62,389	199,461
Utah	9,800	19,800	15,217	34,507
Vermont	3,000	6,200	3,802	8,071
Virginia	7,200	30,800	8,860	37,359
Washington	15,800	50,300	23,369	61,070
West Virginia	700	3,400	976	3,198
Wisconsin	14,200	28,800	17,785	38,245
Wyoming	2,400	8,000	4,586	13,372
Total[1]	655,100	1,935,000	773,900	2,244,000

[e]Estimated.

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

Table 4.—Construction sand and gravel production in the United States in 1984, by size of operation

Size range	Number of operations	Percent of total	Quantity (thousand short tons)	Percent of total
Less than 25,000	1,933	32.6	20,077	2.6
25,000 to 49,999	912	15.4	33,137	4.3
50,000 to 99,999	1,129	19.0	80,267	10.4
100,000 to 199,999	963	16.2	134,622	17.4
200,000 to 299,999	390	6.6	93,689	12.1
300,000 to 399,999	183	3.1	62,409	8.1
400,000 to 499,999	110	1.9	48,917	6.3
500,000 to 599,999	82	1.4	44,421	5.7
600,000 to 699,999	54	.9	34,555	4.5
700,000 to 799,999	44	.7	32,674	4.2
800,000 to 899,999	30	.5	25,319	3.3
900,000 to 999,999	27	.5	25,456	3.3
1,000,000 to 1,499,999	43	.7	52,201	6.7
1,500,000 to 1,999,999	14	.2	23,351	3.0
2,000,000 to 2,499,999	7	.1	14,857	1.9
2,500,000 and over	8	.2	47,923	6.2
Total	5,929	100.0	[1]773,900	100.0

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

Table 5.—Number of construction sand and gravel active operations[1] and processing plants in the United States in 1984, 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	121	278	9	61	4	473
Middle Atlantic	338	180	15	95	17	645
North Central:						
East North Central	337	479	55	124	65	1,060
West North Central	185	660	24	84	174	1,127
South:						
South Atlantic	143	58	4	109	86	400
East South Central	81	87	5	20	69	262
West South Central	196	151	12	63	82	504
West:						
Mountain	237	520	35	52	17	861
Pacific	278	219	26	53	21	597
Total	1,916	2,632	185	661	535	5,929

[1]An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.

Table 6.—Construction sand and gravel sold or used in the United States in 1984, by major use

Use	Quantity (thousand short tons)	Value (thousands)	Value per ton
Concrete aggregate (including concrete sand)	196,914	$678,617	$3.45
Plaster and gunite sands	8,688	33,487	3.85
Concrete products (blocks, bricks, pipe, decorative, etc.)	10,950	40,066	3.66
Asphaltic concrete aggregates and other bituminous mixtures	68,632	218,758	3.19
Road base and coverings	111,604	287,521	2.58
Road stabilization (cement)	1,412	3,282	2.32
Road stabilization (lime)	1,291	2,445	1.89
Fill	51,554	104,619	2.03
Snow and ice control	5,620	14,317	2.55
Railroad ballast	1,299	4,044	3.11
Roofing granules	400	1,833	4.58
Other	8,988	28,246	3.14
Unspecified	306,524	826,721	2.70
Total[1] or average	773,900	2,244,000	2.90

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

Table 7.—Construction sand and gravel sold or used in

(Thousand short tons

Geographic region	Concrete aggregate (including concrete sand)		Plaster and gunite sands		Concrete products, (blocks, bricks, pipe, decorative, etc.)		Asphaltic concrete aggregates and other bituminous mixtures	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Northeast:								
New England	6,196	24,469	130	614	578	1,900	2,682	8,473
Middle Atlantic	11,863	49,791	782	3,335	1,012	3,839	4,694	19,512
North Central:								
East North Central	22,096	66,474	663	2,044	1,745	5,007	13,790	38,164
West North Central	12,644	38,379	433	1,412	934	2,603	6,383	14,200
South:								
South Atlantic	28,328	85,916	1,288	3,417	3,604	15,483	5,519	17,672
East South Central	11,438	33,460	195	794	502	1,630	3,334	11,667
West South Central	41,729	152,406	1,002	3,632	480	1,659	2,968	10,805
West:								
Mountain	21,763	80,196	973	4,990	822	3,194	13,626	40,704
Pacific	40,857	147,527	3,221	13,248	1,272	4,750	15,638	57,561
Total[2]	196,914	678,617	8,688	33,487	10,950	40,066	68,632	218,758

W Withheld to avoid disclosing company proprietary data; included in "Total."
[1]Includes road and other stablization (cement and lime).
[2]Data may not add to totals shown because of independent rounding.

the United States in 1984, by geographic region and major use

and thousand dollars)

Road base and coverings[1]		Fill		Snow and ice control		Railroad ballast		Other uses		Total[2]	
Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
6,488	14,552	3,421	6,981	1,422	3,642	35	164	18,742	52,796	39,694	113,590
5,731	17,039	3,037	7,451	1,607	4,406	--	--	21,260	71,654	49,985	177,028
24,202	58,151	9,719	18,627	994	2,128	62	290	54,373	145,830	127,643	336,715
17,941	33,704	4,166	7,149	551	1,389	257	694	36,998	83,615	80,307	183,146
4,032	11,265	5,633	10,240	W	W	--	--	W	W	63,609	187,397
4,486	10,143	416	596	W	W	--	--	W	W	36,697	99,225
4,635	13,180	6,205	10,034	--	--	--	--	41,729	112,776	98,748	304,493
24,751	64,164	7,183	13,341	450	1,365	222	418	37,542	106,461	107,332	314,833
22,043	71,047	11,774	30,200	536	1,240	722	2,478	73,797	199,477	169,861	527,528
114,307	293,247	51,554	104,619	5,620	14,317	1,299	4,044	315,912	856,800	773,900	2,244,000

Table 8.—Construction sand and gravel sold or used in

(Thousand short tons

State	Concrete aggregate (including concrete sand)		Plaster and gunite sands		Concrete products, (blocks, bricks, pipe, decorative, etc.)		Asphaltic concrete aggregates and other bituminous mixtures	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	4,447	12,362	W	W	232	697	585	1,279
Alaska	169	928	7	55	--	--	375	1,717
Arizona	6,090	22,507	643	3,613	467	1,649	3,179	11,737
Arkansas	4,215	13,743	126	301	W	W	164	384
California	33,872	126,088	2,879	12,442	1,018	3,823	11,881	44,470
Colorado	7,148	30,913	45	277	56	220	3,053	8,159
Connecticut	731	3,082	12	82	29	104	332	1,150
Delaware	W	W	W	W	--	--	--	--
Florida	12,159	30,389	277	1,056	W	W	904	1,844
Georgia	3,094	8,415	262	669	137	367	55	118
Hawaii	W	W	--	--	--	--	W	W
Idaho	991	3,599	28	152	W	W	478	1,597
Illinois	3,546	9,931	206	594	354	956	3,345	11,684
Indiana	2,988	9,135	77	384	467	1,506	1,188	4,039
Iowa	2,410	7,948	W	W	73	257	571	1,303
Kansas	2,680	6,424	W	W	100	330	1,139	2,546
Kentucky	2,514	5,642	--	--	W	W	539	1,459
Louisiana	8,632	34,289	W	W	W	W	390	1,756
Maine	552	2,112	W	W	W	W	607	2,350
Maryland	4,446	13,942	36	115	959	2,879	1,734	5,845
Massachusetts	3,401	13,705	W	W	133	566	739	2,558
Michigan	6,417	20,548	172	463	334	809	4,801	8,589
Minnesota	3,529	10,807	136	526	510	1,369	3,582	7,292
Mississippi	3,334	11,840	4	12	53	178	1,186	3,623
Missouri	2,258	7,635	71	223	127	364	311	770
Montana	571	2,183	W	W	W	W	1,936	6,517
Nebraska	1,115	2,935	88	190	122	282	390	1,279
Nevada	1,378	3,951	43	138	249	1,183	1,375	2,774
New Hampshire	942	3,543	W	W	W	W	523	1,336
New Jersey	3,774	13,721	274	1,008	222	791	1,559	6,144
New Mexico	1,915	6,344	101	248	1	2	1,362	2,765
New York	3,849	15,041	150	586	468	1,362	1,692	6,372
North Carolina	1,941	6,235	326	584	185	669	1,069	3,668
North Dakota	95	325	--	--	--	--	16	31
Ohio	5,651	17,810	159	509	410	1,286	3,149	10,903
Oklahoma	3,415	10,146	263	537	16	42	443	828
Oregon	1,738	5,773	W	W	W	W	950	3,133
Pennsylvania	4,240	21,029	358	1,741	322	1,687	1,443	6,997
Rhode Island	232	713	W	W	--	--	W	W
South Carolina	2,897	8,732	290	531	707	2,353	1,168	4,137
South Dakota	557	2,305	W	W	W	W	374	979
Tennessee	1,143	3,616	185	763	209	719	1,024	5,307
Texas	25,467	94,228	564	2,673	218	1,016	1,971	7,837
Utah	2,881	7,359	70	177	27	80	1,546	4,976
Vermont	338	1,314	([3])	W	W	W	330	616
Virginia	3,035	15,682	W	W	1,483	8,944	423	1,501
Washington	5,059	14,563	329	696	144	499	2,226	7,012
West Virginia	744	2,447	--	--	--	--	165	560
Wisconsin	3,494	9,050	50	95	179	451	1,307	2,948
Wyoming	790	3,340	39	376	W	W	697	2,178
Total[2]	196,884	678,369	8,270	31,816	10,011	37,440	68,276	217,067
Undistributed	33	250	418	1,674	937	2,630	356	1,691
U.S. total[2]	196,914	678,617	8,688	33,487	10,950	40,066	68,632	218,758

W Withheld to avoid disclosing company proprietary data, included by State with "Other and undistributed uses" column, and by use in "Undistributed" line. XX Not applicable.

[1]Includes road and other stabilization (cement and lime).

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

[3]Less than 1/2 unit.

the United States in 1984, by State and major use

and thousand dollars)

Road base and coverings[1]		Fill		Snow and ice control		Railroad ballast		Other and undistributed uses		Total[2]	
Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1,558	3,559	227	267	W	W	--	--	3,301	8,024	10,348	26,188
418	1,670	1,611	5,351	W	W	W	W	28,278	57,161	30,861	66,883
5,241	14,557	2,598	5,921	38	180	--	--	12,182	41,796	30,439	101,959
678	1,189	W	W	--	--	--	--	3,151	8,170	8,334	23,786
15,758	52,440	6,318	17,932	200	334	83	331	30,410	102,569	102,420	360,427
7,037	18,523	1,613	2,613	199	687	53	162	8,820	25,770	28,024	87,324
493	1,769	543	1,393	325	1,001	2	4	4,251	14,233	6,718	22,817
W	W	W	W	--	--	--	--	1,003	2,795	1,003	2,795
W	W	2,348	2,912	--	--	--	--	5,343	12,293	21,032	48,494
56	71	331	478	--	--	--	--	1,413	3,506	5,347	13,623
W	W	--	--	--	--	--	--	437	2,031	436	2,031
2,157	5,180	236	510	W	W	--	--	834	2,471	4,725	13,509
4,023	11,359	2,800	5,805	W	W	W	W	11,694	32,148	25,969	72,477
1,079	3,188	1,131	2,446	208	566	9	46	8,925	23,434	16,071	44,744
3,958	7,593	725	1,488	98	310	W	W	6,046	18,128	13,882	37,027
2,510	4,534	1,106	1,687	122	345	W	W	4,139	10,492	11,796	26,358
214	654	W	W	--	--	--	--	4,571	10,497	7,839	18,252
505	1,533	583	692	--	--	--	--	6,930	16,395	17,040	54,664
2,580	4,446	637	1,422	357	836	([3])	W	3,152	8,062	7,885	19,228
2,100	4,590	1,696	4,761	10	40	--	--	3,252	14,498	14,234	46,671
1,769	4,205	1,748	3,359	434	1,134	W	W	5,944	16,611	14,168	42,139
11,940	26,122	1,362	2,261	368	540	32	109	10,646	17,099	36,071	76,540
4,975	8,982	1,752	2,976	248	522	44	163	7,835	16,451	22,612	49,087
1,166	2,652	76	87	--	--	--	--	6,387	16,563	12,205	34,955
235	543	56	171	34	90	--	--	4,875	9,569	7,967	19,364
1,939	4,940	452	803	65	99	43	131	2,770	6,597	7,776	21,269
2,454	6,277	259	454	22	64	--	--	7,388	16,311	11,839	27,791
1,550	3,618	291	755	78	229	--	--	3,239	7,858	8,202	20,505
893	2,740	171	357	87	196	--	--	3,020	7,881	5,637	16,054
337	1,004	409	1,187	71	298	--	--	2,900	7,726	9,545	31,878
2,785	7,318	425	738	--	--	--	--	1,775	4,974	8,363	22,389
3,921	10,195	2,088	4,220	1,321	3,217	([3])	([3])	12,479	39,872	25,968	80,866
851	2,297	W	W	W	W	--	--	1,939	4,707	6,312	18,159
1,175	1,594	67	145	6	21	195	489	4,872	8,746	6,426	11,351
2,581	8,669	3,299	6,341	156	475	--	--	16,344	58,715	31,748	104,709
449	1,009	1,589	2,546	--	--	--	--	4,808	11,475	10,984	26,582
2,354	7,319	503	1,099	40	121	--	--	7,191	19,673	12,776	37,117
1,473	5,839	539	2,044	215	891	--	--	5,881	24,057	14,472	64,285
58	316	74	118	101	227	--	--	1,018	3,908	1,483	5,282
--	--	418	526	--	--	--	--	365	817	5,845	17,097
2,634	4,182	200	227	21	37	3	3	1,998	4,434	5,786	12,168
1,548	3,278	24	51	--	--	--	--	2,172	6,096	6,304	19,830
3,002	9,449	3,831	6,424	--	--	--	--	27,337	77,832	62,389	199,461
2,888	6,809	1,431	1,759	37	58	--	--	6,337	13,289	15,217	34,507
694	1,075	248	332	117	248	W	W	2,075	4,485	3,802	8,071
723	3,556	327	664	W	W	--	--	2,868	7,013	8,860	37,359
3,499	9,568	3,341	5,819	233	501	634	2,125	7,905	20,288	23,369	61,070
30	83	W	W	W	W	--	--	37	110	976	3,198
4,580	8,812	1,128	1,774	177	351	17	122	6,853	14,642	17,785	38,245
1,154	3,221	138	242	10	25	W	W	1,758	3,991	4,586	13,372
114,022	292,527	50,749	103,157	5,398	13,643	1,115	3,685	319,147	866,263	773,900	2,244,000
285	720	804	1,462	221	676	181	360	XX	XX	XX	XX
114,307	293,247	51,554	104,619	5,620	14,317	1,299	4,044	XX	XX	773,900	2,244,000

Table 9.—Number of construction sand and gravel active operations[1] and processing plants in the United States in 1984, by State

State	Mining operations on land				Dredging operations	Total active operations
	Stationary	Portable	Stationary and portable	No plants or unspecified		
Alabama	22	16	2	10	33	83
Alaska	9	19	2	3	1	34
Arizona	48	71	7	7	1	134
Arkansas	23	24	1	12	8	68
California	154	94	15	11	12	286
Colorado	35	148	13	14	9	219
Connecticut	19	47	2	5	1	74
Delaware	2	4	--	2	1	9
Florida	2	16	--	3	23	44
Georgia	8	1	1	9	31	50
Hawaii	1	3	--	1	--	5
Idaho	25	34	1	7	2	69
Illinois	34	35	16	67	19	171
Indiana	42	66	5	7	12	132
Iowa	45	69	10	28	22	174
Kansas	17	50	3	21	65	156
Kentucky	8	4	1	--	14	27
Louisiana	15	41	--	8	31	95
Maine	17	96	2	24	3	142
Maryland	20	19	2	38	4	83
Massachusetts	47	65	2	11	--	125
Michigan	55	204	14	17	15	305
Minnesota	43	213	3	11	3	273
Mississippi	21	59	1	7	10	98
Missouri	8	58	--	1	24	91
Montana	19	73	1	6	--	99
Nebraska	13	112	2	5	59	191
Nevada	12	43	2	4	1	62
New Hampshire	11	33	2	--	--	46
New Jersey	20	34	2	7	5	68
New Mexico	28	72	3	2	2	107
New York	233	120	10	77	6	446
North Carolina	60	1	--	34	12	107
North Dakota	8	104	2	--	--	114
Ohio	161	30	5	17	19	232
Oklahoma	64	7	2	23	27	123
Oregon	67	18	1	7	4	97
Pennsylvania	85	26	3	11	6	131
Rhode Island	12	2	--	--	--	14
South Carolina	19	5	--	12	8	44
South Dakota	51	54	4	18	1	128
Tennessee	30	8	1	3	12	54
Texas	94	79	9	20	16	218
Utah	33	52	7	8	--	100
Vermont	15	35	1	21	--	72
Virginia	31	12	--	11	5	59
Washington	47	85	8	31	4	175
West Virginia	1	--	1	--	2	4
Wisconsin	45	144	15	16	--	220
Wyoming	37	27	1	4	2	71
Total	1,916	2,632	185	661	535	5,929

[1]An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.

Table 10.—Transportation of construction sand and gravel in the United States in 1984 to site of first sale or use

Method of shipment	(Quantity (thousand short tons)	Percent of total
Truck	688,739	89.0
Rail	3,997	.5
Waterway	16,800	2.2
Not shipped, used at site	60,477	7.8
Unspecified	3,863	.5
Total	[1]773,900	100.0

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

Table 11.—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]
1983				
Bahamas	(2)	10	21	114
Canada	712	2,234	328	1,225
Mexico	162	461	(2)	[r]8
Other	[r]60	[r]1,915	20	[r]463
Total	934	4,620	369	1,810
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

[r]Revised.
[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.

Table 12.—U.S. imports for consumption of construction sand and gravel, by country

(Thousand short tons and thousand dollars)

Country	1983		1984	
	Quantity	C.i.f. value[1]	Quantity	C.i.f. value[1]
Bahamas	9	32	14	110
Canada	104	652	121	1,100
Other	10	363	16	393
Total	123	1,047	151	1,603

[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.

INDUSTRIAL SAND AND GRAVEL

DOMESTIC PRODUCTION

The total output of industrial sand and gravel increased 10% to 29.4 million tons. The North Central region continued to lead the Nation with 41% of the U.S. total, followed by the South with 35%, the Northeast and West with 12% each. Compared with that of 1983, the output of industrial sand and gravel increased 19% in the South, 8% in the North Central, 7% in the Northeast, and 2% in the West.

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, the West with 0.08 ton, and the Northeast with 0.07 ton.

The five leading States in the production of industrial sand and gravel in 1984 were, in descending order of volume, Illinois, Michigan, New Jersey, California, and Texas. Their combined production represented 49% of the national total. Production increased significantly in New Jersey, 14%, and Texas, 13%, and decreased 4% in Michigan.

In 1984, 105 producers of industrial sand and gravel with 177 active operations were canvassed by the Bureau of Mines. About 75% of the industrial sand and gravel produced came from 52 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., Ottawa Silica Co., Jesse S. Morie & Son Inc., Manley Bros. of Indiana Inc., Owens-Illinois Inc., Oglebay Norton Co., Standard Sand & Silica Co., Wedron Silica Co., and Construction Aggregates Corp. Their combined production, from 55 operations, represented 66% of the U.S. total.

Effective August 1, Martin Marietta agreed to lease, with option to purchase, its last industrial sand operation in Wedron, IL, to Wedron Silica, a new corporation formed by a group of Martin Marietta employees and Best Sand Corp. of Chardon, OH. This totally removed Martin Marietta from the industrial sand business. The Wedron operation produces mostly glass sand, foundry sand, and hydraulic fracturing sand.

Pennsylvania Glass Sand of Berkeley Springs, WV, announced plans to expand production of ground silica at four of its operations, at Columbia, SC; Berkeley Springs, WV; Pacific, MT; and Mill Creek, OK. The expansion plans include installation of new automated production and quality control equipment, and automated packaging and shipping facilities.[7]

California Silica Products Co., a subsidiary of Oglebay Norton of Cleveland, OH, purchased the Mission Viejo silica sand operation south of Los Angeles, CA, from Owens-Illinois. This operation produces mainly glassmaking sand.[8]

Georgia Kaolin Co. of Elizabeth, NJ, and Yuba Natural Resources Inc. of Marysville, CA, formed a joint venture to produce silica flour in California. The new company, Yuba Silica Inc. in Marysville, CA, will start producing in the first half of 1985.

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 28.7 million tons of industrial sand sold or used, 40% was consumed as glassmaking sand, and 25% as foundry sand. Other important uses were hydraulic fracturing sand and abrasive sand, each with 7%. 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 uses," which represent about 13% of the U.S. total. On a regional level, most of the glassmaking sand was produced in the South, 40%; followed by North Central, 28%; and West, 18%. Most of the foundry sand was produced in the North Central, 73%, and South, 16%. Of the smaller by volume but important uses, most of the hydraulic fracturing sand was produced in the North Central, 61%, and in the South, 37%, while most of the abrasive sand was produced in the South, 48%.

PRICES

The average value, f.o.b. plant, of U.S. industrial sand and gravel increased 2% to $12.84 per ton. Average unit values for industrial sand and industrial gravel were $12.92 and $9.71 per ton, respectively. Nationally, industrial sand used as silica flour had the highest value per ton, $75.22, followed by silica sand used in ceramics, $26.87, scouring cleansers, $23.44, and fiberglass ground, $22.20.

TRANSPORTATION

Of the total industrial sand and gravel produced, 73% was transported by truck from the plant to the site of first point of sale or use, 25% was transported by rail, 1% by waterway, and 1% was used at site. Because most of the producers had no records of and did not report shipping distances or cost per ton per mile, no transportation cost data were available.

FOREIGN TRADE

Exports.—Exports of industrial sand increased 14% to 1.2 million tons valued at $27.7 million. Of this, 88% went to Canada, and 6% went to Mexico.

Imports.—Imports of industrial sand decreased 44% to 25,528 tons valued at $926,094. Of this, 31% came from the Bahamas, 23% from Australia, and 19% each from Antigua and Canada.

TECHNOLOGY

Starting in 1975, the Bureau of Mines entered into a series of cooperative research agreements with several companies, members of the National Industrial Sand Association, to improve dust control procedures and reduce personal exposure to respirable dust in the industrial sand bagging operations. The study has been completed and demonstrates that proper modification of the fluidized packing equipment reduces the level of dust by up to 83%. Special ventilation procedures, improvements in bag design, as well as addition of moisture, foam, or steam to the dried product reduced the dust content in the baghouse by up to 90%. The results of this study have been termed a significant advancement in the present state-of-the-art bag filling procedures in silica sand operations.[9]

A new state-of-the-art plant operated by Vulcan Materials Co. of Birmingham, AL, was in its first full year of operation producing high-quality hydraulic fracturing sand from Hickory Sandstone near Voca, TX. The plant was a joint venture of Vulcan's Aggregates Div. and its Chemicals Div. The entire processing plant is highly automated with a computerized interactive quality control system being used to monitor and optimize each step of the process.[10]

A new flat glass manufacturing process, perfected independently by several major glassmakers, produces a glass-and-metal composite that reduces significantly the amount of heat released through conventional glass panels. The new "low-emissivity" glass contains a transparent layer of metal oxide particles that are embedded within the glass at high temperature. Despite the fact that the composite glass costs three times as much as plain glass and will add about 15% to the cost of the double-panel windows, it is expected to find wide use in the construction industry.[11]

Since the 1950's, the glass container industry in general and beer and soft drink bottle manufacturers in particular have been working on new solutions to reduce the weight of their products, in order to compete with aluminum and plastic container manufacturers. Progress has been made through the use of the dual surface treatment coating manufacturing technique, the use of plastic label wraps on glass bottles, and more recently the computerized bottle design analysis techniques. The technology to produce a super-lightweight container is available today, and the container of the future will be made from homogeneous, thermally well-conditioned glass manufactured on computer-controlled glass-forming machines.[12]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Rock Products. Particle Size Measured by Optical System. V. 87, No. 7, July 1984, pp. 28-29.

[3]Hedley, P. The C-H Sizer: A Breakthrough in Wet Sizing? Pit & Quarry, v. 77, No. 4, Oct. 1984, pp. 86-88.

[4]Robertson, J. L. Update on Recycling. Rock Prod., v. 87, No. 6, June 1984, pp. 25-27.

[5]Herod, S. Michigan Producer Using Airlift Dredge To Meet Objectives. Pit & Quarry, v. 76, No. 8, Feb. 1984, pp. 28-39.

[6]Pit & Quarry. V. 77, No. 2, Aug. 1984, p. 13.

[7]Industrial Minerals (London). PGS Silica Reaches 1m. Tonnes. No. 203, Aug. 1984, p. 16.

[8]———. Oglebay Norton Buys Silica Operation. No. 205, Oct. 1984, p. 15.

[9]Volkwein, J. C., and R. D. Gaynor. Dust Control in Bag-Filling Operations. BuMines IC 9005, 1985, 21 pp.

[10]Kuennen, T. Vulcan's New Frac Sand Plant. Rock Prod., v. 87, No. 11, Nov. 1984, pp. 35-38.

[11]Brandt, R. Business Week, No. 2894, May 13, 1985, p. 140F.

[12]Southwick, R. D. A Super-Lightweight Container is Feasible. Glass Ind., v. 66, No. 7, June 1985, pp. 14-17.

Table 13.—Industrial sand and gravel sold or used in the United States, by geographic region

Geographic region	1983 Quantity (thousand short tons)	1983 Percent of total	1983 Value (thousands)	1983 Percent of total	1984 Quantity (thousand short tons)	1984 Percent of total	1984 Value (thousands)	1984 Percent of total
Northeast:								
New England	148	1	$3,250	1	186	1	$3,781	1
Middle Atlantic	3,265	12	44,257	13	3,459	12	43,725	12
North Central:								
East North Central	9,601	36	96,840	29	10,260	35	119,035	31
West North Central	1,488	6	22,683	7	1,663	5	25,983	7
South:								
South Atlantic	4,115	15	55,328	16	5,348	18	65,126	17
East South Central	969	4	9,583	3	1,128	4	10,939	3
West South Central	3,649	14	51,906	15	3,881	13	52,655	14
West:								
Mountain	868	3	12,258	4	819	3	11,595	3
Pacific	2,515	9	39,107	12	2,638	9	44,377	12
Total[1]	26,620	100	335,200	100	29,380	100	377,200	100

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

Table 14.—Industrial sand and gravel sold or used in the United States, by State

(Thousand short tons and thousand dollars)

State	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Alabama	418	3,256	442	3,600
Arizona	W	W	W	W
Arkansas	386	4,796	459	6,207
California	2,150	34,066	2,281	39,176
Colorado	212	3,233	149	2,213
Connecticut	W	W	W	W
Florida	329	3,447	1,533	9,815
Georgia	539	7,298	478	6,795
Idaho	W	W	W	W
Illinois	4,060	42,871	4,100	52,197
Indiana	W	W	194	1,129
Kansas	199	2,184	W	W
Kentucky	10	124	W	W
Louisiana	291	4,252	266	3,757
Maryland	--	--	W	W
Massachusetts	W	W	W	W
Michigan	3,545	27,577	3,400	33,060
Minnesota	685	12,932	W	W
Mississippi	W	W	W	W
Missouri	600	7,541	614	8,129
Montana	W	W	W	W
Nebraska	4	W	W	W
Nevada	W	W	489	W
New Jersey	2,386	31,819	2,712	32,287
New York	W	W	25	260
North Carolina	1,066	11,689	1,158	12,864
Ohio	1,226	17,848	1,506	20,829
Oklahoma	1,184	13,221	W	W
Oregon	W	W	--	--
Pennsylvania	W	W	W	W
Rhode Island	--	--	W	W
South Carolina	842	13,169	882	14,889
Tennessee	483	5,455	650	6,903
Texas	1,788	29,637	2,028	29,282
Utah	24	W	11	W
Virginia	W	W	W	W
Washington	337	4,581	356	5,201
West Virginia	W	W	W	W
Wisconsin	621	7,208	1,060	11,821
Other	3,232	47,010	4,587	76,803
Total[1]	26,620	335,200	29,380	377,200

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Data may not add to totals shown because of independent rounding.

Table 15.—Industrial sand and gravel production in the United States in 1984, by size of operation

Size range	Number of operations	Percent of total	Quantity (thousand short tons)	Percent of total
Less than 25,000	41	23.2	365	1.2
25,000 to 49,999	28	15.8	1,030	3.5
50,000 to 99,999	27	15.2	1,931	6.6
100,000 to 199,999	29	16.4	4,084	13.9
200,000 to 299,999	16	9.0	3,746	12.8
300,000 to 399,999	15	8.5	5,375	18.3
400,000 to 499,999	9	5.1	4,096	13.9
500,000 to 599,999	2	1.1	1,186	4.0
600,000 to 699,999	3	1.7	2,017	6.9
700,000 and over	7	4.0	5,551	18.9
Total	177	100.0	[1]29,380	100.0

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

Table 16.—Number of industrial sand and gravel operations and processing plants in the United States in 1984, 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	5
Middle Atlantic	10	--	--	1	8	19
North Central:						
East North Central	36	1	4	--	2	43
West North Central	9	--	--	--	1	10
South:						
South Atlantic	19	--	1	5	9	34
East South Central	10	1	--	1	5	17
West South Central	17	--	1	1	5	24
West:						
Mountain	7	1	--	2	1	11
Pacific	9	1	--	2	2	14
Total	121	4	-6	12	34	177

Table 17.—Transportation of industrial sand and gravel in the United States in 1984 to site of first sale or use

Method of shipment	Quantity (thousand short tons)	Percent of total
Truck	21,490	73
Rail	7,416	25
Waterway	319	1
Not transported	157	1
Total[1]	29,380	100

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

Table 18.—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
1983															
Sand:															
Glassmaking:															
Containers	1,179	$14,619	$12.40	1,645	$12,938	$7.87	2,071	$24,416	$11.79	1,951	$27,962	$14.33	6,847	$79,935	$11.67
Flat (plate and window)	W	W	12.53	200	1,523	7.62	536	5,784	10.79	W	W	17.63	960	10,965	11.42
Specialty	W	W	12.70	207	3,286	15.87	216	2,443	11.31	W	W	30.00	558	7,449	13.35
Fiberglass (unground)	W	W	11.00	330	3,575	10.83	W	W	25.29	147	2,264	15.40	524	6,457	12.32
Fiberglass (ground)	W	W	35.00	79	2,102	26.61	460	9,647	20.97	W	W	28.00	547	12,007	21.95
Foundry:															
Molding and core	556	5,914	10.64	4,850	38,789	8.00	906	8,521	9.41	116	1,728	14.90	6,428	54,952	8.55
Molding and core facings (ground)	W	W	15.67	W	W	35.59	--	--	--	W	W	25.00	51	1,625	31.86
Refractory	W	W	25.50	156	2,221	14.24	W	W	16.09	--	--	--	191	2,898	15.17
Metallurgical:															
Silicon carbide	W	W	25.00	92	858	9.33	--	--	--	W	W	W	94	912	9.70
Flux for metal smelting	--	--	--	--	--	--	--	--	--	74	702	9.49	74	702	9.49
Abrasives:															
Blasting	190	3,786	19.93	225	4,225	18.78	1,170	18,787	16.06	201	1,614	8.03	1,785	28,411	15.92
Scouring cleaners (ground)	--	--	--	W	W	23.92	W	W	21.48	--	--	--	165	3,769	22.84
Sawing and sanding	W	W	22.00	--	--	--	W	W	W	--	--	--	W	W	32.00
Chemicals (ground and unground)	W	W	12.13	96	811	8.45	127	1,996	15.72	W	W	23.50	271	3,400	12.55
Fillers (ground):															
Rubber, paints, putty, etc	W	W	67.32	47	2,214	47.11	50	2,891	57.82	W	W	29.80	141	7,693	54.56
Ceramic (ground):															
Pottery, brick, tile, etc	W	W	42.39	97	3,472	35.79	52	1,382	26.58	W	W	12.50	179	6,067	33.89
Filtration	11	260	23.64	14	333	23.79	65	492	7.57	12	337	28.08	102	1,422	13.94
Traction (engine)	12	144	12.00	83	759	9.14	39	373	9.56	61	1,122	18.39	195	2,398	12.30
Coal washing	W	W	9.50	--	--	--	W	W	21.00	--	--	--	W	W	11.80
Roofing granules and fillers	W	W	16.50	W	W	9.75	238	2,786	11.71	32	590	18.44	296	3,778	12.76
Hydraulic fracturing	W	W	W	400	9,042	22.61	558	12,490	22.38	W	W	26.16	990	22,376	22.60
Miscellaneous uses	W	W	11.91	W	W	15.00	145	1,589	10.96	84	731	8.70	286	3,002	10.50

Other uses	1,419	21,782	15.35	2,485	32,622	13.13	1,729	19,704	13.55	664	13,913	20.95	XX	XX	XX
Total[1] or average	W	W	13.81	11,009	118,771	10.79	8,361	113,302	13.55	W	W	15.25	26,080	329,500	12.64
Gravel: Metallurgical:															
Silicon, ferrosilicon	--	--	--	W	W	9.00	W	W	8.86	W	W	10.34	267	2,441	9.14
Filtration	W	W	21.76	W	W	13.00	W	W	19.00	W	W	6.00	57	1,149	20.16
Grinding	--	--	--	--	--	--	--	--	--	W	W	W	W	W	W
Other uses	--	--	--	80	752	9.40	373	3,515	9.45	--	--	--	XX	XX	XX
Total[1] or average	W	W	21.76	80	752	9.40	372	3,515	9.45	W	W	10.23	537	5,667	10.55
Grand total[1] or average	3,414	47,507	13.92	11,089	119,523	10.78	8,733	116,817	13.38	3,382	51,365	15.19	26,620	335,200	12.59
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 facing (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 cleaners (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, paints, 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

See footnotes at end of table.

Table 18.—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															
Sand —Continued															
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	28,676	370,372	12.92
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

W Withheld to avoid disclosing company proprietary data, included with "Other uses" (1983), and with "Other uses -specified" (1984); also included in "U.S. total" by use. 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 19.—U.S. exports of industrial sand, by country

(Thousand short tons and thousand dollars)

Country	1983 Quantity	1983 F.a.s. value[1]	1984 Quantity	1984 F.a.s. value[1]
North America:				
Bahamas	4	115	3	115
Canada	918	12,566	1,045	13,587
Costa Rica	11	178	10	151
Dominican Republic	1	171	3	231
Mexico	58	2,167	70	2,245
Panama	11	280	5	152
Other	3	366	1	390
Total[2]	1,007	15,842	1,138	16,871
South America:				
Argentina	(3)	39	4	238
Peru	2	229	6	693
Venezuela	(3)	53	1	171
Other	1	177	1	309
Total[2]	3	499	11	1,410
Europe:				
Germany, Federal Republic of	5	1,084	5	1,381
Italy	1	87	1	153
Netherlands	6	3,442	3	1,573
Norway	2	168	1	86
United Kingdom	5	408	6	441
Other	4	510	4	740
Total[2]	22	5,698	20	4,373
Asia:				
Indonesia	1	155	2	253
Japan	3	1,150	4	1,149
Singapore	2	706	4	883
Other	2	474	2	466
Total[2]	8	2,485	11	2,752
Middle East and Africa:				
Turkey	--	--	3	565
Saudi Arabia	(3)	177	1	73
United Arab Emirates	2	245	2	672
Other	3	677	3	496
Total	5	1,099	9	1,806
Oceania	1	435	3	444
Grand total[2]	1,047	26,057	1,193	27,656

[1]Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

Table 20.—U.S. imports for consumption of industrial sand, by country

(Thousand short tons and thousand dollars)

Country	1983 Quantity	1983 C.i.f. value[1]	1984 Quantity	1984 C.i.f. value[1]
Antigua	--	--	5	83
Australia	45	1,235	6	167
Bahamas	10	36	8	15
Canada	1	52	5	155
Other	1	[r]296	2	506
Total	[2]58	1,619	26	926

[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.

Silicon

By Gerald F. Murphy[1]

Demand for silicon ferroalloys and silicon metal in 1984 increased significantly compared with that of 1983, the result of continued recovery by the iron and steel, aluminum, and chemical industries. Overall production and shipments of silicon ferroalloys were up by about one-third but those of silicon metal increased by only one-sixth. Imports declined and domestic producers gained a larger share of the domestic market. However, the high value of the dollar against other currencies put further strain on domestic producers, making it more difficult for them to compete in the world market. Exports increased dramatically but were still small compared with imports. Owing to stronger demand by major consuming industries for silicon materials, prices for most silicon products began to firm in 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 20 canvassed operations to which a survey collection request was made, 19 responded, representing about 90% of the total production shown in table 1. Production for the remaining nonrespondent was estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in the United States in 1984

(Short tons, gross weight, unless otherwise specified)

Alloy	Silicon content (percent)		Producers' stocks as of Dec. 31, 1983	Gross production	Net shipments	Producers' stocks as of Dec. 31, 1984
	Range	Typical				
Silvery pig iron	5-24	18	W	W	W	W
Ferrosilicon (including briquets)	25-55	48	59,792	344,311	305,409	60,579
Do	56-95	76	22,701	129,029	120,667	29,157
Silicon metal (excluding semiconductor grades)	96-99	98	11,778	144,005	139,393	10,432
Miscellaneous silicon alloys (excluding silicomanganese)	32-65	--	11,861	78,710	71,991	14,300

W Withheld to avoid disclosing company proprietary data.

Legislation and Government Programs.—In 1984, there were a number of significant Government actions relative to ferrosilicon and other ferroalloys. The U.S. Department of Commerce published the final results of its administrative review under the Tariff Act of 1930, of the countervailing duty order on ferroalloys imported into the United States from Spain during 1982. Commerce instructed the U.S. Customs Service to assess countervailing duties on imports of ferrosilicon and several other ferroalloys. On January 24, the International Trade Commission (ITC) found that imports of Soviet origin 50% ferrosilicon during the second half of 1983 did not significantly harm the domestic ferroalloy industry. The ITC had been requested, by the U.S. Trade Representative, to conduct an investigation under Section 406 of the

Trade Act of 1974 to determine whether the Soviet ferrosilicon imports had caused market disruptions. Commerce released a statement on May 10 announcing that the President had determined that imports of ferroalloys do not threaten the national security. The Ferroalloys Association had petitioned the Government in August 1981 for import relief under the National Security Clause (Sec. 232) of the Trade Act of 1962.

Higher U.S. import duties for seven ferroalloy classes, including ferrosilicon and silicon metal, were deleted from the Omnibus Trade Bill on October 5, 1984, by House-Senate conferees. An amendment (No. 4291) to the Senate version of the bill (S. 3398) that would have imposed a minimum "fair price" or "breakpoint" was struck out. The U.S. Department of Defense (DOD) plans to use some 1985 Defense Production Act Title III funds to support the domestic production capability of high-purity silicon. There is reportedly no domestic capacity for producing high-purity silicon for military applications, and the Pentagon presently purchases it from a West German producer. The decision reflects a new emphasis by DOD on use of title III funds. In its first allocation of such funding since the 1950's, DOD is also planning to guarantee purchase levels of several other materials and products considered critical to domestic defense, rather than follow its previous approach of creating domestic capacity through direct investments in industries.

DOMESTIC PRODUCTION

Production of silicon materials followed the general improvement in economic activity. Particularly large increases were made for silicon ferroalloys.

Overall production of silicon ferroalloys increased by about one-half, compared with that of 1983, reaching the highest level since 1981. Production of 25% to 55% ferrosilicon was up by about one-half, while that of 56% to 95% ferrosilicon was up by three-fifths. Miscellaneous silicon alloys were up by about one-half. The miscellaneous silicon alloys are special purpose alloys mainly composed of ferrosilicon but with other elements added. Magnesium ferrosilicon accounts for the major portion of this category. Other silicon alloys include calcium silicon, silicon-manganese-zirconium, and proprietary inoculants. Production of silicon metal increased by about one-sixth, compared with that of 1983, and except for 1979, attained the highest level ever.

Norway's Elkem A/S, one of the world's largest ferroalloy producers, increased its share in Elkem Metals Co., Pittsburgh, PA, from 49% to 67%. The Globe Metallurgical Div. of Interlake Inc., a major producer of ferrosilicon and silicon metal, was sold for about $37 million to Pickands Mather & Co., Cleveland, OH, a subsidiary of Moore McCormack Resources Inc., Stamford, CT. The acquisition included both of Globe's plants, one in Selma, AL, and the other in Beverly, OH. Ohio Ferro-Alloys Corp. (OFA) ceased production of ferrosilicon at its Philo, OH, plant in September and silicon metal production at its Powhatan Point, OH, plant in October. Low-priced imports and high energy and labor costs were among the reasons cited for these actions. OFA continued to produce silicon metal at its third plant in Montgomery, AL. The Hanna Mining Co. attempted to obtain a low power rate through mid-1990 from the Bonneville Power Administration (BPA). If Hanna is not successful in obtaining a longer term power contract from BPA, future operations at its Riddle, OR, facility are uncertain. Hanna produces ferrosilicon at the Riddle plant for use in the production of ferronickel.

Estimated ferrous scrap consumption by the domestic silicon ferroalloys industry was 310,000 tons in 1984, compared with 220,000 tons in 1983 and 210,000 tons in 1982.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1984

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.
Hanna Mining 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	Philo, OH	Do.
Do	Powhatan Point, OH	Si.
Reynolds Metals Co	Sheffield, AL	Do.
SKW Alloys Inc	Calvert City, KY	FeSi.
Do	Niagara Falls, NY	Do.

CONSUMPTION AND USES

Demand for silicon ferroalloys and silicon metal increased by about one-fifth and one-tenth, respectively, compared with that of 1983. The increase in demand for silicon ferroalloys was attributed to a continued recovery by the steel and ferrous foundry industries, while that of silicon metal was mainly the result of increased demand by the aluminum and chemical industries. Cast iron shipments, exclusive of ingot molds, as reported by the Bureau of the Census, rose from 8.0 million net tons in 1983 to about 9.6 million net tons in 1984, an increase of about 20%.

The largest demand in 1984 was for the 50% ferrosilicon grade and silicon metal, followed, on the basis of silicon content, by the 75% ferrosilicon grade, silicon carbide, and miscellaneous silicon alloys. The decreasing order of end uses for silicon materials was steel, cast iron, silicones and silanes, and nonferrous alloys, with about 80% 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 93% of 50% ferrosilicon usage; 90% of silicon metal went into silicones and silanes and nonferrous alloys.

Increases in consumption paralleled increases in major markets for silicon alloys and metal. Iron foundries and the steel industry experienced production increases of about one-sixth and one-tenth, respectively. The aluminum industry, which uses silicon metal to make wrought and cast products, showed a production increase of about one-sixth. The increase was in large part caused by increases in the transportation and housing industries. Consumption of silicon metal for silicones and silanes also increased in 1984 by about 15% compared with that of 1983.

Silicon metal produced by tonnage methods is used as raw material for the manufacture of the relatively small quantity of ultra-high-purity polycrystalline silicon for semiconductors, photovoltaic cells (solar 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 1984, domestic production of polycrystalline silicon was estimated at 1,800 tons.

Union Carbide Corp. started up the first of 48 reactors at its new polycrystalline silicon plant at Moses Lake, WA. All 48 reactors are scheduled to be in use by May 1985. Plant output is expected to be about 1,300 tons per year. The facility now gets its silica from West Virginia but soon will be supplied by Hanna, Wenatchee, WA. The company reportedly already planned to expand the new plant from one and one-half to twice its existing size. Union Carbide also announced plans to build a second $200 million polycrystalline silicon plant with an output of about 3,300 tons per year, the site of which was to be determined. Shin-Etsu Itandotai Co. Ltd., Japan, reached an agreement in principle to acquire 25% of Hemlock Semiconductor Corp., Hemlock, MI, a subsidiary of Dow Corning Corp. Hemlock plans to build a new polycrystalline silicon plant with a capacity of about 2,700 to 3,900 tons per year. The proposed facility reportedly will supply 25% of production to Shin-Etsu beginning in 1986. In 1984, Dow Corning reportedly was negotiating with Monsanto Co. in Missouri to bring that firm into a joint polycrystalline silicon production program.

Monsanto, Shin-Etsu, and Wacker Chemi GmbH reportedly were negotiating an agreement under which Wacker would construct a polycrystalline silicon plant in Portland, OR. The United States and Japanese firms would supply part of the required funds.

Allied Corp. awarded a contract to Chem-Pro Corp. to construct an oximino silanes plant at Marcus Hook, NJ. Allied initially plans to offer methyl tris silane, vinyl tris silane, and methyl vinyl bis silane. These products are used in room-temperature vulcanizing silicone sealant as cross linkers and chain extenders enabling the formulation of a neutral, low-odor sealant with a variety of properties. Dow Corning and Lucky Development Co. Ltd., Republic of Korea, have formed a joint venture to produce and sell silicone products in that country. The new company, Lucky-DC Silicone, began to make industrial silicone products early in the year.

Spire Corp., Bedford, MA, received a $3 million contract from the U.S. Department of Energy's (DOE) Solar Energy Research Institute to develop photovoltaic cells (solar cells) with a high conversion efficiency. The goal is to make multijunction amorphous silicon alloy solar cells with a conversion efficiency of at least 18% by 1988.

Stauffer Chemical Corp. planned to build a new ethyl silicate plant at its Weston, MI, facility. The plant will be based on Stauffer's new process that synthesizes ethyl silicate from silicon and ethyl alcohol. The costlier, conventional ethyl silicate process uses silicon tetrachloride as a starter and makes large amounts of unwanted byproduct.

Overall, consumer stocks showed a slight decline of about 2%. Stocks of 25% to 55% ferrosilicon and miscellaneous silicon alloys dropped by about one-sixth and three-tenths, respectively, while those of 71% to 80% ferrosilicon and silicon metal increased by a little less than one-tenth and by about one-half, respectively.

Table 3.—Consumption, by major end use, and stocks of silicon alloys and metal in the United States in 1984

(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)	53,736	(4)	19,316	(4)	(4)	2,221	25
Stainless and heat-resisting		--	31,260	(4)	26,349	(4)	(4)	(4)	--
Full alloy		(4)	23,378	(4)	7,133	777	(4)	1,024	(4)
High-strength low-alloy		(4)	5,646	--	1,454	(4)	(4)	(4)	(4)
Electric		--	(4)	(4)	(4)	--	--	(4)	--
Tool		--	1,462	--	1,073	--	--	--	--
Unspecified		138	6,501	3,356	22,792	1,159	1,248	420	227
Total		138	121,983	3,356	78,117	1,936	1,248	3,665	252
Cast irons		9,243	123,102	838	24,727	378	(5)	27,005	32,219
Superalloys		(5)	246	--	(5)	(5)	65	--	--
Alloys (excluding alloy steels and superalloys)		174	3,589	--	99	3	41,564	95	2
Silicones and silanes		--	--	--	--	--	61,262	--	--
Miscellaneous and unspecified		12	14,823	--	67	51	[6]10,214	1	--
Total		9,567	263,743	4,194	103,010	2,368	114,353	30,766	32,473
Percent of 1983		69	122	85	114	168	115	112	154
Total silicon content[7]		1,722	126,596	2,726	78,287	2,012	112,066	14,768	20,782
Consumers' stocks, Dec. 31		1,121	11,461	245	7,917	196	5,612	1,830	1,480

[1]Includes briquets.
[2]Primarily magnesium-ferrosilicon but also includes other silicon alloys. Average silicon content estimated as 48%, based on 1984 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 10,000 tons consumed for unspecified chemicals.
[7]Estimated based on typical percent content.

PRICES

Owing to stronger demand by the steel and ferrous foundry industries for ferrosilicon and by the aluminum and chemical industries for silicon metal, posted prices for domestic silicon materials began to firm in 1984. For example, on a cents per pound of contained silicon basis, the average price per year for domestic material increased from 42.1 in 1983 to 42.9 in 1984 for 50% ferrosilicon, from 42.7 to 44.3 for 75% ferrosilicon, and from 57.2 to 62.9 for silicon metal containing 1% maximum iron.

Imports of silicon ferroalloys and silicon metal also showed a firming trend in 1984 but were still priced significantly lower than equivalent domestically produced materials. For example, the average price per year for the 50% grade of ferrosilicon went from 36.1 in 1983 to 40.7 in 1984, from 36.0 to 41.3 for the 75% grade of ferrosilicon, and from 53.1 to 59.8 for silicon metal with up to 1% iron.

The posted price of certain domestically produced silicon materials did not change. These included calcium silicon, all grades of magnesium ferrosilicon, and a number of proprietary materials.

Because of increased demand for silicon materials, discounting was not as evident as in the years 1981-83.

FOREIGN TRADE

Exports of ferrosilicon were the highest in quantity since 1975 and were the highest ever in terms of value. The largest amounts were exported to Canada and Japan, 19,597 and 4,290 tons, respectively, which together accounted for about 80% of both total quantity and value. Exports went to 29 countries. Silicon metal exports showed a substantial increase, about three-fifths higher compared with those of 1983. Principal recipients were Japan, 1,764 tons; Mexico, 1,629 tons; Canada, 515 tons; and Malaysia, 154 tons, which combined accounted for about 90% of total quantity and 80% of total value. Exports of silicon metal went to 34 countries.

Compared with those of 1983, ferrosilicon and silicon metal imports each decreased by about 10% in quantity on a gross weight basis but increased 8% and 6%, respectively, in value. Imports of regular-grade 75% ferrosilicon (60% to 80% silicon) were the most significant on a quantity basis, amounting to about two-thirds of total ferrosilicon imports. Norway and Venezuela each shipped slightly more than one-fourth of the total in this range, while Brazil and Canada with about one-fifth and one-tenth of the total, respectively, were the next largest sources. Imports in this range from Canada, France, and Iceland declined notably compared with those of 1983. The next largest import class was regular-grade 50% ferrosilicon (30% to 60% silicon), which amounted to a little more than one-fifth of ferrosilicon imports. The three main sources within that class were the U.S.S.R., Brazil, and Canada. Total imports of silicon metal decreased by about one-tenth in terms of gross weight, compared with those of 1983. Canada, France, Yugoslavia, and Brazil were the dominant sources of commercial-purity silicon metal. The Federal Republic of Germany and Italy supplied four-fifths 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 smaller share of the domestic market, declining from a little more than one-fourth in 1983 to about one-fifth in 1984.

The marked increase in exports and moderate decline in imports did not change the U.S. position as a net importer of ferrosilicon. Net imports amounted to 114,000 tons and a trade deficit of about $52 million.

The high value of the dollar, with respect to other currencies, continued to make the United States one of the most attractive markets for exporters throughout the world. The strong dollar also made it more difficult for U.S. producers to compete in the world market.

Table 4.—U.S. exports of ferrosilicon and silicon metal

Year	Quantity (short tons)	Value (thousands)
FERROSILICON		
1980	27,488	$18,572
1981	15,768	12,136
1982	14,932	11,996
1983	[r]13,338	10,712
1984	29,364	21,135
SILICON METAL		
1980	14,372	65,478
1981	8,673	57,001
1982	2,411	34,335
1983	2,767	47,826
1984	4,420	88,543

[r]Revised.

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country

Grade and country	1983 Quantity (short tons) Gross weight	1983 Quantity (short tons) Silicon content	1983 Value (thousands)	1984 Quantity (short tons) Gross weight	1984 Quantity (short tons) Silicon content	1984 Value (thousands)
Ferrosilicon:						
Over 8% but not over 30% silicon:						
Canada	29	6	$11	42	6	$3
United Kingdom	--	--	--	5	1	10
Total[1]	29	6	11	46	7	13
Over 30% but not over 60% silicon, with over 2% magnesium:						
Brazil	3,911	1,817	3,091	5,564	2,530	2,845
Canada	2,395	1,141	840	351	178	151
France	587	276	401	964	446	662
Germany, Federal Republic of	62	33	93	256	143	321
Italy	19	9	12	273	122	201
Japan	14	6	24	182	82	311
Norway	4,512	2,087	3,412	3,244	1,488	2,688
Spain	--	--	--	78	41	73
Venezuela	2,075	1,003	436	--	--	--
Total[1]	13,575	6,372	8,308	10,912	5,030	7,252
Over 30% but not over 60% silicon, not elsewhere classified:						
Brazil	1,652	810	879	7,160	3,473	2,428
Canada	8,684	4,168	2,499	7,221	3,627	2,113
France	1,433	820	1,491	2,703	1,578	2,694
Germany, Federal Republic of	286	150	357	868	480	948
Italy	--	--	--	76	41	72
Japan	--	--	--	18	8	31
Mexico	1,048	539	249	--	--	--
Netherlands	--	--	--	18	11	16
Norway	--	--	--	1,090	437	408
Spain	--	--	--	939	589	1,019
U.S.S.R	16,647	7,749	2,804	11,514	5,424	3,151
Venezuela	4,358	2,214	988	--	--	--
Total[1]	34,108	16,449	9,267	31,607	15,668	12,880
Over 60% but not over 80% silicon, with over 3% calcium:						
Brazil	2,852	1,921	1,951	4,436	2,802	3,841
France	929	566	1,033	1,118	691	1,209
Germany, Federal Republic of	1,562	965	1,770	1,054	678	999
Italy	265	167	268	146	104	148
Mexico	--	--	--	44	26	10
United Kingdom	63	39	72	--	--	--
Total	5,671	3,658	5,094	6,798	4,301	6,207
Over 60% but not over 80% silicon, not elsewhere classified:						
Argentina	2,179	1,663	984	1,743	1,319	759
Belgium-Luxembourg	--	--	--	17	13	53
Brazil	22,021	16,510	9,599	17,793	13,311	9,209
Canada	19,733	14,905	11,154	8,652	6,564	5,096
Chile	--	--	--	1,068	822	598
France	3,741	2,874	1,957	575	440	492
Germany, Federal Republic of	513	381	887	968	727	1,401
Iceland	8,264	6,537	3,064	2,582	1,937	1,259
Israel	--	--	--	4,327	3,245	1,919
Japan	18	14	13	--	--	--
Mexico	1,863	1,323	802	--	--	--
Norway	27,021	20,384	11,447	23,710	17,746	11,619
Poland	--	--	--	799	589	372
Portugal	--	--	--	4,021	3,056	2,099
South Africa, Republic of	--	--	--	1,382	1,079	796
Sweden	323	243	129	111	83	111
Venezuela	18,918	13,555	4,058	25,377	19,074	10,046
Yugoslavia	1,446	1,122	658	--	--	--
Total[1]	106,041	79,512	44,752	93,125	70,005	45,829
Over 80% but not over 90% silicon:						
Belgium-Luxembourg	--	--	--	76	69	59
Brazil	--	--	--	220	187	158
Canada	20	15	13	55	45	19
France	--	--	--	38	32	23
Norway	--	--	--	441	383	203
Spain	--	--	--	231	206	156
Total[1]	20	15	13	1,063	923	619

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	1983 Quantity (short tons) Gross weight	1983 Quantity (short tons) Silicon content	1983 Value (thousands)	1984 Quantity (short tons) Gross weight	1984 Quantity (short tons) Silicon content	1984 Value (thousands)
Ferrosilicon —Continued						
Over 90% but not over 96% silicon:						
Belgium-Luxembourg	--	--	--	38	36	$33
Canada	(2)	(2)	(2)	20	20	11
Italy	--	--	--	41	38	32
South Africa, Republic of	--	--	--	(2)	(2)	(2)
Total[1]	(2)	(2)	(2)	100	94	76
Total ferrosilicon[1]	159,443	106,012	$67,445	143,651	96,027	72,874
Silicon metal:						
Over 96% but not over 99% silicon:						
Argentina	494		374	--		--
Canada	3,710		3,598	3,101		3,425
France	48		49	114		106
Portugal	--		--	22		15
South Africa, Republic of	--		--	244		247
Spain	--	NA	--	105	NA	71
Sweden	553		512	--		--
Switzerland	--		--	37		29
United Kingdom	1		(2)	--		--
Yugoslavia	2,728		2,132	3,130		3,219
Total[1]	7,535	NA	6,665	6,753	NA	7,113
Over 99% but not over 99.7% silicon:						
Argentina	1,023	1,014	908	1,203	1,181	1,322
Belgium-Luxembourg	(2)	(2)	1	115	107	103
Brazil	5,926	5,582	5,691	2,665	2,640	2,792
Canada	7,990	7,864	8,698	5,123	5,076	6,196
China	682	676	558	441	434	411
Denmark	--	--	--	(2)	(2)	1
France	1,027	1,020	1,066	3,988	3,956	4,354
Germany, Federal Republic of	--	--	--	(2)	(2)	1
Italy	--	--	--	337	335	347
Norway	602	596	444	660	655	693
Portugal	--	--	--	887	880	930
South Africa, Republic of	1,462	1,450	1,445	1,745	1,729	1,840
Spain	--	--	--	252	250	259
Yugoslavia	1,241	1,215	886	172	166	113
Total[1]	19,953	19,418	19,699	17,588	17,408	19,361
Over 99.7% silicon:						
Australia	(2)		61	--		--
Austria	1		3	--		--
Belgium-Luxembourg	33		1,214	--		--
Canada	--		--	49		121
China	28		889	35		398
Denmark	22		320	21		502
Finland	--		--	(2)		6
France	1		255	22		370
German Democratic Republic	7		158	(2)		2
Germany, Federal Republic of	445		15,801	618		21,608
Hong Kong	--	NA	--	5	NA	289
Israel	--		--	(2)		3
Italy	79		3,608	93		3,547
Japan	62		3,077	34		1,952
Korea, Republic of	(2)		22	(2)		6
Malaysia	--		--	(2)		9
Poland	(2)		(2)	--		--
Sweden	2		8	4		37
Switzerland	(2)		6	(2)		57
Taiwan	5		157	--		--
United Kingdom	1		78	--		--
Total[1]	685	NA	25,659	880	NA	28,907
Total silicon metal[1]	28,173	XX	52,026	25,221	XX	55,381

NA Not available. XX Not applicable.
[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

WORLD REVIEW

World demand for silicon ferroalloys and silicon metal increased moderately compared with those levels of 1983, owing to increased production by world steel producers and the aluminum and chemical industries, the major consumers of ferrosilicon and silicon metal. Overcapacity and oversupply continue to be the principal problems facing the world ferroalloy industry. A major gain in ferrosilicon capacity in Brazil was offset by reductions in the United States and Japan. Other countries that have recently installed new silicon ferroalloy or silicon metal capacity, or plan to do so, are Egypt and Iceland. The world ferrosilicon industry is closely tied to the fortunes of the steel industry, which is still a long way from full recovery following the recent, severe recession. Demand for silicon metal is dependent on the aluminum and chemical industries.

The European Economic Community (EEC) initiated an investigation of silicon carbide dumping in response to a complaint by the European Council of Chemical Manufacturers' Federations (Cefic). The countries involved were China, Czechoslovakia, Norway, Poland, Spain, the U.S.S.R., and Yugoslavia. Cefic claimed that these exporters have taken 41% of the EEC's $100 million market.

By accepting the International Monetary Fund's (IMF) conditions of strict monetary policy, curtailed government spending, and fewer imports, many developing countries were able to restructure their large debts in 1984. However, these countries have not yet begun to reduce their debts. The largest debtor countries, such as Brazil and Mexico, made substantial economic progress during the year, enjoying large trade surpluses. Debtor countries and their lending institutions began to work out realistic long-term schedules for repaying huge loans. Argentina, which initially had objected strenuously to the IMF's strict conditions in connection with its debt restructuring, eventually accepted the IMF's austerity program.

Brazil.—Alcan Alumínio do Brasil S.A., a subsidiary of Alcan Alumínio da America Latina Ltda., held talks with parties concerned with the sale of its ferroalloy plant in the State of Minas Gerais. Alcan put the plant up for sale to raise funds to cover the cost of expanding its aluminum facility. Also, Alcan's special power contract with the Brazilian Government was due to expire, and the new power rates were expected to increase. The plant consists of two ferrosilicon furnaces with a total transformer capacity of 21,300 kilovolt amperes (kV•A) and six silicomanganese furnaces with a total transformer capacity of 16,300 kV•A.[2] Brazil's state-owned Cia. Vale do Rio Doce (CVRD) and Eletrometalur S.A. Indústria e Comércio, a major ferroalloy producer, have formed a new ferrosilicon company, Eletrovale, to transform the Picarro iron ore minesite into a ferroalloy plant, with a production capacity of about 27,000 tons per year of 75% ferrosilicon with low calcium content. The minesite, which is expected to be exhausted in early 1985, was chosen for the new facility to take advantage of existing infrastructure. Ownership was divided on a 60% to 40% basis between the Brazilian companies and Japan's Kawasaki Steel Corp. and Mitsubishi Corp. The plant will either be equipped with two Brazilian 15,000-kV•A electric furnaces or one 35,000-kV•A furnace procured from Elkem A/S, Norway, or Mannesmann Demag Hüttentechnik, the Federal Republic of Germany. About 40% of the annual production is expected to go to the Japanese steel producers.[3] Italmagnesio S.A. Indústria e Comércio brought a new 24,000-kV•A furnace on-line in November at its Braganca plant in Minas Gerais for production of ferrosilicon or silicon metal. The furnace is reportedly capable of producing 13,000 tons of silicon metal per year. The company also planned to install three additional furnaces by the end of 1986, which would produce ferrosilicon or silicon metal.

Italmagnesio reached a basic long-range agreement with C. Itoh & Co. Ltd. to act as its Japanese sales agent. In return, C. Itoh is to make available a large amount of funds to Italmagnesio. Cia. de Ferroligas Minas Gerais brought a second ferrosilicon furnace, with a capacity of 1,100 tons per month, on-stream at its plant in Pirapora early in the year. The company planned to bring another furnace on-line in October.

Canada.—Elkem Metals Canada Inc., owned 90% by Elkem A/S and 10% by the Jebsen Group of Norway, purchased Union Carbide Canada Ltd.'s silicon and manganese operations in Quebec, effective July 25. This acquisition completes the takeover, begun in 1981, of Union Carbide's ferroalloy operations in North America and Norway. The transaction included plants at Beauharnois and Chicoutimi, Quebec. The Beauharnois plant has been idle since May 1982.[4]

France.—The dispute between state-owned Pechiney and Compagnie Minière de l'Ogooue S.A. (Comilog) concerning the ownership of Bozel Electrometallurgie, a calcium silicon producer and a subsidiary of Nobel Bozel, was resolved in October with Comilog's decision not to appeal the French Commercial Tribunal's award of the company to Pechiney. Nobel Bozel had previously promised to sell Bozel Electrometallurgie to Comilog.[5] Pechiney announced that it was studying the possibility of starting ferrosilicon production at its St. Beron plant when it ceased medium-carbon ferromanganese production at that facility in 1985. Pechiney also reduced its share of Hidro Nitro Españolas S.A., a ferrosilicon and silicon metal producer, from 49% to 45%.[6]

Air Liquide commissioned a high-purity silane gas plant at Chalon-sur-Saône in eastern France. The company's first silane plant came on-stream in 1983 in Japan through its subsidiary Teisan KK.[7]

Rhône-Poulenc S.A. entered into a joint venture with Siltec Corp., United States, to produce silicon wafers and ingots in France for the West European semiconductor market. Silicon wafers are used by the semiconductor industry to manufacture integrated circuits. The new $30 million venture is expected to start up in mid-1985 and supersedes a previous agreement, which was terminated in April.

Germany, Federal Republic of.—Dynamit Nobel AG, and Cabot Corp., United States, agreed to set up a joint venture company, Cabot-Nobel GmbH, for the production of highly dispersed fumed silica. The new facility, to be constructed at Rheinfelden, is expected to be in operation in early 1987 and will produce about 8,000 tons per year of fumed silica using Cabot technology. The raw material will be silicon tetrachloride produced at Rheinfelden. Fumed silica is used as a reinforcing, thickening, thixotropic, and flow control agent in various applications.

Iceland.—Sumitomo Corp., a Japanese trader, signed an agreement with the Icelandic Government and Elkem to buy 15% of Icelandic Alloys Ltd. The Japanese company bought 15% of Elkem's share. The Icelandic Government's and Elkem's share of Icelandic Alloys now amount to 55% and 30%, respectively. Sumitomo will receive a long-term supply of ferrosilicon, amounting to about 22,000 tons per year, beginning in the third quarter of 1984. The Grundartangi facility, completed in 1980, is equipped with two 35,000-kV•A electric furnaces with a combined capacity of about 61,000 tons per year.[8]

The Icelandic Parliament approved plans for a new 27,000-ton-per-year silicon metal plant at Reydarfjordur. Icelandic Metal PLC, which had been given a Government mandate to proceed with the project, began a search for foreign and domestic partners to share the cost of the facility.

India.—Power shortages continue to be the principal problem of the Indian bulk ferroalloy industry. Exports of ferrosilicon have been banned since July 1984 owing to acute power shortages in the States of Karnataka and Orissa where ferrosilicon capacity is concentrated. Ferrosilicon producers have been most concerned with the continuous underutilization of capacity, even though confronted with high costs of energy and raw materials. The plant load factor of power stations in India was reported to be only 47.5% in 1983.[9]

A National Silicon Facility was set up in 1984 by the Indian Government to assure availability of high-purity silicon for the manufacture of photovoltaic cells (solar cells) and electronic devices. The National Silicon Facility was expected to construct a polysilicon metal plant with a capacity of about 200 tons per year at the Indian Petro-Chemicals complex near Baroda in Gujarat.

Japan.—In June, the Japan Ferroalloy Association's ferrosilicon producing members withdrew their dumping complaint against Brazil, France, and Norway. The complaint, which was filed with the Finance Ministry in March, charged Norway and France with dumping their ferrosilicon into Japan and Brazil with unfair competition through subsidizing their ferrosilicon exports to Japan. Combined imports from the three countries were expected to amount to about 153,000 tons. Japan's Ministry of International Trade and Industry (MITI) had received assurances from the Governments of the countries involved that there had been no dumping and that exports of ferrosilicon had been in accordance with the General Agreement on Tariffs and Trade (GATT) regulations. Also, equally important in the decision to drop the dumping suit was that the price of ferrosilicon imported into Japan had reached a level approximately equal to that of Japanese-produced material. MITI formed a new commission in March that, similar to the

ITC, will have powers to exclusively handle complaints of dumping and unfair competition filed by Japanese industries against foreign imports.

In January, the Japanese Government's Tariff Council recommended that the 5.3% GATT-based import duty and the 12% non-GATT duty imposed on imports of silicon metal should be abolished effective April 1. The duty, introduced to protect Japanese producers from cheap imports, became redundant when the last Japanese producer of silicon metal ceased production in December 1982.

The Japanese ferroalloy industry has steadily declined since 1979. Ferrosilicon has been hardest hit followed by ferrochromium and ferromanganese. A basic factor in the decline is rapidly rising energy and power costs, which are making it prohibitive to produce energy-intensive metals. Coincidentally, ferroalloy imports have soared, further exacerbating the problems of Japanese producers.

Tokuyama Chemical Co. Ltd. began production of polycrystalline silicon in 1984. Initial capacity at the Tokuyama plant will be 200 tons per year, but the company planned to increase production to approximately 1,000 tons per year by October 1985. Shin-Etsu Chemical Corp. completed its newest polycrystalline silicon plant near yearend and expected to begin operations in January 1985. Japan's demand for polycrystalline silicon in 1984 was expected to be about 2,200 to 2,700 tons, with approximately 1,000 tons imported, mainly from the United States and Western Europe.[10]

Kanegafuchi Chemical Industry, Osaka, was expected to become the first Japanese chemical company to mass produce solar cells. Production was expected to begin as early as 1985. The company has developed the technology to produce two types of photoelectric cells by chemical vapor deposition on either a glass or stainless steel substrate. Both types feature p-type amorphous silicon carbide on i- and n-type amorphous silicon layers.[11]

Norway.—Norwegian ferroalloys producers reportedly operated at near capacity. Hydroelectric power is cheap in Norway but is limited in supply. Although the country has plenty of hydroelectric potential remaining to be developed, expansion of the available power base has been restricted by environmental pressures. A Government report on energy development was to be considered by the Norwegian Parliament late in the year. Several major ferroalloy producers would likely expand capacity if they were able to acquire additional power rights. Norway is the world's largest exporter of ferrosilicon and silicon metal, and the world's second largest exporter of ferromanganese and silicomanganese.

Tinfos Jernverk A/S restarted silicon metal production at its Notodden plant in December. The company's initial startup in midyear was unsuccessful owing to technical difficulties. The transfer of silicomanganese capacity to the Oye Smelteverk in Kvinesdal resulted in spare capacity in Notodden, which could be used for silicon metal production.[12]

Spain.—The Spanish ferroalloy industry completed its restructuring plan for ferrosilicon and ferromanganese producers in the latter part of the year. Overall capacity was cut back 50% in return for concessionary power rates by the Government. Production of the various alloys has been divided among the producers. Under the rationalization plan, the Government designates which companies are allowed to export and sets production levels. The ferroalloy industry's main purpose now is to supply that country's steel industry, with only Hidro Nitro Españolas S.A. able to export a significant amount of its production, about 50%. Because of Government restrictions on production, only about 17,000 tons of ferrosilicon was expected to be exported. Once Spain obtains full membership in the EEC, certain export incentives and Spain's protective high import tariffs will be phased out.

United Kingdom.—The British Government announced in November that it had decided to dismantle its strategic stockpile. The British Department of Trade and Industry said that the stockpile materials will be disposed of over a period of years. The principal contents of the United Kingdom stockpile were reported to be manganese and chromium materials.[13]

BOC Special Gases began production early in the year at Europe's first silane plant in Crawley, Sussex. The plant's capacity reportedly is sufficient to be able to meet projected European demand for the next 5 years. Previously, world production was limited to the United States and Japan.[14]

Epichem's new silane gas plant in Bromborough was expected to begin full production in the first half of 1984. The plant reportedly will be able to produce a full range of silanes of highest research standards. Silane is a key raw material used in the production of silicon semiconductors for the microelectronics industry.[15] Monsanto Co., United States, announced in May that it planned to build a silicon wafer plant in the United Kingdom. The plant is expected to produce about $20 million per year of silicon wafers.

Venezuela.—C.V.G. Ferrosilicio de Venezuela C.A. (FESILVEN) lost its entire ferrosilicon production owing to an explosion in one of its two 52,000-kV•A furnaces at the end of April. The explosion resulted in one fatality, with injuries to others. The plant's other furnace was shut down for scheduled repairs. Both furnaces were reported to be operating at 80% of capacity by the end of August. FESILVEN exports the majority of its production and expected to begin shipments to the United States and Europe in September.[16]

TECHNOLOGY

High-technology ceramics are the subject of intensive research in the United States, Japan, and to a somewhat lesser degree in Europe and Australia. Advanced ceramics such as silicon carbide, silicon nitride, and sialon (a material of silicon, aluminum, oxygen, and nitrogen) are being studied for their applications in the electronics industry and in metal substitution. These materials have excellent mechanical properties under heavy stress, exceptional resistance to high temperatures and corrosive environments, and outstanding electrical and optical properties. Because high-technology ceramics have high heat, wear, and corrosion resistance, they are used in cutting tools, burner nozzles, and heat exchangers. However, most ceramics have had their use greatly restricted in structural applications because of their brittleness, which can result in catastrophic failure. Advanced ceramics also are costly and difficult to make. If the cost and reliability of ceramic parts were improved fairly quickly, their markets would be expected to grow at a rapid rate.

One of the prime incentives for research and development of high-technology ceramics is the potentially huge market for these materials in automobile and other engines. Introduction of important ceramic components in engines such as piston heads and turbochargers, and the increased use of heat- and wear-resistant ceramic parts such as bearings in other than automotive applications would result in a large demand for those materials. Automobile engines could be substantially improved if critical parts could be made of advanced ceramic materials. A lightweight ceramic turbocharger rotor accelerates more rapidly than a heavier metallic rotor because it has less inertia. However, the greatest automotive use of high-technology ceramics is expected to be in gas turbine engines and in adiabatic diesel engines. Conventional diesel engines are cooled because of the metals they use otherwise could not withstand the engine's high operating temperatures.

DOE currently supports two demonstration projects to develop ceramic-containing gas turbine engines for automobiles. One project, conducted by the Allison Turbine Operations and the Pontiac Div. of General Motors Corp., uses silicon carbide in the high-temperature areas, such as the power turbine and gasifier. The other project, a joint effort by Garrett Corp. and the Ford Motor Co., uses either silicon carbide or silicon nitride in the turbine and other high-temperature areas.[17]

The National Aeronautics and Space Administration's Lewis Research Center is conducting in-house research and is involved in management of outside research relative to the development and application of structural ceramics for advanced heat engines. The in-house program is directed at a more basic understanding of the effect of processing variables on the properties of silicon carbide and silicon nitride. The Los Alamos National Laboratory has reported synthesizing ultrafine and ultrapure ceramic powders such as beta silicon carbide and silicon nitride using a radio frequency plasma system. According to Industrial Materials Technology Inc., hot isostatic pressing will be the technique used to manufacture ceramic parts such as silicon nitride, silicon carbide, and sialon for the automobile gas turbine. Research and development conducted by SKF Industries Inc. has found that properly manufactured silicon nitride bearings have fatigue lives comparable to those of the best steel bearings. The low density of silicon nitride rolling elements is beneficial owing to the reduction in centrifugal loading in high-speed bearings.[18] Martin-Marietta Corp. planned to double the size of its central research and development laboratory facilities to support expanded research in the field of advanced ceramics, among others. In addition to corrosion and wear-resistant coatings, the facility is investigating ways to handle uniform submicrometer ceramic particles whose ability to pack densely may lead to the production of high-reliability ceramic structures.[19]

IIT Research Institute, in Illinois, planned to conduct a study program of structural ceramics. The program will investigate the technical and economic suitability of ceramic material and processing options for various types of high-performance applications, including piston and turbine engines.[20]

W. R. Grace & Co. acquired Metaramics Inc., in California, in 1984. Metaramics manufactures ceramic packages for the semiconductor industry and ceramic-to-metal seals and headers for the electronic and aerospace industries.[21] Pechiney, France, reached an agreement with Lafarges Refractaires to buy that company's Ceramiques Techniques Demarquest Div. The division, which produces high-performance ceramics of silicon nitride, among others, is developing new applications for the automotive and aeronautics industries.[22] Metal-fiber composites are currently attracting attention by researchers because they exhibit high strength combined with low density. Aluminum reinforced with silicon carbide fibers is exceptionally strong, stiff, and light. Silicon nitride fibers made from silanes are being evaluated as reinforcing agents in materials used in gas turbine engines. Compared with fibers, silicon carbide whiskers, which are thinner and shorter than fibers, produce composites with greater fracture toughness, stiffness, and tensile strength. These metal matrix composites are expected to have applications in industries such as the aerospace industry where properties of light weight, high strength, and stiffness are prime considerations.

Rockwell International's Science Center has developed a high-strength, lightweight aluminum-silicon carbide composite with superplastic properties. Fine grain aluminum alloy 7475 is combined with silicon carbide whiskers and particulates. The composite is expected to have applications as a replacement for materials used in aerospace, ship, and missile structures. Cost savings of up to 33% and weight savings of 32% are projected.[23]

DOE supports research aimed at reducing the cost of photovoltaic power. The principal problem facing photovoltaic cell manufacturers is the high cost of single-crystal silicon, the material from which most solar cells are made. Solar-grade silicon is produced by advanced Siemens (trichlorosilane) methods, a costly process. Research is in progress to develop alternate lower cost processes for production of polycrystalline silicon.

Photovoltaic cells are not yet economical enough to compete with conventional power sources in the bulk power market. Single-crystal cells continue to dominate the industry. Despite substantial improvements recently achieved with the advanced Siemens processes, the need for a material considerably cheaper than single-crystal silicon is still a most important issue. Significant improvement in conversion efficiency is also mandatory before photovoltaic cells can become a viable source of electricity. Currently, research is being directed at the development of multijunction amorphous silicon cells, silicon concentrator cells, and other types of amorphous thin-film technology, which may meet the cost and efficiency thresholds needed for bulk power generation.[24]

Application of plasma technology (the direct-current (dc) electric arc furnace) has progressed beyond the pilot plant stage. The plasma process is being investigated for application in the production of silicon ferroalloys and silicon metal. There is at least one dc electric arc furnace in full production in the Republic of South Africa using this innovative technology to produce high-carbon ferrochromium from ore. Other countries are also assessing plasma technology. A plasma is generated by ohmic heating of a neutral or chemically reactive gas by means of an electrical discharge (arc) struck between two electrodes. There are two different modes by which the arc may be formed and heat transferred to the charge: (1) transferred-arc mode, in which the material being processed is one of the electrodes, and (2) nontransferred arc mode, in which both electrodes are confined in a single device, from which the plasma is blown into a reactor by passing a flow of gas through the device. The most important feature of the plasma furnace is that it can process ore fines directly, without prior briqueting or pelletizing, a costly process normally required for conventional submerged arc electric furnaces. Other advantages claimed for the dc arc plasma furnace include use of low-cost coal in place of more expensive coke, less noise pollution, and lower electrode consumption.

The Idaho National Engineering Laboratory is conducting research for the Bureau of Mines on metal-gas reactions in thermal plasmas. The objective of this ongoing research program is to obtain a better understanding of physical and chemical phenomena in the thermal plasmas.[25]

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[1]Physical scientist, Division of Ferrous Metals.

[2]The Tex Report. V. 16, No. 3825, Oct. 30, 1984, p. 18.

[3]Mining Journal. V. 303, No. 7780, Sept. 28, 1984, p. 223.

[4]Iron Age. V. 227, No. 20, Oct. 15, 1984, p. 21.

[5]Metal Bulletin (London). No. 6933, Oct. 30, 1984, p. 21.

[6]———. No. 6946, Dec. 14, 1984, p. 15.

[7]European Chemical News. V. 42, No. 1129, Apr. 30, 1984, p. 10.

[8]Metal Bulletin (London). No. 6924, Sept. 28, 1984, p. 17.

[9]Metal Bulletin Monthly. No. 167, Nov. 1984, pp. 21-23.

[10]Metal Bulletin (London). No. 6943, Dec. 4, 1984, p. 14.

[11]Chemical Week. V. 135, No. 13, Sept. 26, 1984, p. 41.

[12]Metal Bulletin (London). No. 6951, Jan. 8, 1985, p. 15.

[13]———. No. 6938, Nov. 16, 1984, p. 17.

[14]European Chemical News. V. 42, No. 1118, Feb. 13, 1984, p. 8.

[15]———. V. 42, No. 1124, Mar. 26, 1984, p. 12.

[16]Metals Week. V. 55, No. 34, Aug 20, 1984, p. 7.

[17]Chemical & Engineering News. High-Tech Ceramics. V. 62, No. 28, July 9, 1984, pp. 26-40.

Industrial Minerals (London). No. 200, May 1984, pp. 155-167.

[18]Metal Progress. V. 125, No. 1, Jan. 1984, pp. 89-92.

[19]American Metal Market. V. 92, No. 104, May 28, 1984, p. 8.

[20]———. V. 92, No. 94, May 14, 1984, p. 11.

[21]Chemical Marketing Reporter. V. 225, No. 8, Feb. 20, 1984, p. 9.

[22]American Metal Market. V. 92, No. 10, Jan. 16, 1984, p. 11.

[23]Work cited in footnote 2.

[24]Pizzini, S., and C. Calligarich. On the Effect of Impurities on the Photovoltaic Behavior of Solar-Grade Silicon. J. Electrochem. Soc., v. 131, No. 9, Sept. 1984, pp. 2128-2132.

Maycock, P. D., and E. N. Stirewalt. Photovoltaics: Sunlight to Energy in One Step. Brick House Pub. Co., Andover, MA, 1985, 274 pp.

[25]Idaho National Engineering Laboratory (Dep. of Energy). Strategic and Critical Materials Program Annual Report (contract JO134035). BuMines OFR 79-85, May 1984, pp. 51-104; for information contact W. N. Fitch, senior staff scientist, Div. of Extractive Metallurgy Technology, Bureau of Mines, Washington, DC.

Silver

By Robert G. Reese, Jr.[1]

Domestic mine production of silver remained about the same in 1984 as in 1983 despite a general falling silver price. Exploration for new precious metals deposits continued both domestically and in foreign countries because the silver price, even though declining, remained relatively high when compared with historical silver prices and with other base metal prices in 1984. World mine production of silver increased, reflecting the continued need by some countries to earn foreign exchange for debt servicing, and because currency devaluation in terms of the U.S. dollar moderated the impact of the falling silver price.

Despite a robust U.S. economic growth rate, silver consumption for industrial uses declined, especially for jewelry and sterlingware, with some analysts attributing the lower consumption in these end uses to the changing styles and tastes of the U.S. consumer.

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,

Table 1.—Salient silver statistics

	1980	1981	1982	1983	1984
United States:					
Mine production thousand troy ounces	32,329	40,683	40,248	43,415	44,440
Value thousands	$667,278	$427,922	$319,975	$496,671	$361,773
Percentage derived from:					
Precious metals ores	51	54	68	76	80
Base-metal ores	49	46	32	24	20
Placers	(1)	(1)	(1)	(1)	(1)
Refinery production:					
Domestic and foreign ores and concentrates thousand troy ounces	39,353	47,007	44,170	50,450	49,019
Secondary (old scrap) do	53,131	39,067	27,171	25,549	24,070
Exports:					
Refined do	57,206	15,131	12,876	13,658	10,340
Other do	23,645	12,772	12,594	18,294	14,108
Imports for consumption:					
Refined do	64,859	75,921	96,917	161,199	93,546
Other do	13,936	18,194	20,541	18,692	21,420
Stocks, Dec. 31:					
Industry do	17,255	20,875	20,467	r17,536	21,173
Futures exchanges do	120,798	96,511	106,182	151,232	137,631
Consumption:					
Industry and the arts do	124,694	116,670	118,840	r116,464	114,841
Coinage do	72	179	1,846	2,128	2,665
Price, average per troy ounce[2]	$20.63	$10.52	$7.95	$11.44	$8.14
Employment[3]	2,400	3,600	2,900	2,400	2,600
World:					
Mine production thousand troy ounces	r342,804	r359,571	381,533	p392,268	e398,554
Consumption:[4]					
Industry and the arts do	354,500	336,800	348,700	348,000	371,000
Coinage do	13,700	9,000	12,800	18,600	8,300

eEstimated. pPreliminary. rRevised.
1Less than 1/2 unit.
2Handy & Harman.
3Mine Safety and Health Administration.
4Market economy countries only. Source: Handy & Harman.

copper, lead, and zinc. Of the 180 lode silver operations to which a survey form was sent, 64% responded, representing 93% of the total U.S. mine production figures shown in tables 1, 2, 3, 5, 6, and 7. Production for the remaining 65 firms was estimated using prior reported production levels adjusted for economic trends and other sources, such as company annual reports, news or journal articles, or State agency reports.

Legislation and Government Programs.—Public Law 98-525, Department of Defense Authorization Act, 1985, signed by the President on October 19, 1984, terminated all previous authority to dispose of material in the National Defense Stockpile effective September 30, 1984. Section 902 of the law authorized the disposal of 10 million troy ounces of silver from the stockpile effective October 1, 1984. Actual disposal of silver under the authority of this law was deferred until the President submitted to Congress the report required by Public Law 97-114, The Defense Appropriation Act of 1982. Contained in Public Law 97-114 was a requirement for the President to redetermine whether the silver in the stockpile is excess to U.S. defense needs, and to submit to Congress a report containing an analysis of defense requirements, an analysis of disposal methods for any excess silver, and a recommended method of disposal. The report had not been submitted to Congress by yearend 1984.

The U.S. Department of the Treasury continued sales of gold and silver coins commemorating the 1984 Summer Olympics held in Los Angeles, CA. Preliminary data indicated that 2.6 million ounces of silver was used to manufacture 3.4 million Olympic silver coins during 1984. Treasury reported that sales of the gold and silver coins had generated nearly $68 million in profits by yearend, which were divided between the U.S. Olympic Committee and the Los Angeles Olympic Organizing Committee.

DOMESTIC PRODUCTION

Silver production was reported at 143 mines, including 12 placer operations. Silver was produced from precious metals ores at 88 mines, while 43 mines produced silver as a byproduct of the processing of copper, lead, and zinc ores. The 25 largest mines accounted for 90% of total domestic mine output. In 1984, 13 mines each produced more than 1 million ounces of silver, which when aggregated, equaled 74% of the total domestic production.

In general, 1984 was a year of mixed activity in the precious metals mining industry. Relatively high gold and silver prices, compared with other base metal prices and with gold and silver prices before 1980, continued to encourage companies to explore for precious metals deposits, primarily in the Western States of California, Idaho, and Nevada. Development work at several silver projects was completed, and these new mines began production during the year. However, a number of mines producing byproduct silver closed in the second half of the year as a result of declining precious metals prices and continued low copper and lead prices.

Alaska.—Noranda Mining Inc. submitted a revised environmental impact statement to the U.S. Forest Service after requesting that over 17,000 acres near its main silver-lead-zinc ore deposit at Greens Creek be excluded from the Admiralty Island National Monument. The 1980 Alaska National Interest Lands Conservation Act required that all exploration work within the monument be completed and any resulting mine claims be patented by yearend 1985. Removal of the 17,000 acres from the monument would eliminate the time deadline for exploration of the area and enable Noranda to explore the land in conjunction with its underground mining operations.

Cominco Ltd. awarded a contract near midyear to Dames and Moore Inc. for the geotechnical investigation and design of the tailings and water dams for the proposed Red Dog lead-zinc-silver mine. Cominco also awarded contracts for drilling at the project to Interstate Exploration Inc. and Nana-Coates Drilling Co. Cominco and its partner, NANA Development Corp., applied for a right-of-way across the Cape Krusenstern National Monument to connect the Red Dog deposit with a proposed port on the Chukchi Sea. Approval of the proposed right-of-way had not been obtained by yearend.

An informal survey of Alaskan silver producers by the Alaska State Division of Geological and Geophysical Surveys indicated that over 20,000 ounces of silver was produced in Alaska during the year, compared with less than 3,000 ounces reported to the Bureau of Mines on a voluntary basis by producers.

Arizona.—The Bagdad Mine, a copper-molybdenum-silver-gold property owned by Amoco Minerals Co., was closed early in the year and reopened in November after operations at the mine were restructured. Operating costs were reduced through development of a new mining plan to reduce overburden removal, by negotiating new smelting contracts, and by obtaining a power rate concession from the Arizona Public Service Co. About 350 workers were recalled in late October, and the mine was operating at capacity by yearend.

ASARCO Incorporated closed its Sacaton copper-silver-gold and Silver Bell copper-silver mines during 1984. The Sacaton Mine was closed near midyear reportedly because reserves minable by open pit methods were exhausted. The Silver Bell Mine was closed in mid-August because of low copper prices, according to company officials.

Current employees at Phelps Dodge Corp.'s Arizona operations, many of which produce byproduct silver, voted during the fourth quarter to decertify the United Steelworkers of America union as their bargaining agent. Members of the union had been on strike at the facilities for over a year and were declared ineligible to vote on the decertification issue.

Anamax Mining Co. officials began hiring replacements in September for workers who had been on strike at the company's Twin Buttes Mine for over a year. The company reportedly gave the striking workers the opportunity to be rehired at the copper-silver-molybdenum operation under the company's new economics package, which included wage and benefit reductions.

Colorado.—Hecla Mining Co. halted mining and milling operations at the Sherman lead-silver mine on September 14 because of low silver and lead prices. Near the end of December, Hecla reached an agreement with Leadville Corp. allowing Leadville to purchase Hecla's 50-year operating lease of the mine for $1.5 million. The mine remained closed through yearend. Silver production at the mine was reported at 530,000 ounces for the year.

Standard Metals Corp., owners of the Sunnyside Mine, filed for reorganization under chapter 11 of the Federal Bankruptcy Code on March 5. The filing was reportedly caused by losses in the company's pipelaying and lead smelting subsidiaries. Production of gold and silver at the mine continued throughout the year.

Idaho.—Silver production began at a number of mines in the State during the year. The Blackstone Mine, an open pit operation owned by Circa Inc., began production near the end of February. Initial production averaged nearly 200 ounces of silver per day. The Canyon Silver Mine, closed since 1973, returned to production in May. The property was leased from Canyon Silver Mines Inc. in late 1982. Production through yearend 1984 averaged 500 short tons of silver-lead-zinc ore per month. Goldsil Resources Ltd. began heap leaching at its Diamond Hill Mine in late August. The Estes Mountain Mine, owned by U.S. Antimony Corp., began production during October at a rate of 50 tons of ore per day. The Star-Morning Mining Co. obtained a lease in June to reopen and mine a section of the Star Mine. The mill at the mine was rehabilitated and underground work begun by yearend.

Workers at the Galena Mine, operated by Asarco, voted in January to extend their existing labor contract with the company for an additional 3 years. The new contract did not provide for a wage increase; however, cost-of-living adjustments were retained. Asarco reported that 4.2 million ounces of silver was produced at the Galena Mine.[2] Workers at the Lucky Friday Mine agreed to a new labor contract in April. The agreement between employees and Hecla established a two-tiered wage system at the mine, with workers hired after March 31, 1984, receiving the lower wages. Silver production at the Lucky Friday Mine was 4.8 million ounces.[3]

Mining operations at the Clayton Mine, owned by Clayton Silver Mines Inc., resumed in early 1984 after the company installed a larger capacity pumping system. The silver-lead-zinc mine was closed in late October 1983 by an earthquake, which stimulated an increased waterflow into the mine, flooding the lower levels.

A suit by Continental Materials Co. against Superior Oil Co. and Earth Resources Co. over the profit distribution from the DeLamar gold-silver mine was partially settled by an out-of-court agreement in March. Continental and its subsidiary, Continental Quicksilver Inc., owned a 7.5% net profit interest in the mine. Superior agreed to pay Continental for the amounts claimed through September 1983, and to make quarterly payments of the percentage of profits Superior owed the company. Continental reached an out-of-court settlement with

Earth Resources in mid-September. Continental agreed to sell a 3.9% net profit interest in the mine to Earth Resources for $2.1 million. NERCO Inc. bought Earth Resources' controlling operating interest in the mine in October.

Hecla sold its interest in the Sunshine Mine to the Sunshine Mining Co. as part of the agreement between Hecla and Sunshine, which allowed Hecla to acquire Ranchers Exploration & Development Corp. Acquisition of Hecla's 25% share increased Sunshine's interest in the mine to 75%. In 1984, Sunshine celebrated the centennial anniversary of mining at the Sunshine Mine. Silver production was reported at 4.8 million ounces.[4]

Asarco reported that 2.5 million ounces of silver was produced at the Coeur Mine.[5] Bunker Limited Partnership announced that the silver concentrates produced at the Crescent Mine were being shipped overseas for processing and that production at the mine had increased owing to improved efficiency. Shaft development at Callahan Mining Corp.'s Caladay project continued.

Montana.—Asarco submitted a plan of operation to the U.S. Forest Service and the Montana Department of State Lands near midyear, as the first step in obtaining the necessary permits to develop the Rock Creek project. The Rock Creek deposit, which contains silver-copper ore, is primarily in the Cabinet Mountains Wilderness Area and was compared by the company geologically with the deposit at the Troy Mine. The plan of operations proposed that all mining be done using underground methods similar to those used at the Troy Mine and that all major surface facilities be outside the wilderness area. Asarco estimated that the permitting process could take at least 2 more years, and when fully operational, the mine would employ 375 workers.

Asarco reported that 3.0 million ounces of silver was produced at the Troy Mine in 1984.[6] Heap leaching at the Zortman Mine produced 61,200 ounces of silver and 31,500 ounces of gold during the year.[7]

Nevada.—Silver production began at a number of new mines during the year. Rayrock Mines Inc. opened the Dee Mine, a gold operation with some byproduct silver, on October 18. The mine is an open pit operation at which both heap leaching and carbon-in-pulp processes are used for ore treatment. Duval Corp. began shipments of gold-silver bullion from its Fortitude Mine in December. Standard Slag Co. began production at the Lewis Mine in Humboldt County in August. Standard's gold-silver heap leach operation was unique because for the first time partial financing for development of a mine was obtained through the use of State-authorized Industrial Development Bonds.

Homestake Mining Co. acquired a 25% interest in the Round Mountain Mine through its merger with Felmont Oil Co. The mine's capacity was increased from 11 million tons of overburden and gold-silver ore to 17 million tons through the addition of larger size loading and haulage equipment during the year. NERCO purchased the 50% nonoperating interest of Agnew Enterprises Inc. in the Taylor Mine during the year. The Taylor Mine was closed on December 31 because of low silver prices, according to the company. Silver production at Sunshine's Sixteen-to-One Mine was reported to be 837,000 ounces.[8]

Other States.—Workers struck the byproduct silver mines in the Missouri Lead Belt near midyear. During the strike period, supervisors and nonstriking workers maintained some production from the mines. Agreements to end the strikes were negotiated in December. Hecla obtained control of the Escalante Mine in Utah through its acquisition of Ranchers Exploration & Development. The Escalante Mine produced 2.2 million ounces of silver.[9] The Deer Trail Mine in Washington was closed in early September because of low silver prices. Hecla reported that the Knob Hill Mine in Washington produced 80,967 ounces of silver during the year.[10]

CONSUMPTION AND USES

U.S. industrial consumption of silver declined in 1984 to its lowest level since 1963, when consumption was estimated at 110 million ounces by the U.S. Bureau of the Mint. The decline in consumption was led by lower silver usage in jewelry and sterlingware, which some analysts attributed to the changing tastes of U.S. consumers. Continued low U.S. inflation rates and the possibility of higher monetary returns from other investments may also have been factors in the decline of jewelry and sterlingware consumption. Silver consumption for contacts and conductors also declined. The lower consumption in this end use was probably due in part to the declining demand for some prestige electronic products, such as personal computers.

U.S. silver consumption for photographic materials recovered significantly reflecting the recovery in the U.S. economy.

STOCKS

Refiner, fabricator, and dealer stocks declined during the first half of 1984 to 16.3 million ounces from 17.7 million ounces at yearend 1983. During the second half, industrial stocks increased to 21.1 million ounces. The fluctuations in industrial stock levels were due in part to movement in the silver price and continued high U.S. interest rates, which affected the cost of holding silver stocks.

Silver depository stocks held by Commodity Exchange Inc. (COMEX) decreased to 113.6 million ounces by the end of May from 127.4 million ounces at yearend 1983, then increased to 120.9 million ounces at the end of June before declining to 114.5 million ounces at the end of October. COMEX stocks increased during the remainder of the year, but remained lower than at yearend 1983. The depository stocks held by the Chicago Board of Trade (CBT) continued to increase in early 1984, reaching 25.5 million ounces by the end of January. CBT stocks remained near this level through May, then from June through December gradually declined, finishing the year much lower than at yearend 1983.

PRICES

Other than for a slight rally during February and early March, the silver price continued the downward trend begun in mid-1983. Analysts attributed the weakness in the silver price during January to factors such as the strength of the U.S. dollar in terms of foreign currency exchange rates, a continued low U.S. inflation rate, and relatively high U.S. interest rates. Increased Mideast tension from an escalation of the Iran-Iraq war, forecasts of a rising U.S. inflation rate and larger Government budget deficits, and a slight weakening of the dollar were believed to have been the factors causing the silver price to rise during February. From March through December, the silver price drifted lower as the U.S. dollar continued to increase in value in relation to other currencies, and U.S. interest rates remained relatively high. The strong dollar created negative pressure on silver and other commodity prices by making U.S. goods and services more expensive to foreign buyers, thereby reducing the demand for U.S. products. The relatively high U.S. interest rates made interest-bearing investments more attractive by providing the investor with a definite monetary return at a time of low daily price volatility for silver. U.S. interest rates also discouraged investment in silver by making the cost of borrowing money for purchases relatively high. The rate of decline in the silver price increased during November and December according to analysts because of reduced inflation expectations owing to rapidly falling world oil prices.

The silver price followed the same pattern on the London Metal Exchange as in the United States. The price began the year at \$8.96 per ounce and declined during the first half of January before rising to its peak for the year of \$10.11 on March 5. During the remainder of 1984, the price gradually declined, reaching the low for the year of \$6.22 on December 20. The yearend price was \$6.29, while the average for the year was \$8.14 per ounce.

Futures contracts representing 33.7 billion ounces of silver were traded on COMEX, an increase of 1.6 billion ounces over the volume traded in 1983. After receiving permission from the Commodity Futures Trading Commission, COMEX began trading options on its silver futures contract during October. Each option entitled the holder to either buy or sell one COMEX futures contract representing 5,000 ounces of silver at a given price for a certain period of time. The silver trading volume at the CBT declined by nearly 900 million ounces to 1.9 billion ounces in 1984, in part because the CBT discontinued trading its 5,000-ounce silver contract. Silver futures trading on the Mid-America Commodity Exchange represented 32 million ounces in 1984, a significant decrease from the 127 million ounces traded in 1983.

FOREIGN TRADE

The strong U.S. dollar was probably the primary factor in the decline of U.S. silver exports in 1984. In 1983, the United Kingdom was the largest recipient country of U.S. silver exports; however, in 1984, the British pound was among the market economy countries' currencies that declined most relative to the U.S. dollar, and exports of silver to the United Kingdom fell by nearly 80% from that of 1983. Silver exports to countries such as Canada and Japan, whose currencies depreciated by smaller amounts than most countries, in terms of the U.S. dollar, remained near the same levels as in 1983.

U.S. imports of silver for consumption declined, in part because of the weakness in industrial consumption of silver, and because of lower demand for the metal as an investment by individuals. The most significant decrease was in imports of refined bullion from the United Kingdom, which fell by more than 62 million ounces. Imports of refined bullion from Canada, Mexico, and Peru, the major source countries, increased by 1.3 million ounces, 8.8 million ounces, and 100,000 ounces, respectively.

Imports for consumption of doré and precipitates more than doubled. The most significant increases in shipments of doré and precipitates were recorded by Chile, 885,000 ounces; Canada, 723,000 ounces; the Dominican Republic, 667,000 ounces; Guatemala, 656,000 ounces; Mexico, 487,000 ounces; and Peru, 343,000 ounces.

The United States was a net importer of silver. Net import reliance calculated as a percentage of apparent consumption was approximately 59%.

WORLD REVIEW

World mine production of silver increased slightly, in part because of the continued need by many developing countries to earn foreign exchange for debt repayment, and because foreign currency devaluations in terms of the U.S. dollar moderated the impact of the falling silver price on corporate earnings. Exploration for precious metals deposits continued to be very active, especially in Australia and Canada. Projects to reduce unit costs of production were either completed or initiated by many producers during the year. However, as in the United States, a number of byproduct silver mines temporarily closed for part of the year to reduce inventories or because of low prices for other coproduct metals such as copper and lead.

Reported estimates of the total consumption of silver by market economy countries totaled 379.3 million ounces, an increase of 11.2 million ounces over the revised figures for 1983.[11] Of the 379.3 million ounces consumed, 371 million ounces was used in industrial applications, an increase of 21.5 million ounces over the 1983 level. The remaining 8.3 million ounces was used for coinage. Privately held bullion stocks increased by 52.1 million ounces during the year.

The total silver required for industry, coinage, and bullion stocks by all market economy countries, including the United States, exceeded their primary production by 116.2 million ounces. The shortfall was met with silver obtained from the following sources: old scrap, 75.1 million ounces; outflow from stocks held in India, 32.1 million ounces; demonetized coin, 4 million ounces; and withdrawals from Government stocks, 5 million ounces.

Australia.—Aberfoyle Ltd. reported that nearly 219,000 tons of ore was produced at the Que River Mine in Tasmania.[12] The output was only slightly lower than the 240,000 tons produced in 1983 despite an 11-week strike in 1984 over the miners' contract wages. Ore grades at the zinc-lead-silver-gold mine were 14.9% zinc, 8.6% lead, 8.2 ounces of silver per ton, and 0.1 ounce of gold per ton.

MIM Holdings Ltd. reported that it was able to maintain production for its various commodities despite a 16% reduction in its work force. The company instituted restrictions on new hiring and the replacement of employees who resigned, and offered an early retirement package to those workers over 55 years old as a means of reducing production costs. At the Mount Isa Mine in Queensland, a record high 4.5 million tons of ore was treated during the fiscal year ended June 30, 1984. Refined silver production at Mount Isa was nearly 12.1 million ounces during fiscal year 1984, an increase of nearly 1.2 million ounces over that of fiscal year 1983. At the Teutonic Bore Mine, in which MIM has a 40% interest, 426,000 ounces of silver in concentrate was produced during fiscal year 1984.

Production at the North Mine in New South Wales was 418,000 tons of ore grading 6.2 ounces of silver per ton for the fiscal year July 1, 1983, to June 30, 1984, according to North Broken Hill Holdings Ltd.'s annual report.[13] The production for fiscal year 1984 was 79,000 tons less than that of fiscal year 1983 and was attributed to a strike at the mine during April and May during which 34 days of production were lost. The strike was settled on May 18, 1984, by a new labor agreement that allowed the company to reduce the number of workers assigned to a drilling machine, to stope on weekends, and to make more efficient use of maintenance and mill personnel in exchange for increased pension benefits, a 2-hour reduction in surface working hours to 38 per week, and increased earnings for workers. In January 1984, tailings dump retreatment operations began at the mine. For fiscal year 1984, the mill at the North Mine processed 416,000 tons of ore and produced 2.1 million ounces of silver in lead and low-grade concentrate.

In June, North Broken Hill announced an offer to acquire the remaining stock of EZ Industries Ltd. that it did not already own. By the close of the takeover offer on September 7, North Broken Hill held 95.57% of EZ's issued capital. EZ reported that 784,000 tons of ore grading 6.9 ounces of silver per ton was produced at the Elura Mine in New South Wales during its first full year of operation (July 1, 1983, to June 30, 1984). The mill at the Elura Mine produced over 49,000 tons of silver-lead concentrates with an average silver content of nearly 46 ounces per ton in fiscal year 1984.

Phelps Dodge reached an agreement in September to sell its one-third interest in the Woodlawn Mine to CRA Ltd. of Australia, a coowner of the mine. Placer Development Ltd. reduced its interest in Kidston Gold Mines Ltd. to 70% from 80%. Kidston developed the Kidston Mine in Queensland. Placer must reduce its interest in Kidston by an additional 15% by March 1986 to comply with Australia's foreign investment guidelines.

At the Mount Lyell Mine in Tasmania, nearly 2 million tons of ore was milled and more than 1.7 million ounces of silver in concentrate was produced during 1984.

Canada.—Asarco closed the Buchans Mine in October following the exhaustion of the mine's ore reserves. The lead-zinc-silver mine in Newfoundland had been closed in December 1981 but was reopened in mid-1983. Approximately 180 employees were affected by the closure. Asarco reported that 244,000 ounces of silver in concentrate was produced from the milling of 102,000 tons of ore during the year.[14]

Cominco reported that a record high amount of ore was mined at the Sullivan Mine in British Columbia. Of the 2.7 million tons of ore milled during the year, 60% of the material was mined using mobile rubber-tired mining equipment, reflecting the results of the recent mechanization project at the mine. Other factors in achieving the record high production were the use of large-diameter blasthole drilling and blasting techniques, and improvements to the crushing and conveying systems. The average grade of the ore milled was 1.7 ounces of silver per ton.

On September 20, 1984, Cominco announced that it would reduce its holdings in Pine Point Mines Ltd. by selling 800,000 shares of Pine Point's stock. The sale was completed in January 1985, and Cominco's interest in the company was reduced from 69% to 51%. Cominco reported that productivity was increased significantly at the Pine Point Mine in the Northwest Territories through the use of larger shovels and trucks. Operations at the concentrator were suspended for 11 days at the end of December to reduce inventories.

Operations at Cominco's Polaris Mine in the Northwest Territories were suspended for 1 month in mid-December because of low metal prices.

At the Trail, British Columbia, smelter-refinery complex, Cominco reported that 10,609,200 ounces of refined silver was recovered from company-produced and purchased concentrate.[15] In 1983, 10,235,000 ounces of refined silver was produced at Trail.

The Silvana Mine, owned by Dickenson Mines Ltd., returned to production on September 6, 1984. The mine had been closed in mid-December 1983 because of low silver prices and an unsuccessful exploration program. Exploration was successful in locating and outlining a new ore zone in early 1984. During the 4 months of operation, 8,137 tons of ore was milled and 170,000 ounces of silver was produced at the mine.[16]

Newmont Mining Corp. reported that 206,898 ounces of silver was produced from the treatment of 7,183,000 tons of ore at the Similkameen Mine in British Columbia.[17] A new labor agreement effective through 1987 with slightly lower wage rates was negotiated for the mine during the year. Silver production at the Fox and Ruttan Mines, in which Newmont has a 34.7% interest, was reported as 143,684 ounces and 214,942 ounces, respectively.

Noranda reported that 12,207,000 ounces of silver was produced at its operations.[18] The largest producing mines were the No. 12 Mine of Brunswick Mining and Smelting Corp. Ltd. (6.6 million ounces), in which Noranda has a 64% interest; the Lyon (1.9 million ounces) and Geco Mines (1.4 million ounces), 100% owned by Noranda; and the Mattabi Mine (1.2 million ounces), 60% owned by Noranda. At Noranda's CCR refinery, 24.2 million ounces of refined silver was produced, an increase of 1.8 million ounces compared with 1983 output.

Northgate Exploration Ltd. reached an agreement with workers at its Copper Rand and Portage Mines in Quebec. The agreement did not provide for an increase in basic wages, but included a partial cost-of-living adjustment. The tonnage of ore mined at the Copper Rand Mine declined because of the company's emphasis on grade control as a means of enhancing gold production. Construction of a new cyanidation plant adjacent to the Copper Rand mill was begun during the year in order to eventually increase the gold recovery of the operation. Reported silver production was Copper Rand Mine, 90,119 ounces, and Portage Mine, 41,796 ounces.[19]

Equity Silver Mines Ltd., a subsidiary of Placer, of Canada, produced 4,624,000 ounces of silver in concentrate during the year, 334,000 ounces less than in 1983.[20] The lower production was attributed in part to a metallurgical change in the type of ore mined, which resulted in a lower silver recovery. A new scavenger circuit at the Equity Mine is expected to increase the recovery of precious metals and partially offset the effects of the change in ore composition. Leaching operations at the mine were stopped in April 1984 because of lower impurities in the ore and a corresponding greater market acceptance of the unleached concentrates. The leaching facilities were being maintained on a standby basis at yearend.

United Keno Hill Mines Ltd. reported that company operations milled 72,400 tons of ore and produced 1,233,400 ounces of silver.[21] Underground production was from the Ruby Mine (5,300 tons) and the Husky S. W. Mine (3,900 tons). Surface production was from the Calumet 1-15 pit, Calumet 4-11 pit, and the Hector Fault pit. The Elsa Mine remained closed throughout 1984.

Westmin Resources Ltd. reported a lower mill throughput because of a 3-month dispute between management and labor. The mill processed 224,700 tons of ore grading 3.08 ounces of silver per ton. In 1983, mill throughput was 273,787 tons of ore grading 3.53 ounces of silver per ton. In 1984, approximately 72% of the ore processed was produced at the Lynx Mine, with the remainder produced at the Myra Mine. Productivity improvements made at the Lynx Mine during the year included the phasing in of bulk mining methods to replace the more costly cut-and-fill methods used in some areas of the mine and upgrading the mine's transportation system.

Mexico.—México, Desarrollo Industrial Minero S.A. (MEDIMSA) increased the total mill capacity at the San Martin Mine to 7,500 tons per day, through the installation of a new 4,850-ton-per-day concentrator. MEDIMSA also began a project during the year to expand the existing 1,400-ton-per-day mining and milling capacity of the Charcas Mine to 3,800 tons per day. MEDIMSA reported that its eight major silver producing mines had a combined output of 21.2 million ounces of silver, compared with 17.1 million ounces in 1983.

For the second year in a row, the Real de Ángeles Mine operated above its designed capacity. Minera Real de Ángeles S.A. de C.V. reported that 4.8 million tons of ore was produced yielding 9.0 million ounces of silver in concentrate. In 1983, 3.7 million tons of ore was milled and 7.8 million ounces of silver in concentrate was produced. The higher production in 1984 was due in part to higher mill throughput resulting from modifications to the flotation circuit. Silver recovery at the concentrator also improved slightly following the processing of the last of the stockpiled oxidized ore.

AMAX Inc. reported that silver production at the Fresnillo-Zimapan operations was 10.3 million ounces in 1984 compared with 9.0 million ounces in 1983. The capacity of the El Somberete Mine was increased to 6,800 tons of ore per day by Industria Minera México S.A. The mine is now capable of producing 5.6 million ounces of silver per year according to the company. Lacana Mining Corp. reported that its 30%-owned

Torres mining complex in Guanajuato produced over 4.2 million ounces of silver in 1984, and that its 40%-owned Encantada Mining Group, in Coahuila, produced over 1.8 million ounces of silver during the year.[22] In 1983, Torres produced 4.1 million ounces of silver, and Encantada, 1.8 million. Mexicana de Cobre S.A. received financing and loan guarantees from the U.S. Export-Import Bank to buy a $5.5 million conveyor system for the La Caridad Mine.

The Government of Mexico began marketing a 1-troy-ounce silver bullion coin in the United States during the year. The coins were limited production issues dated 1982, 1983, and 1984, and were legal Mexican tender.

Peru.—A project undertaken by Cía. Minera Arcata S.A. to expand the mill capacity of the Arcata Mine to 900 tons per day from 600 tons per day was completed. The quantity of ore treated increased 10.5% to 266,000 tons, yielding nearly 3.3 million ounces of silver, 5% more than that of 1983. The Caylloma Mine, in which Arcata has about a 35% interest, produced over 2.3 million ounces of silver.

Silver production at the Julcani Mine, operated by Cía. de Minas Buenaventura S.A., declined 300,000 ounces to 1.6 million ounces, in part because of labor problems. At the Orcopampa Mine, a project to increase mill capacity to 1,000 tons per day from 500 tons per day was begun during the year. Silver production at the Orcopampa Mine was 2.3 million ounces compared with 2.2 million ounces in 1983. At the Uchucchacua Mine, silver production declined to 2.6 million ounces from 2.9 million ounces in 1983, in part because of labor problems. A project to expand the capacity of the Uchucchacua concentrator to 30,000 tons per month from 21,000 tons per month was begun during the year.

At Empresa Minera del Centro del Perú (Centromín Perú), silver production increased to 13.2 million ounces compared with 11.7 million ounces produced in 1983. The increased silver output was due primarily to increased production at the Cerro-San Expedito Mine, 1.1 million ounces compared with 100,000 ounces in 1983, and at the Cerro-Paragsha Mine, 3.2 million ounces compared with 2.7 million ounces in 1983. At Centromín Perú's La Oroya complex, production of refined silver increased despite labor problems and a terrorist attack. The metallurgical complex, which treats concentrates from both Centromín Perú and other companies, produced 23.6 million ounces of refined silver, a 1.9-million-ounce increase over that of 1983.

Southern Peru Copper Corp. (SPCC) reported that 2.5 million ounces of silver was produced at the Toquepala and Cuajone Mines.[23] Silver production at the two mines was significantly greater than the 2.1 million ounces produced in 1983, primarily because of fewer labor problems in 1984. During the year, over 19 million tons of ore from the Cuajone Mine was treated to produce 1.4 million ounces of silver. At the Toquepala Mine, treatment of 15.4 million tons of ore yielded 1.1 million ounces of silver. SPCC completed construction of an anode slime processing plant near its Ilo copper refinery in November. The plant was expected to recover 1.4 million ounces of silver per year. Through yearend, the plant produced over 73,000 ounces of silver.

Other Countries.—Bougainville Copper Ltd. announced that a 13th ball mill would need to be installed at the Bougainville Mine in Papua New Guinea to partially offset declining ore grades. Production began in mid-May at the OK Tedi Mine in Papua New Guinea. Operations at the mine were suspended several times during the year because of problems with the cyanidation process and the mine's tailings dam.

Creditor banks of the Philippines' Marinduque Mining & Industrial Corp. foreclosed on the company in August to recover various loans. The assets of the company, including the Sipalay Mine, a copper-silver producer, were subsequently sold by auction in September to the creditor banks.

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[1]Physical scientist, Division of Nonferrous Metals.
[2]ASARCO Incorporated. 1984 Annual Report. 32 pp.
[3]Hecla Mining Co. 1984 Annual Report. 32 pp.
[4]Sunshine Mining Co. 1984 Annual Report. 36 pp.
[5]Work cited in footnote 2.
[6]Work cited in footnote 2.
[7]Gold Reserve Corp. 1984 Annual Report. 16 pp.
[8]Work cited in footnote 4.
[9]Work cited in footnote 3.
[10]Work cited in footnote 3.
[11]Handy & Harman. The Silver Market, 1984. 68th Annual Report. 26 pp.
[12]Aberfoyle Ltd. 1984 Annual Report. 25 pp.
[13]North Broken Hill Holdings Ltd. 1984 Annual Report. 52 pp.
[14]Work cited in footnote 2.
[15]Cominco Ltd. 1984 Annual Report. 36 pp.
[16]The Dickenson Group. 1984 Annual Report. 33 pp.
[17]Newmont Mining Corp. 1984 Annual Report. 56 pp.
[18]Noranda Mines Ltd. 1984 Annual Report. 48 pp.
[19]Northgate Exploration Ltd. 1984 Annual Report. 32 pp.
[20]Placer Development Ltd. 1984 Annual Report. 40 pp.
[21]United Keno Hill Mines Ltd. 1984 Annual Report. 20 pp.
[22]Lacana Mining Corp. 1984 Annual Report. 29 pp.
[23]Southern Peru Copper Corp. 1984 Annual Report. 32 pp.

Table 2.—Mine production of recoverable silver in the United States, by State

(Troy ounces)

State	1980	1981	1982	1983	1984
Alaska	8,354	2,372	2,080	4,123	W
Arizona	6,267,588	8,055,231	6,309,327	4,491,532	4,093,036
California	49,257	53,286	34,048	26,899	W
Colorado	2,987,058	3,008,994	1,934,312	2,145,616	2,199,888
Idaho	13,694,902	16,545,648	14,830,351	17,684,278	18,869,186
Illinois	W	W	W	W	W
Michigan	W	W	W	--	--
Missouri	2,357,236	1,837,011	2,241,159	2,021,343	1,401,070
Montana	2,023,893	2,988,810	6,168,711	5,707,963	5,652,847
Nevada	939,997	3,039,480	3,142,263	5,163,724	6,477,032
New Mexico	W	1,632,346	804,594	W	W
New York	20,702	28,829	27,212	33,137	W
Oregon	841	7,487	--	856	W
South Carolina	--	W	--	--	--
South Dakota	51,257	55,792	26,241	62,314	50,036
Tennessee	W	W	W	W	W
Utah	2,203,289	2,882,671	4,342,333	4,566,610	W
Washington	W	67,390	W	W	W
Total	32,329,373	40,683,173	40,248,409	43,415,267	44,440,291

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	1980	1981	1982	1983	1984
January	3,271	3,062	3,643	3,198	3,761
February	3,365	3,404	3,283	3,148	3,884
March	3,280	3,408	4,039	3,873	4,188
April	3,335	3,314	3,733	3,778	4,013
May	3,006	3,151	3,713	3,772	3,878
June	3,163	3,315	3,568	3,864	3,767
July	1,993	3,577	3,090	3,685	3,563
August	1,741	3,408	2,987	3,852	3,707
September	1,776	3,503	3,014	3,659	3,234
October	2,074	3,795	2,889	3,505	3,650
November	2,144	3,354	3,241	3,511	3,312
December	3,181	3,392	3,048	3,570	3,483
Total	32,329	40,683	40,248	43,415	44,440

Table 4.—Twenty-five leading silver-producing mines in the United States in 1984, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Sunshine	Shoshone, ID	Sunshine Mining Co	Silver ore.
2	Lucky Friday	do	Hecla Mining Co	Do.
3	Troy	Lincoln, MT	ASARCO Incorporated	Do.
4	Galena	Shoshone, ID	do	Do.
5	Candelaria	Mineral, NV	NERCO Inc	Do.
6	Coeur	Shoshone, ID	ASARCO Incorporated	Do.
7	Escalante	Iron, UT	Helca Mining Co	Do.
8	DeLamar	Owyhee, ID	NERCO Inc	Gold-silver ore.
9	Utah Copper (Bingham).	Salt Lake, UT	Kennecott	Copper ore.
10	Taylor	White Pine, NV	Silver King Mines Inc	Silver ore.
11	Black Pine	Granite, MT	Black Pine Mining Co	Do.
12	Bulldog	Mineral, CO	Homestake Mining Co	Do.
13	Tyrone	Grant, NM	Phelps Dodge Corp	Copper ore.
14	Sierrita	Pima, AZ	Duval Corp	Do.
15	Sixteen-to-One	Esmeralda, NV	Sunshine Mining Co	Silver ore.
16	Morenci	Greenlee, AZ	Phelps Dodge Corp	Copper ore.
17	Crescent	Shoshone, ID	Bunker Limited Partnership	Silver ore.
18	Gooseberry	Storey, NV	Asamera Minerals (U.S.) Inc	Gold-silver ore.
19	Buick	Iron, MO	AMAX Lead Co. of Missouri	Lead ore.
20	Eisenhower	Pima, AZ	Eisenhower Mining Co	Copper ore.
21	San Manuel	Pinal, AZ	Magma Copper Co	Do.
22	St. Cloud	Sierra, NM	St. Cloud Mining Co	Silver ore.
23	Ray	Pinal, AZ	Kennecott	Copper ore.
24	Battle Mountain	Lander, NV	Duval Corp	Gold ore.
25	Magmont	Iron, MO	Cominco American Incorporated	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
1980	467	5,510,745	749,785	872,019	1,953,874	2,064,191	13,699,057
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	7,488,153	30,063,899
1984:							
Alaska	W	--	--	--	--	--	--
Arizona	--	W	W	W	W	W	W
California	W	W	W	W	W	--	--
Colorado	--	W	W	W	W	W	W
Idaho	--	W	W	W	W	955,704	17,099,485
Illinois	--	--	--	--	--	--	--
Missouri	--	--	--	--	--	--	--
Montana	--	7,767,871	170,149	W	W	3,291,610	5,471,140
Nevada	--	11,932,839	592,854	761,755	988,446	3,013,036	4,589,445
New Mexico	--	W	W	2,800	19,118	W	W
New York	--	--	--	--	--	--	--
Oregon	--	W	W	--	--	--	--
South Dakota	--	1,897,319	50,036	--	--	--	--
Tennessee	--	--	--	--	--	--	--
Utah	--	W	W	W	W	W	W
Washington	--	W	W	--	--	--	--
Total	3,703	24,581,032	1,333,227	1,587,850	2,890,407	7,804,144	31,328,954
Percent of total silver	([1])	XX	3	XX	7	XX	70

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
1980	220,293,487	11,135,824	10,080,986	2,534,828	370,702	20,956
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:						
Alaska	--	--	--	--	--	--
Arizona	126,305,079	3,727,075	W	W	--	--
California	--	--	--	--	--	--
Colorado	--	--	W	W	--	--
Idaho	--	--	W	W	--	--
Illinois	--	--	--	--	--	--
Missouri	--	--	5,234,776	1,401,070	--	--
Montana	--	--	--	--	--	--
Nevada	--	--	--	--	--	--
New Mexico	W	W	--	--	--	--
New York	--	--	--	--	W	W
Oregon	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--
Tennessee	--	--	--	--	W	W
Utah	W	W	--	--	W	W
Washington	--	--	--	--	--	--
Total	[2]164,345,710	[2]6,372,847	5,272,047	1,723,368	923,843	61,505
Percent of total silver	XX	14	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
1980	3,256,562	2,112,419	67,623	[3]122,163	242,516,315	32,329,373
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	208,222,243	43,415,267
1984:						
Alaska	--	--	--	--	--	W
Arizona	--	--	W	W	126,436,767	4,093,036
California	--	--	W	W	W	W
Colorado	W	W	--	--	880,966	2,199,888
Idaho	--	--	W	W	9,573,980	18,869,186
Illinois	--	--	W	W	W	W
Missouri	--	--	--	--	5,234,776	1,401,070
Montana	--	--	W	W	11,060,754	5,652,847
Nevada	--	--	W	W	22,836,171	6,477,032
New Mexico	--	--	--	--	W	W
New York	--	--	--	--	W	W
Oregon	--	--	--	--	W	W
South Dakota	--	--	--	--	1,897,319	50,036
Tennessee	W	W	--	--	W	W
Utah	--	--	--	--	W	W
Washington	--	--	--	--	W	W
Total	([5])	([5])	[6]15,377,223	[3 7]726,280	219,891,849	44,440,291
Percent of total silver	XX	([5])	XX	2	XX	100

W Withheld to avoid disclosing company proprietary data; included in "Total." XX Not applicable.
[1]Less than 1/2 unit.
[2]Includes copper-zinc ores and silver recovered from copper-zinc ores 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 ores and silver recovered from copper-zinc ores in Tennessee are included in totals for copper ore, and lead-zinc ores and silver recovered from lead-zinc ores in Colorado are included in total "Old tailings, etc."
[6]Includes lead-zinc ores in Colorado to avoid disclosing company proprietary data.
[7]Includes silver recovered from lead-zinc ores in Colorado 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 (short tons)	Silver recovered (troy ounces)	Ore treated (short tons)	Silver recovered (troy ounces)
1980	3,874,576	1,819,604	3,390,069	818,205
1981	4,434,835	2,579,957	7,413,219	2,047,709
1982	7,575,476	4,713,226	12,295,132	1,384,326
1983	[r]9,337,730	[r]5,893,270	12,687,440	2,185,551
1984	10,764,741	6,552,063	15,780,594	2,907,574

[r]Revised.
[1]May include small quantities recovered by leaching with thiourea, by bioextraction, and by proprietary processes.
[2]Includes 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: Ore treated (short tons)	Amalgamation: Silver recovered (troy ounces)	Cyanidation: Ore treated (short tons)	Cyanidation: Silver recovered (troy ounces)	Smelting of concentrates: Ore concentrated (short tons)	Smelting of concentrates: Concentrates smelted (short tons)	Smelting of concentrates: Silver recovered (troy ounces)	Smelting of ore: Ore smelted (short tons)	Smelting of ore: Silver recovered (troy ounces)	Total ore processed[1] (short tons)	Total silver recovered (troy ounces)
1980	[r]1,294	1,502	[r]7,264,645	2,637,809	[r]234,684,172	6,050,679	28,643,779	566,204	1,045,816	[r]242,516,315	32,328,906
1981	[r]790	6	[r]11,848,054	4,627,666	[r]296,500,821	7,157,354	34,815,156	486,916	1,238,506	[r]308,836,581	40,681,334
1982	--	--	[r]19,870,608	6,097,552	[r]202,892,296	5,256,363	33,467,476	353,088	681,369	[r]223,115,992	40,246,397
1983	[r]3,400	50	[r]22,025,170	8,078,821	[r]185,909,477	4,939,057	34,503,489	284,196	829,030	[r]208,222,243	43,411,390
1984:											
Arizona	--	--	W	W	126,279,237	2,427,092	3,735,433	W	W	126,436,767	4,093,036
California	--	--	W	W	W	W	W	W	W	W	W
Colorado	--	--	W	W	529,769	66,676	2,158,726	W	W	880,966	2,199,888
Idaho	--	--	W	W	8,742,707	65,258	17,145,181	W	W	9,573,980	18,869,186
Illinois	--	--	--	--	W	W	W	--	--	W	W
Missouri	--	--	--	--	5,234,776	512,770	1,401,070	--	--	5,234,776	1,401,070
Montana	--	--	7,767,869	169,960	3,289,474	50,822	5,462,114	3,411	20,773	11,060,754	5,652,847
Nevada	--	--	13,080,497	5,131,084	9,755,647	19,955	1,341,932	27	4,016	22,836,171	6,477,032
New Mexico	--	--	--	--	W	W	W	W	W	W	W
New York	--	--	--	--	W	W	W	--	--	W	W
Oregon	--	--	--	--	--	--	--	W	W	W	W
South Dakota	--	--	1,897,319	50,036	--	--	--	--	--	1,897,319	50,036
Tennessee	--	--	--	--	W	W	W	--	--	W	W
Utah	--	--	W	W	21,985,247	W	1,630,173	--	--	W	W
Washington	--	--	W	W	W	W	W	--	--	W	W
Total	--	--	26,545,335	9,459,637	193,193,346	4,108,185	34,498,868	153,168	478,083	219,891,849	44,436,588

[r]Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1]Includes old tailings. Excludes fluorspar, molybdenum, and tungsten ores from which silver was recovered as a byproduct and ores leached for recovery of copper.

Table 8.—U.S. refinery production of silver

(Thousand troy ounces)

Raw material	1980	1981	1982	1983	1984
Concentrates and ores:					
Domestic	36,171	44,487	43,825	50,281	48,892
Foreign	3,182	2,520	344	169	126
Total[1]	39,353	47,007	44,170	50,450	49,019
Old scrap	53,131	39,067	27,171	25,549	24,070
New scrap	65,642	44,738	37,812	41,839	45,513
Grand total[1]	158,127	130,812	109,153	117,838	118,602

[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]	1980	1981	1982	1983	1984
Electroplated ware	4,350	3,904	3,254	3,154	3,542
Sterlingware	9,082	4,407	6,579	7,022	3,638
Jewelry	5,893	5,368	6,260	6,885	5,773
Photographic materials	49,825	51,025	51,769	[r]51,827	55,322
Dental and medical supplies	2,212	1,709	1,688	1,532	1,569
Mirrors	672	581	970	970	970
Brazing alloys and solders	8,508	7,718	7,384	5,837	5,889
Electrical and electronic products:					
Batteries	5,976	3,803	4,167	[r]2,800	2,671
Contacts and conductors	27,796	26,411	27,730	26,298	25,633
Bearings	649	297	228	170	260
Catalysts	3,035	3,830	2,418	[r]2,424	2,448
Coins, medallions, commemorative objects	4,693	2,622	1,832	2,979	2,564
Miscellaneous[2]	2,005	4,995	4,562	4,567	4,562
Total net industrial consumption[3]	124,694	116,670	118,840	[r]116,464	114,841
Coinage	72	179	1,846	2,128	2,665
Total consumption	124,766	116,849	120,686	[r]118,592	117,506

[r]Revised.
[1]End use as reported by converters of refined silver.
[2]Includes silver-bearing copper, silver-bearing lead anodes, ceramics, paint, 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)

	1980	1981	1982	1983	1984
Industry	17,255	20,875	20,467	[r]17,536	21,173
Futures exchanges	120,798	96,511	106,182	151,232	137,631
Department of the Treasury	38,890	38,732	36,768	34,565	31,889
Department of Defense	4,510	3,810	1,750	100	342
National Defense Stockpile	139,500	137,500	137,500	137,500	137,500

[r]Revised.

Table 11.—U.S. silver prices[1]

(Dollars per troy ounce)

Period	Low	(date)	High	(date)	Average
1980	10.80	(May 22)	48.00	(Jan. 21)	20.63
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:					
January	7.90	(Jan. 11)	8.58	(Jan. 3)	8.18
February	8.70	(Feb. 13)	9.81	(Feb. 28)	9.13
March	9.34	(Mar. 23)	10.04	(Mar. 5)	9.65
April	8.90	(Apr. 30)	9.62	(Apr. 2)	9.22
May	8.63	(May 8)	9.26	(May 29)	8.97
June	8.33	(June 27)	9.44	(June 1)	8.74
July	6.90	(July 27)	8.30	(July 2)	7.42
August	7.90	(Aug. 1)	7.92	(Aug. 15)	7.61
September	7.02	(Sept. 17)	7.64	(Sept. 26)	7.26
October	7.14	(Oct. 9)	7.66	(Oct. 3)	7.32
November	7.02	(Nov. 30)	7.80	(Nov. 13)	7.49
December	6.26	(Dec. 20)	7.14	(Dec. 4)	6.69
Average	XX		XX		8.14

XX Not applicable.
[1]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
1980	307	5,925	21,074	526,577	2,264	50,353	57,206	1,326,878	80,851	1,909,733
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:										
Belgium-Luxembourg	355	3,004	2,026	17,814	1	13	92	846	2,473	21,675
Canada	255	2,011	3,611	30,239	92	754	4,609	38,700	8,568	71,704
France	--	--	2,639	22,122	27	265	8	52	2,675	22,439
Germany, Federal Republic of	398	2,991	350	2,486	103	906	488	3,333	1,339	9,716
Japan	(2)	20	10	66	211	1,994	4,171	34,474	4,392	36,554
Spain	--	--	569	4,440	60	415	120	800	749	5,654
Sweden	--	--	865	7,177	--	--	25	217	890	7,394
United Kingdom	--	--	1,906	17,569	197	1,871	73	725	2,176	20,165
Other	41	310	84	540	308	2,961	751	7,193	1,185	11,005
Total[1]	1,048	8,335	12,059	102,452	1,001	9,178	10,340	86,339	24,447	206,306

[1]Data may not add to totals shown because of independent rounding.
[2]Less than 1/2 unit.

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
1980	9,700	187,019	1,956	37,567	2,281	49,547	64,859	1,331,877	78,795	1,606,010
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:										
Brazil	391	3,219	8	74	3	42	68	609	471	3,942
Canada	360	2,149	231	1,948	952	7,982	35,161	288,949	36,704	301,028
Chile	540	4,523	338	3,406	2,825	27,428	2,263	19,771	5,966	55,128
Dominican Republic	--	--	3	43	1,460	11,615	--	--	1,463	11,658
Guatemala	--	--	32	216	656	6,003	653	5,972	1,341	12,192
Honduras	433	3,292	--	--	--	--	--	--	433	3,292
Japan	--	--	2	12	96	468	197	1,829	296	2,309
Korea, Republic of	--	--	--	--	32	257	684	6,136	716	6,393
Mexico	2,841	22,762	68	573	808	5,053	36,539	307,260	40,255	335,649
Peru	7,313	61,275	1	13	461	4,169	15,390	131,318	23,165	196,774
Philippines	108	656	27	207	--	--	258	2,235	393	3,098
Spain	139	1,157	--	--	--	--	725	6,227	864	7,385
Switzerland	--	--	1	4	91	745	405	3,439	497	4,187
United Kingdom	693	5,196	7	64	27	526	86	739	812	6,525
Uruguay	1	7	--	--	--	--	443	4,543	444	4,553
Other	201	1,350	187	1,314	86	613	673	5,812	1,147	9,086
Total[1]	13,018	105,587	903	7,871	7,499	64,901	93,546	784,838	114,966	963,198

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

Table 14.—Silver: World mine production, by country[1]

(Thousand troy ounces)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Algeria[e]	100	110	110	120	120
Argentina	2,357	2,518	2,684	2,500	2,500
Australia	24,654	23,906	29,156	33,849	32,000
Bolivia	6,099	6,394	5,472	6,025	4,920
Brazil[3]	[r]784	765	760	743	800
Bulgaria[e]	930	930	930	930	930
Burma	587	450	526	558	[4]576
Canada	33,340	36,298	42,246	35,559	[4]37,568
Chile	9,598	11,610	12,288	15,055	15,000
China[e]	2,500	2,500	2,500	2,500	2,500
Colombia[5]	152	143	136	99	100
Costa Rica[e]	2	2	2	2	2
Czechoslovakia[e]	1,300	1,300	1,300	1,300	1,300
Dominican Republic	1,623	[r]2,034	2,100	1,350	1,200
Ecuador	29	32	[e]10	(6)	(6)
El Salvador	146	137	86	22	25
Fiji	7	8	19	[e]15	18
Finland	[r]852	[r]823	694	868	870
France	[r]89	[r]88	115	[r] [e]120	120
German Democratic Republic[e]	1,510	1,450	1,450	[r]1,380	1,360
Germany, Federal Republic of	1,058	1,126	1,279	1,167	1,250
Ghana[e]	18	17	[4]17	14	14
Greece	1,672	1,945	1,582	1,797	1,800
Greenland	[r]547	[r]490	480	400	340
Guatemala[e]	10	8	8	8	7
Honduras	1,766	1,823	2,100	2,587	2,650
India[5]	366	555	463	469	800
Indonesia	701	830	1,134	1,135	1,120
Ireland	771	[r]596	352	320	300
Italy[5] [7]	1,366	1,768	1,791	2,361	2,000
Japan	8,603	9,010	9,843	9,877	[4]10,403
Korea, North[e]	1,600	1,600	1,600	1,600	1,600
Korea, Republic of	2,292	3,061	3,237	3,366	3,000
Malaysia (Sabah)	[r]439	[r]465	502	481	500
Mexico	50,052	52,916	59,175	63,607	67,800
Morocco	3,154	[e]2,120	[e]2,640	[e]2,850	[4]2,409
Namibia	3,365	3,456	2,812	3,535	[4]3,393
New Zealand	1	--	--	(6)	(6)
Nicaragua	164	140	76	63	50
Papua New Guinea	1,180	1,363	1,387	1,524	1,427
Peru	44,419	46,940	53,479	55,878	[4]56,534
Philippines	1,952	2,024	1,984	1,913	[4]1,593
Poland	24,627	20,576	21,123	21,798	22,000
Portugal	20	39	24	32	[4]28
Romania	900	850	[e]850	820	810
Solomon Islands	(6)	(6)	(6)	(6)	[4]--
South Africa, Republic of	[r]7,144	7,568	6,943	5,559	[4]6,997
Spain	4,526	5,347	3,787	1,496	2,000
Sweden	[r]5,337	[r]5,170	5,395	5,491	5,500
Taiwan	95	215	504	345	[4]364
Tunisia	235	84	115	90	100
Turkey[e]	200	200	220	220	220
U.S.S.R.[e] [5]	46,000	46,500	46,900	47,200	47,400
United States	32,329	40,683	40,248	43,415	[4]44,440
Yugoslavia[5]	4,790	4,437	3,343	3,987	[4]4,051
Zaire	2,733	2,580	1,751	[e]2,000	2,000
Zambia	764	714	887	933	[4]795
Zimbabwe	949	857	918	935	950
Total	[r]342,804	[r]359,571	381,533	392,268	398,554

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

[1]Recoverable content of ores and concentrates produced unless otherwise specified. Table includes data available through July 2, 1985.

[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]Partially revised officially reported output; 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): 1980—47; 1981—144; 1982—123; 1983—247; and 1984—not available.

[4]Reported figure.

[5]Smelter and/or refinery production.

[6]Less than 1/2 unit.

[7]Includes production from imported ores.

Slag—Iron and Steel

By Donald P. Mickelsen[1]

Domestic production of iron and steel slag increased moderately during the year. Sales and use of iron slag increased significantly, while sales and use of steel slag increased only moderately. Air-cooled 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 blast furnace slag was used mainly for road base, fill, concrete aggregate, and as asphaltic concrete aggregate. The main growth areas for iron slag include replacement for cement in concrete construction, use in bituminous mixtures, and use in lightweight concrete applications. Steel slag was typically used as road base and fill. The average unit value of blast furnace slag increased 6% and steel slag increased 9% in unit value over that of 1983.

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 77 operations canvassed, 68, or 88%, responded, representing 98% of the total sales or use data shown in table 1. Data for the nine nonrespondents were estimated by using reported prior year sales and use levels adjusted by trends in the industry and other guidelines.

DOMESTIC PRODUCTION

Iron and steel slag production increased in accordance with the increase in iron and steel production over that of 1983. Sales and end use of blast furnace slag increased significantly, and that of steel slag increased moderately compared with that of 1983. This was attributed to a combination of increases in construction activity in certain areas of the country, increases of available funds for highway construction, and the increased use of iron slag as a replacement for cement. According to the U.S. Department of Commerce, total new construction was 12% higher in 1984, and new highway and bridge construction was up nearly 15%. This was the result of increased Federal funding owing to an additional 5-cent-per-gallon Federal tax on motor fuels, increased State gasoline taxes in 1981-83, and moderation of highway construction costs.[2] In general, most processors showed strong sales increases, especially many of the larger operations.

Blast furnace slag sold or used increased 24% in quantity and 32% in value compared with that of 1983, totaling 16.8 million short tons valued at $85.4 million. Fifty-four percent of this, in decreasing order, was marketed in Pennsylvania, Indiana, and Ohio. Of the total blast furnace slag sold or used, 91% was air cooled. During 1984, 38 plants processed iron slag, and 2 were inactive. Steel slag sold or used totaled 5.3 million tons valued at $17.3 million, up 9% in quantity and 19% in value compared with that of 1983. Forty-eight plants processed steel slag. Of all iron and steel slag products shipped, 90% traveled by truck with an average marketing range of 24 miles, 6% traveled by rail with an average marketing range of 181 miles, and 3% traveled by waterway with an average marketing range of 404 miles. The remaining 1% was used at the plantsite.

C. J. Langenfelder & Sons Inc. started operations under a contract with Bethle-

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								Steel slag		Total slag[2]	
	Air-cooled		Granulated		Expanded		Total iron slag[2]					
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1980	17,113	65,313	772	2,938	1,156	8,028	19,041	76,279	6,158	16,270	25,199	92,549
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

[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.

hem Steel Corp. to process steel slag from the basic oxygen and open-hearth furnaces at the Sparrows Point plant in Baltimore, MD. Beginning in August, Fritz Enterprises Inc. took over all processing and sales of blast furnace slag from United States Steel Corp. at its Lorain Works in Ohio.

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 because of shortages of natural aggregates in some areas.

Essentially all iron-blast-furnace slag produced is eventually utilized. Of the air-cooled blast furnace slag sold or used in 1984, 52% was used as road base, 10% as fill, 9% as concrete aggregate, 8% as asphaltic concrete aggregate, and 7% as railroad ballast. The remaining 14% was used for producing mineral wool and in concrete products, roofing, sewage treatment, soil conditioning, glass manufacture, ice control, and other miscellaneous uses. 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, the main growth areas for iron slag include replacement for cement in concrete construction, use in bituminous mixtures, and use in lightweight concrete applications. As a replacement for cement, ground granulated blast furnace slag offers a savings in natural resources and the energy required to manufacture cement clinker.

According to the latest published information, 75% to 80% of domestic steel slag produced is recycled to the blast furnace or used in aggregate applications.[3] Statistics developed by the Bureau of Mines indicate that 3.1 million tons of steel slag was recycled to blast furnaces in 1984. Steel slag processed and sold was primarily used as road base, 49%; fill, 20%; and asphaltic concrete aggregate, 10%. The remaining 21% was used for railroad ballast, ice control, and other uses. Steel slag usage for asphaltic concrete aggregate is expected to be a major growth area.

PRICES

The average unit price, f.o.b. plant, for all iron-blast-furnace slag sold increased 6% over that of 1983 to $5.09 per ton. Air-cooled slag increased 5% to $4.33 per ton, and expanded slag increased 19% to $11.49 per ton. Price information for granulated slag was withheld to avoid disclosing company proprietary data. Steel slag unit value was $3.28 per ton, up 9% over that of 1983. High prices in some use categories indicate that additional processing was required to meet some users' specifications.

FOREIGN TRADE

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 151 tons of basic slag valued at $9,886 was imported from Canada and Japan, and 2,056 tons valued at $183,154 was exported to Italy and Mexico.

U.S. export and import information for iron and other steel slag cannot be determined because slag is classified in combined categories and cannot be separated. U.S. exports of slag are classified under the schedule headings "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. Trial shipments of water granulated blast furnace slag have been received by several domestic processors from Belgium, France, and Japan for use in the production of blended cement. Inactivity over the last few years has been supplanted by renewed interest in these imports resulting from increased acceptance and usage of slag cements domestically.

WORLD REVIEW

Estimated world production of iron-blast-furnace slag and steel slag was 123 million and 56 million tons, respectively. These estimates are based on iron slag generation representing 23% of all blast furnace production and steel slag generation representing 18% of all raw steel production minus 60% of the latter, which is recycled to the blast furnace.[4] Reported production of iron and steel slag by country is incomplete owing to late reporting, incompleteness of data, and lack of reporting by some countries where slag is thought of as a waste product rather than a resource.

Europe.—Indicated levels of slag production were essentially unchanged since iron and steel production in Europe increased only slightly compared with that of 1983. The most current data published by the statistical office of the European Economic Community indicate that a total of 20,887,672 tons of iron-blast-furnace slag was produced in Europe in 1983.[5]

Japan.—Based on 1984 pig iron and raw steel production and slag generation rates from previous years, it is estimated that 26 million tons of iron slag and 14 million tons of steel slag were produced in Japan, compared with 22 million tons and 12 million tons, respectively, reported for 1983. Increasingly more amounts of blast furnace slags are being sold and used in cement production. The Japan Iron and Steel Federation projected that in 1985, 44% of all blast furnace and steel slag used will be for construction, 27.7% in cement, 21.8% in concrete, and 6.5% in other uses. Also in 1985, 45% of the slag would be water granulated compared with 26.4% in 1978.

A joint venture between Kawasaki Steel Corp. and Ube Industries Ltd. to market blast furnace slags was officially formed in May 1984. The new company, Chiba Riverment and Cement Corp., was building a slag processing plant, scheduled for completion in May 1985. The plant, located at the Chiba works, will have a production capacity of 375,000 tons per year and will produce powdered, water granulated slags for use in blast furnace cements, building materials, fertilizers, ceramics, and other applications. Nippon Steel Corp. was also expanding its slag-derived products to include a ceramic fiber that can withstand temperatures up to 1,400° C.[6]

TECHNOLOGY

Technical information on iron and steel slag is difficult to obtain owing to the diversity of its applications and uses and lack of publications. One major source for technical data on slag is the National Slag Association. The National Slag Association is a nonprofit organization established in 1918 for the purpose of developing and disseminating information pertaining to the production, processing, properties, and uses of slags produced by the iron and steel industry. With extensive information resources, it provides reference services to its members and others including architects, engineers, and contractors.

A new slag granulation process, using a continuous filtering system, was developed in 1984. This system employs a rotating drum instead of the static filter that is used in classic granulated slag dewatering systems. Water granulated slag is distributed homogeneously over the length of the dewatering drum, and axial vanes inside the drum continuously lift and deposit this slag on a conveyor belt for disposal, while water is allowed to filter through the drum's fine mesh exterior for further recycling. Adjunct systems can be added to meet local conditions and environmental regulations, such as a cooling tower integrated into a closed loop circuit for cold water granulation only, or a specially designed condensation tower replacing conventional stacks for steam condensation. This system purportedly offers lower capital costs compared with static bed systems, compact design, continuous filtering and evacuation, air pollution control, low maintenance and operation costs, and reliability. It also offers flexibility to produce any slag-sand mixture desired.[7]

A recent article published by the American Society for Testing and Materials discussed the benefits of using blast furnace slag cement to enhance the durability of concrete mixtures. The article stated that research in the United States and Europe has shown that the durability of modern concrete has become unsatisfactory in some applications, particularly concerning chemical resistance, owing to contemporary construction technology. Current concrete building techniques are likely to result in high hydration temperatures that cause excessive thermal stress, stress cracks, and porosity. The higher temperatures also accelerate alkali-aggregate reactions that deteriorate concrete. It was found that the addition of blast furnace slag and fly ash in portland cement and concrete mixtures helps control hydration heat and alkali-aggregate reactions resulting in a concrete having a higher density and lower porosity and permeability. This enhances the concrete's durability and chemical resistance. The benefits and strength development of blast furnace slag cements need further testing and research to define appropriate testing methods.[8]

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[1]Mineral data specialist, Division of Ferrous Metals.

[2]U.S. Department of Commerce. Construction Review. V. 30, No. 6, Nov.-Dec. 1984, pp. 3, 11-12.

[3]Lewis, D. W. Resource Conservation by Use of Iron and Steel Slags. ASTM Spec. Tech. Publ. 774, 1982, pp. 31-42.

[4]Emery, J. J. Slag Utilization in Pavement Construction. ASTM Spec. Tech. Publ. 774, 1982, pp. 95-118.

[5]Statistical Office of the European Economic Community. 1984 Iron and Steel Yearbook. P. 74.

[6]Kawata Publicity Inc. Japan's Iron and Steel Industry, 1984. Japan, pp. 119, 137-138.

[7]Paul Worth SA, Luxembourg. INBA—A New Concept of Slag Granulation With Continuous Filtering System. Company brochure, 1984.

[8]Idorn, G. M., and D. M. Roy. Factors Affecting the Durability of Concrete and the Benefits of Using Blast-Furnace Slag Cement. Cement, Concrete, and Aggregates, CCAGDP, v. 6, No. 1, Summer 1984, pp. 3-10.

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	1983				1984			
	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	4,050	12,344	W	W	4,878	16,780	W	W
Ohio	2,155	10,380	W	W	2,348	12,225	W	W
Total[2]	6,204	22,724	6,645	25,683	7,226	29,005	7,751	32,387
Middle Atlantic:								
Pennsylvania	2,891	14,226	W	W	3,773	20,485	W	W
Maryland, New York, West Virginia	1,026	4,371	W	W	957	4,374	W	W
Total[2]	3,917	18,598	4,651	29,375	4,730	24,859	5,656	40,619
West: Colorado, Texas, Utah	1,104	3,629	1,104	3,629	2,225	6,071	2,225	6,071
South: Alabama and Kentucky	777	4,864	777	4,864	858	5,329	858	5,329
Pacific: California	377	1,184	377	1,184	288	1,026	288	1,026
Grand total[2]	12,380	50,999	13,554	64,735	15,325	66,289	16,776	85,432

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]

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
Alabama:							
Alabama City:							
Vulcan Materials Co	1	--	--	1	--	1	--
Birmingham:							
Jim Walter Resources Inc	1	--	--	--	--	--	--
Fairfield:							
Vulcan Materials Co	1	--	--	1	--	1	--
Total	3	--	--	2	--	2	--
California: Fontana:							
Heckett Co	1	--	--	1	--	1	--
Colorado: Pueblo:							
Fountain Sand and Gravel Co	1	--	--	--	--	--	--
Delaware: Claymont:							
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:							
C & L Cartage Co	1	--	--	--	--	--	--
Heckett Co	1	--	--	1	--	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	3	--	--	4	--	2	3
Indiana:							
Burns Harbor:							
The Levy Co. Inc	1	1	--	1	1	1	--
East Chicago:							
Heckett Co	--	--	--	1	--	1	--
Vulcan Materials Co	1	--	--	--	--	--	--
Total	2	1	--	2	1	2	--
Kentucky:							
Ashland:							
Heckett Co	1	--	--	1	--	1	--
Owensboro:							
Heckett Co	--	--	--	1	--	--	1
Total	1	--	--	2	--	1	1
Maryland:							
Baltimore:							
Maryland Slag Co	1	--	--	--	--	--	--
Sparrows Point:							
Atlantic Cement Co. Inc	--	--	1	--	--	--	--
C. J. Langenfelder & Sons Inc	--	--	--	1	1	1	--
Total	1	--	1	1	1	1	--

See footnote at end of table.

Table 3.—Locations and processing methods of iron slag and sources of steel slag[1] —Continued

State, city, and company	Processing method of iron slag: Air-cooled	Processing method of iron slag: Expanded	Processing method of iron slag: Granulated	Steel slag	Sources of steel slag: Open hearth	Sources of steel slag: Basic oxygen process	Sources of steel slag: Electric
Michigan:							
Detroit:							
Edward C. Levy Co	1	1	--	1	--	1	1
Ecorse:							
Edward C. Levy Co	--	--	--	1	--	1	1
Trenton:							
Edward C. Levy Co	1	1	--	1	--	1	--
Total	2	2	--	3	--	3	2
Minnesota: Newport:							
International Mill Service Co	--	--	--	1	--	--	1
New Jersey: Perth Amboy:							
International Mill Service Co	--	--	--	1	--	--	1
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	--
United States Steel Corp	1	--	--	--	--	--	--
Lordstown:							
Standard Slag Co	--	--	1	--	--	--	--
Mansfield:							
Heckett Co	--	--	--	1	--	--	1
Middletown:							
American Materials Corp	1	--	1	--	--	--	--
McGraw Construction Co	--	--	--	1	1	1	--
Mingo Junction:							
International Mill Service Co	--	--	--	1	--	1	--
Standard Slag Co	1	--	--	--	--	--	--
Warren:							
Heckett Co	--	--	--	1	--	--	1
Heckett Co	--	--	--	1	--	1	--
Standard Slag Co	1	--	--	--	--	--	--
Total	8	--	2	8	1	5	4
Oklahoma: Sand Springs:							
International Mill Service Co	--	--	--	1	--	1	--
Pennsylvania:							
Bala-Cynwyd:							
Warner 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

See footnote at end of table.

Table 3.—Locations and processing methods of iron slag and sources of steel slag[1] —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
Pennsylvania —Continued							
Lebanon:							
Sheridan Slag Corp	1	--	--	--	--	--	--
Midland:							
International Mill Service Co	--	--	--	1	--	--	1
Morrisville:							
Heckett 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	11	5	2	5
South Carolina: Darlington:							
APAC-Carolina Inc	--	--	--	1	--	--	1
Georgetown: Heckett Co	--	--	--	1	--	--	1
Total	--	--	--	2	--	--	2
Texas:							
Baytown:							
Heckett Co	--	--	--	1	--	--	1
Beaumont:							
International Mill Service Co	--	--	--	1	--	--	1
Lone Star:							
Gifford-Hill Co. Inc	1	--	--	1	1	--	--
Midlothian:							
International Mill Service Co	--	--	--	1	--	--	1
Total	1	--	--	4	1	--	3
Utah: Provo:							
Heckett Co	1	--	--	1	1	--	--
Washington: Seattle:							
Heckett Co	--	--	--	1	--	--	1
West Virginia:							
Weirton:							
International Slag Co	--	--	--	1	--	1	--
Standard Slag Co	1	--	--	--	--	--	--
Total	1	--	--	1	--	1	--
Grand total	35	5	4	50	10	22	26

[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 1984, by method of transportation

Method of transportation	Quantity (thousand short tons)
Truck	19,797
Rail	1,295
Waterway	731
Not transported (used at plantsite)	240
Total	22,063

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	1983		1984	
	Quantity	Value	Quantity	Value
Concrete aggregate	1,327	6,129	1,396	6,350
Concrete products	412	2,085	539	2,588
Asphaltic concrete aggregate	1,189	6,126	1,271	6,601
Road base	5,179	20,865	8,020	32,632
Fill	1,969	5,092	1,515	4,671
Railroad ballast	867	2,894	1,136	4,522
Mineral wool	564	3,016	607	3,913
Roofing, built-up and shingles	264	1,421	283	1,670
Sewage treatment	W	W	121	461
Soil conditioning	W	W	49	158
Glass manufacture	139	1,810	165	2,022
Other[2]	469	1,560	224	701
Total[3]	12,380	50,999	15,325	66,289

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 uses indicated by symbol W.
[3]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	1983				1984			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Lightweight concrete aggregate	--	--	302	3,180	--	--	229	2,271
Concrete products	--	--	237	1,993	--	--	W	W
Cement manufacture	(2)	(2)	W	W	(2)	(2)	W	W
Road base	(2)	(2)	W	W	(2)	(2)	W	W
Soil conditioning	(2)	(2)	W	W	(2)	(2)	W	W
Other[3]	--	--	636	8,563	--	--	1,223	16,871
Total	(2)	(2)	1,175	13,736	(2)	(2)	1,452	19,142

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 uses 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	1983		1984	
	Quantity	Value	Quantity	Value
Asphaltic concrete aggregate	460	1,898	551	2,854
Road base	2,100	5,699	2,595	7,463
Fill	1,133	3,598	1,037	3,230
Railroad ballast	532	1,863	W	W
Other[2]	607	1,488	1,104	3,780
Total	4,832	14,546	5,287	17,327

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, miscellaneous uses, and use indicated by symbol W.

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		
1980	3.82	3.81	6.94	4.01	2.64	3.67
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

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 1984, 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
Concrete aggregate	4.54	1.79- 9.56	--	--	--	--	--	--
Lightweight concrete aggregate	--	--	--	--	9.92	9.63-14.85	--	--
Concrete products	4.80	1.55- 9.34	--	--	W	W	--	--
Cement manufacture	W	W	W	W	W	W	--	--
Asphaltic concrete aggregate	5.19	2.12- 8.49	--	--	--	--	5.18	1.62-8.25
Road base	4.06	1.50- 6.75	W	W	--	--	2.87	.54-8.86
Fill	3.08	1.77- 6.48	--	--	--	--	3.11	.75-5.21
Railroad ballast	3.98	2.00- 7.44	--	--	--	--	3.89	1.50-8.51
Mineral wool	6.45	2.61-10.35	--	--	--	--	--	--
Roofing, built-up and shingles	5.90	2.00-15.00	--	--	--	--	--	--
Sewage treatment	3.79	3.57- 4.84	--	--	--	--	--	--
Soil conditioning	3.25	2.36- 4.85	W	W	W	W	--	--
Glass manufacture	12.26	10.00-15.00	--	--	--	--	--	--
Other	3.13	1.73- 5.63	--	--	W	W	W	W

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

Sodium Compounds

By James P. Searls[1]

The U.S. soda ash industry was essentially unchanged from that of 1983 in both production and apparent consumption. Continued improvements in the world economy and an estimated decrease in the price of soda ash provided improved demand in most end uses, excluding the glass container industry. Profitability for the domestic producers, however, was not improved.

The U.S. sodium sulfate industry produced slightly more product, while consumption declined by 4% and stocks increased accordingly. One producer was forced to shut down in May because of the flooding of its solar evaporation ponds. The shutdown could last several years.

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 natural sodium sulfate operations to which a survey request was sent, all responded, representing 100% of the total production data shown in table 1. Several soda ash operations did not report sales value on these forms; the value of production was estimated for these operations.

Legislation and Government Programs.—Minor leasing rule changes for sodium and other solid minerals other than coal and oil shale were announced by the Bureau of Land Management, U.S. Department of the Interior. The Environmental Protection Agency released a final ruling that soda ash and sodium sesquicarbonate were to be added to the list of generally recognized as safe materials for the drying of freshly cut hay.

Table 1.—Salient sodium compound statistics

(Thousand short tons and thousand dollars)

	Soda ash		Sodium sulfate	
	1983	1984	1983	1984
United States:				
Production[1]	8,467	8,511	855	872
Value[2]	[e]$685,100	[e]$611,000	$79,772	$80,433
Exports	1,636	1,648	91	76
Value	$154,584	$160,774	$11,380	$9,587
Imports for consumption	20	17	343	265
Value	$2,704	$2,301	$27,921	$21,198
Stocks, Dec. 31: Producers	[3]307	[3]322	[4]48	[4]59
Consumption, apparent	6,868	6,864	1,089	1,050
World: Production	[p]31,291	[e]31,499	[p]4,410	[e]4,364

[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]Includes synthetic soda ash.
[4]Natural only.

DOMESTIC PRODUCTION

Sodium Carbonate.—The natural and synthetic industry produced slightly more soda ash than in 1983 and operated at 76% of total nameplate capacity. About 11.7

million short tons of trona was mined in Wyoming in 1984 to produce the natural product. Over the past several years, all of the trona mining firms in Wyoming have been slowly reducing the work force and operating costs by various measures in attempts to maintain profitability. The FMC Corp. received a permit from the Wyoming Environmental Quality Council in March 1984 to develop a commercial trona solution mine. The company had experimented with the solution mining technology as it applies to trona mining for several years with a significant decrease in production costs as its goal. The Allied Chemical Co. sodium bicarbonate facility at the Syracuse, NY, synthetic soda ash plant was sold to Church & Dwight Co. at yearend 1984.

Sodium Sulfate.—The domestic natural industry produced slightly more salt cake than in 1983 and operated at nameplate capacity for the year. The Great Salt Lake Minerals & Chemicals Corp. ponds were flooded on May 5 by a breach in their outer dike. The company, protected by insurance against such an occurrence, was not shut down permanently. The company's capability to produce salt, sulfate of potash, and magnesium chloride bitterns was lost probably for several years, owing to the dissolution of pond bottoms and the dilution of the 1983 solar concentrates. Salt cake, however, was produced by the company during 1984.

Table 2.—Producers of soda ash and natural sodium sulfate in 1984

Product and company	Plant nameplate capacity (thousand short tons)	Plant location	Source of sodium
Soda ash, natural:			
Allied Chemical Co	2,200	Green River, WY.	Underground trona.
FMC 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	1,960	Green River, WY.	Underground trona.
Tenneco Minerals Co	1,000	do	Do.
Texasgulf Chemicals Co	1,000	Granger, WY	Do.
Soda ash, synthetic:			
Allied Chemical Co.[1]	700	Syracuse, NY	Ammonia-soda process.
Total	11,160		
Sodium sulfate:			
Great Salt Lake Minerals & Chemicals Corp.[2]	40	Ogden, UT	Salt lake brine.
Kerr-McGee Chemical Corp	225	Westend, CA	Dry lake brine.
Ozark-Mahoning Co	70	Brownfield, TX.	Subterranean brine.
Do	100	Seagraves, TX	Do.
Total	435		

[1]Plant was downrated from 900,000 tons per year in Jan. 1982.
[2]Solar ponds were flooded May 5, 1984.

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]	
1980	W	W	768,168	8,275
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

[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
1980	676	464	1,139	583	36,389
1981	666	445	1,111	608	43,186
1982	463	401	864	W	W
1983	427	427	855	423	39,425
1984	444	428	872	435	40,125

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

The trends that were noted in 1983 continued and probably indicated that fundamental structural changes in the end uses of both soda ash and salt cake were occurring.

Soda Ash.—Sales to glass container producers continued to decline as soft drink bottlers responded to the customer preference for soft drinks in large, 2-liter, polyethylene terephthalate (PET) bottles. Industry estimates put the glass container market share at about 40% of the soft drink market, down from 60% in the late 1970's. The plastic bottle market share was put at about 25% with aluminum cans controlling the rest of the market.[2] The U.S. Department of the Treasury, Bureau of Alcohol, Tobacco, and Firearms, was allowed by the Supreme Court to approve the use of PET containers for the retail sale of liquor. Wine, fruit juices, and ketchup were some of the consumer products newly retailed in PET bottles. Otherwise, the demand for soda ash for many end uses increased at moderate, though continuous, rates. There was increasing interest in the use of trona- or nahcolite-derived compounds for flue gas desulfurization. The interest appeared to be centered in the Southwestern United States where the sources of trona or nahcolite are situated, ensuring a relatively low delivered cost in comparison with that of calcium carbonate compounds. Because of the natural aridness of the region, the higher solubilities of the sodium-based over calcium-based end products would not be as hazardous to the surface and ground water supplies as in less arid regions.

Salt Cake.—Apparent consumption declined slightly owing to decreases in consumption in both the kraft paper and glass bottle industries. The substitution by caustic soda and emulsified sulfur for salt cake in the kraft paper industry continued as the industry found it useful to decouple the ratio of sodium to sulfur and supply each batch with each element as required. Announced price increases for both caustic soda and sulfur did not result in a significant increase in the demand for salt cake. The substitution of plastic bottles for glass bottles in the soft drink market depressed the demand for salt cake slightly. The consumption of salt cake as a filler in powder detergents declined because some formulations were converted to contain slightly more soda ash and less salt cake.

Table 5.—Estimated consumption of soda ash in the United States, by end use

(Thousand short tons)

End use	1983	1984
Glass:		
Bottle and container	2,400	2,300
Flat	575	600
Fiber	230	250
Other	245	250
Total	3,450	3,400
Chemicals	1,400	1,550
Soaps and detergents	620	600
Pulp and paper	200	250
Water and stackgas[1]	230	600
Other[2]	968	464
Total	3,418	3,464
Grand total	6,868	6,864

[1]Included only water treatment in 1983.
[2]Includes soda ash used in petroleum and metal refining, leather tanning, enamels, etc.

STOCKS

Soda Ash.—Yearend stocks of finished product in plant silos, warehouses, terminals, and on teamtracks increased about 5% and represented about 2 weeks of average production.

Salt Cake.—Yearend stocks of natural product—excluding synthetic product stocks—increased 23% and totaled about 3-1/2 weeks of average production.

PRICES

Soda Ash.—Continued low demand levels relative to the supply of natural soda ash kept prices relatively low. Individual producers announced list price increases through reductions of the temporary voluntary allowance through the year and apparently were able to make such moves effective as gradual increases. The average annual value of bulk natural soda ash, f.o.b. Green River, WY, and Searles Valley, CA, was not available from all producers; the industry average value was estimated to be approximately $67 per ton.

Salt Cake.—The average annual value of bulk natural product, f.o.b. mine or plant, as reported by producers, was $92.16 per ton.

Table 6.—Sodium compounds yearend prices

		1983	1984
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	69.00	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.

FOREIGN TRADE

Soda Ash.—According to the Bureau of the Census, exports were about the same as the 1983 level. About 19% of domestic production was exported to market economy countries and developing nations for the manufacture of glass, chemicals, detergents, and miscellaneous products. The regional export distribution was Asia, 50%; Latin America, 30%; Canada, 8%; Africa, 7%; Europe, 4%; and Oceania, 1%. Compared with that of 1983, shipments to Asia, Canada, and Europe rose, while shipments to Africa, Latin America, and Oceania fell. The reorganized soda ash exporting group, operating under the Webb-Pomerene Act, commenced as the American Natural Soda Ash Corp. with offices in Westport, CT. A provisional antidumping duty of European Credit Unit[3] (Ecu) 44.34 per metric ton was imposed in August by the European Economic Community (EEC) Commission on imports of U.S. soda ash into any of the EEC member countries. The duty was in addition to the Ecu24.37 per metric ton antidumping duty imposed in March 1983.

Salt Cake.—Exports dropped because the high relative value of the U.S. dollar deterred importing countries from buying U.S. salt cake. Imports dropped between 1982 and 1984, because domestic consumption declined relative to domestic capacity. Imports, coming from relatively expensive natural sources in Canada and Mexico, appear to have been displaced by output from byproduct producers. Byproduct producers, such as rayon and chrome salt producers, were more flexible in their pricing.

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]
1981	1,051	121,107	124	12,980
1982	1,109	140,616	111	12,162
1983	1,636	154,584	91	11,380
1984	1,648	160,774	76	9,587

[1]F.a.s. U.S. port.

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]
1981	136	8,038	139	11,097	275	19,135
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

[1]Includes Glauber's salt as follows: 1981—30 tons ($13,800); 1982—2 tons ($1,241); 1983—3 tons ($1,648); and 1984—12 tons ($4,997).
[2]C.i.f. U.S. port.

Source: Bureau of the Census.

Table 9.—U.S. imports for consumption of sodium carbonate

	1983		1984	
	Quantity (short tons)	Value[1] (thousands)	Quantity (short tons)	Value[1] (thousands)
Sodium carbonate, calcined	19,991	$2,703	16,659	$2,292
Sodium carbonate, hydrated, and sesquicarbonate	([2])	1	5	9
Total	19,991	2,704	16,664	2,301

[1]C.i.f. U.S. port.
[2]Less than 1/2 unit.

Source: Bureau of the Census.

WORLD REVIEW

Australia.—Denison Resources Ltd., Poseidon Ltd., and Adelaide Brighton Cement Holdings agreed to study the Denison Trough in southwest Queensland for possible sodium commodities production. Soda ash, sodium bicarbonate, and caustic soda were the main products of interest. The proposed caustic soda production could be a source of supply to a large alumina plant on the northeast coast of Australia. The Government commenced an antidumping investigation concerning imports of U.S.-produced soda ash.

Botswana.—British Petroleum Botswana Ltd. finished its feasibility study for soda ash production at the Sua Pan brine deposit in the Makgadikgadi Basin in northeastern Botswana and began test operations using the Kerr-McGee Chemical Corp. technique of brine carbonation to precipitate crude sodium bicarbonate. Production at this site appears to be favored over a Solvay plant on the south coast of the Republic of South Africa for the supply of soda ash to the region, even with the complete lack of infrastructure around the deposit.

Thailand.—The soda ash project that the Government of Thailand had proposed as its part of the Association of Southeast Asian Nations regional development program was postponed in the spring because of the low delivered price of U.S. natural soda ash. Exports from Thailand would have to compete with the U.S. natural product, which did not seem feasible. The project backers resubmitted a scaled down version of the project to the Government in the fall.

Turkey.—Under an agreement with Etibank, the state mining organization, the trona reserves at Heypazari, near Ankara, were under study for potential development by FMC.

[1]Physical scientist, Division of Industrial Minerals.
[2]Chemical Week. Plastic Containers—Now Even the Glassmaker Choice. V. 135, No. 11, Sept. 12, 1984, pp. 46-48.
[3]An Ecu is a basket of 10 European Economic Community member currencies. For 1984, Ecu1.267379=US$1.00, or Ecu1.00=US$0.78903.

Table 10.—Sodium carbonate: World production, by country[1]

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Albania[e]	27,600	27,600	27,600	27,600	27,600
Australia[e]	330,000	330,000	330,000	330,000	330,000
Austria[e]	190,000	190,000	190,000	190,000	165,000
Belgium	360,376	300,931	361,170	[e]282,600	286,600
Brazil	194,007	207,234	[e]210,000	[e]210,000	210,000
Bulgaria	1,629,977	1,618,948	1,607,940	1,400,918	1,610,000
Canada[e]	500,000	500,000	500,000	[r]470,000	400,000
Chad[e 2]	8,800	5,500	5,500	NA	NA
Chile[e]	12,000	11,000	NA	NA	NA
China	1,778,026	[r]1,821,016	1,911,406	1,976,442	2,070,000
Colombia	137,380	[r]183,226	122,136	130,392	130,000
Czechoslovakia	135,192	130,293	117,313	104,694	110,000
Denmark[3]	148	164	[e]165	[e]165	165
Egypt	20,777	25,754	45,496	47,399	45,000
France[e]	[4]1,719,824	1,765,000	1,765,000	1,650,000	1,600,000
German Democratic Republic	[r]954,600	[r]967,828	972,237	977,749	980,000
Germany, Federal Republic of	[r]1,555,359	[r]1,310,647	1,218,053	1,342,614	1,320,000
Greece[e]	1,100	1,100	1,100	1,100	1,100
India	578,320	[e]676,000	646,836	820,481	790,000
Italy[e]	105,000	105,000	100,000	95,000	100,000
Japan	1,494,107	1,298,185	1,281,323	1,216,265	1,150,000
Kenya[2]	224,616	275,578	176,855	213,506	220,000
Korea, Republic of	244,625	222,736	204,666	254,193	[4]273,292
Mexico[5]	447,538	442,026	429,901	[e]440,000	440,000
Netherlands[e]	460,000	460,000	460,000	460,000	440,000
Norway[e]	29,800	29,800	29,800	29,800	29,800
Pakistan	84,878	[r]106,267	118,157	115,414	115,700
Poland	839,960	771,617	822,323	909,406	880,000
Portugal[e]	195,000	190,000	190,000	180,000	165,000
Romania	1,032,865	[r]1,020,739	959,010	[r e]940,000	940,000
Spain[e]	550,000	550,000	550,000	550,000	610,000
Sweden[e]	[r]1,100	[r]1,100	[r]1,100	[r]1,100	1,100
Switzerland[e]	50,000	51,000	51,000	50,000	49,000
Taiwan	102,008	79,437	65,279	103,419	118,000
Turkey[e]	65,000	65,000	65,000	[4]42,808	45,000
U.S.S.R	5,269,042	5,357,227	5,250,303	5,620,679	5,700,000
United Kingdom[e]	1,500,000	1,430,000	1,430,000	1,430,000	1,430,000

See footnotes at end of table.

Table 10.—Sodium carbonate: World production, by country[1] —Continued

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
United States[5]	8,275,230	8,281,495	7,819,083	8,467,118	[4]8,511,359
Yugoslavia	142,274	162,212	200,488	[e]210,000	205,000
Total	[r]31,246,529	[r]30,971,660	30,236,240	31,290,862	31,498,716

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Table includes data available through May 28, 1985. 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.

Table 11.—Sodium sulfate: World production, by country[1]

(Thousand short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Natural:					
Argentina	42	57	47	50	50
Canada	530	590	603	500	427
Chile[3]	1	([4])	1	1	1
Egypt	3	[e]3	3	2	2
Iran[e]	10	11	11	[r]13	13
Mexico[5]	410	467	141	[r e]165	165
South Africa, Republic of	14	5	3	1	([4])
Spain	172	[r]207	232	345	353
Turkey	97	73	72	59	61
U.S.S.R.[e 6]	386	386	397	397	397
United States	583	608	[7]W	423	[8]435
Total	2,248	[r]2,407	1,510	1,956	1,904
Synthetic:					
Austria[e]	61	61	61	61	55
Belgium[e]	276	276	276	276	276
Chile[9]	77	64	52	57	55
Finland[e]	50	50	50	50	50
France[e]	[8]165	165	165	[r]165	165
German Democratic Republic	[r]137	[r]141	157	168	171
Germany, Federal Republic of	248	281	236	138	132
Greece[e]	12	12	13	14	13
Hungary[e]	11	11	11	11	11
Italy[e]	[r]110	[r]99	[r]94	[r]99	99
Japan	343	314	282	287	312
Netherlands[e]	55	55	55	55	50
Portugal	58	64	[e]63	[e]62	55
Spain[e 10]	193	193	187	187	187
Sweden[e]	116	116	116	116	116
U.S.S.R.[e 6]	276	276	276	276	276
United States[11]	556	503	[7]864	432	[8]437
Total	[r]2,744	[r]2,681	2,958	2,454	2,460
Grand total	[r]4,992	[r]5,088	4,468	4,410	4,364

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Table includes data available through May 28, 1985.
[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).

Crushed Stone

By Valentin V. Tepordei[1]

A total of 956 million short tons of crushed stone valued at $3.8 billion, f.o.b. plant, was estimated to have been produced in the United States in 1984, an increase of 11% over the 1983 production. This tonnage is the sixth largest production ever recorded in the United States and is only 13% below the record high production of 1.1 billion tons reported in 1979. About three-quarters of crushed stone production continued to be limestone and dolomite, followed by granite, traprock, sandstone and quartzite, shell, marl, volcanic cinder, marble, and slate, in order of volume.

Foreign trade in crushed stone remained relatively minor. Exports decreased 1% to 2.4 million tons; total imports for consumption increased 21% to 3.2 million tons. Limestone represented 92% of the exported and 56% of the imported crushed stone. Apparent consumption of crushed stone was 957 million tons.

Table 1.—Salient U.S. crushed stone statistics

(Thousand short tons and thousand dollars)

	1980	1981	1982	1983	1984
Sold or used by producers:					
Quantity[1]	983,500	872,600	[e]790,030	[r]861,600	[e]956,000
Value[1]	$3,265,800	$3,125,000	[e]$2,918,300	[r]$3,327,000	[e]$3,755,600
Exports (value)	$21,239	$25,949	$19,026	$23,021	$23,970
Imports for consumption (value)	$13,900	$13,473	$16,382	[r] [2]$12,610	[2]$17,543

[e]Estimated. [r]Revised.
[1]Does not include American Samoa, Guam, Puerto Rico, and the Virgin Islands.
[2]Excludes precipitated calcium carbonate.

Domestic Data Coverage.—To reduce the Federal Government's paperwork and costs, as well as the respondents' reporting burden, the Bureau of Mines implemented new canvassing procedures for its stone surveys. Beginning with 1981 data, the complete survey of crushed stone producers is conducted for odd-numbered years only.

For even-numbered years, the annual preliminary survey, which collects only total production information on a sample basis, is used to generate annual estimates at the State level. This survey canvasses most of the large companies in each State producing up to 75% of the State total tonnage. The production estimates for 1984 may be revised in the 1985 crushed stone chapter, if additional information is furnished by the producers at that time.

Legislation and Government Programs.—In March, the U.S. Congress approved 6-month Interstate Cost Estimate legislation that gives the U.S. Department of Transportation authority to disburse the collected Federal Highway Trust Fund to the States' construction funds. The action was 6 months late and released only one-half of the funds already available in the Trust Fund. Most of these funds are being used for highway construction and repair work, and, therefore, their late release impacted to some extent on the demand for crushed stone.

DOMESTIC PRODUCTION

The production estimates indicate that in 1984 the output of crushed stone increased in every geographic region. The South Atlantic region continued to lead the Nation in the production of crushed stone with an estimated 249 million tons or 26% of the U.S. total. Next was the East North Central region with 16% of the total, followed by West South Central with 14%.

Crushed stone was produced in every State except Delaware and North Dakota. The 10 leading States in the estimated production of crushed stone, in order of volume, were Texas, Florida, Pennsylvania, Illinois, Virginia, Georgia, Missouri, California, Ohio, and North Carolina. Their combined production represented 54% of the national total. Production increased in 36 States, including all of the top 10. The increases were significant in the following major producing States: Florida, Ohio, Tennessee, Texas, and Virginia. Iowa was the only large producing State that showed a decrease in output.

In November, Lone Star Industries Inc., the fourth largest U.S. producer of crushed stone, sold its Florida aggregates operations as well as its ready-mixed concrete and concrete block plants to Tarmac PLC of Wolverhampton, United Kingdom.

In the second half of 1984, the Executive Committees of the Boards of Directors of the National Crushed Stone Association and the National Limestone Institute approved the consolidation of the two trade associations into one organization called the National Stone Association. After the merger, scheduled for January 1, 1985, the new organization will be the sole trade association representing the crushed stone industry.

Table 2.—Crushed stone sold or used in the United States, by region

(Thousand short tons and thousand dollars)

Region	1983		1984[e]	
	Quantity	Value	Quantity	Value
Northeast:				
New England	19,535	98,683	21,650	108,300
Middle Atlantic	[r]95,815	[r]432,121	102,800	438,000
North Central:				
East North Central	138,765	485,749	157,600	567,000
West North Central	[r]93,912	[r]327,832	96,200	347,500
South:				
South Atlantic	[r]214,622	[r]905,892	248,800	1,077,800
East South Central	86,186	[r]329,166	97,500	375,300
West South Central	[r]119,400	[r]393,097	134,000	465,300
West:				
Mountain	26,776	[r]99,509	28,050	108,700
Pacific	66,635	254,936	69,400	267,700
Total[1]	[r]861,600	[r]3,327,000	956,000	3,755,600

[e]Estimated. [r]Revised.
[1]Data may not add to totals shown because of independent rounding.

Table 3.—Crushed stone sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1983 Quantity	1983 Value	1984[e] Quantity	1984[e] Value
Alabama	20,558	95,374	22,000	98,500
Alaska	1,981	9,460	2,500	10,800
Arizona	4,755	24,079	5,200	27,300
Arkansas	13,448	51,267	15,200	59,800
California	35,582	146,289	38,600	158,000
Colorado	6,790	22,749	7,200	26,200
Connecticut	7,692	45,890	8,300	49,400
Florida	57,282	235,700	68,500	290,000
Georgia	41,100	[r]186,193	45,900	220,000
Hawaii	5,532	29,703	5,400	29,700
Idaho	1,935	7,480	1,800	7,100
Illinois	42,761	166,860	48,500	191,600
Indiana	24,051	82,782	26,700	99,400
Iowa	24,844	101,097	23,800	100,000
Kansas	[r]12,687	[r]45,121	13,600	48,500
Kentucky	33,399	117,842	37,300	133,000
Louisiana	5,758	25,702	4,100	19,500
Maine	848	2,851	1,300	4,400
Maryland	19,284	80,429	22,100	94,000
Massachusetts	7,740	36,002	8,400	39,000
Michigan	24,763	82,152	28,100	92,000
Minnesota	8,580	25,320	8,900	25,800
Mississippi	1,651	4,377	2,000	5,800
Missouri	39,454	120,700	41,600	137,000
Montana	872	[r]2,320	950	2,400
Nebraska	[r]4,442	[r]22,612	4,500	23,400
Nevada	1,269	5,358	1,100	4,700
New Hampshire	946	2,853	850	2,700
New Jersey	12,301	70,421	13,500	75,000
New Mexico	4,730	[r]15,118	4,700	17,000
New York	[r]31,991	[r]134,752	33,100	135,000
North Carolina	33,694	[r]145,001	38,100	168,000
Ohio	32,937	114,059	38,500	139,000
Oklahoma	23,865	76,941	25,500	86,000
Oregon	13,089	[r]39,873	12,500	37,500
Pennsylvania	51,523	226,948	56,200	228,000
Rhode Island	971	5,507	1,000	5,800
South Carolina	15,786	61,054	17,900	72,500
South Dakota	3,906	12,982	3,800	12,800
Tennessee	30,578	[r]111,573	36,200	138,000
Texas	[r]76,328	[r]239,187	89,200	300,000
Utah	4,407	14,636	5,200	16,400
Vermont	1,339	5,579	1,800	7,000
Virginia	[r]38,036	[r]159,553	47,200	196,000
Washington	10,451	29,607	10,400	31,700
West Virginia	9,439	37,962	9,100	37,300
Wisconsin	14,252	39,896	15,800	45,000
Wyoming	2,019	7,769	1,900	7,600
Total[1]	[r]861,600	[r]3,327,000	956,000	3,755,600

[e]Estimated. [r]Revised.
[1]Data may not add to totals shown because of independent rounding.

FOREIGN TRADE

Exports.—Exports of crushed stone decreased 1% to 2.4 million tons, while the value increased 4% to $24 million; of this, 92% was limestone, of which 96% went to Canada.

Imports.—Imports for consumption of crushed stone increased 28% to 2.9 million tons and 41% in value to $15.1 million. About 56% of this tonnage was limestone, 72% of which came from Canada.

Imports of calcium carbonate fines decreased 24% to 292,000 tons, while the value increased 30% to $2.5 million. Of the natural calcium carbonate (aragonite), 99% came from the Bahamas, while most of the processed calcium carbonate was imported from France, Japan, and the United Kingdom. Precipitated calcium carbonate is no longer included in this chapter.

Table 4.—U.S. exports of crushed stone, by destination

(Thousand short tons unless otherwise specified)

Destination	Quartzite 1983	Quartzite 1984	Limestone[1] 1983	Limestone[1] 1984	Other 1983	Other 1984	Total[2] 1983	Total[2] 1984
North America:								
Canada	3	1	2,244	2,098	77	78	2,324	2,177
Mexico	--	1	--	(3)	19	17	19	18
Other	--	(3)	--	1	--	2	--	3
Total[2]	3	1	2,244	2,099	96	97	2,343	2,197
South America:								
Venezuela	--	--	39	75	1	1	40	75
Other	--	(3)	3	5	4	(3)	7	5
Total[2]	--	(3)	42	80	5	1	47	81
Europe:								
France	1	79	--	--	2	8	3	87
Netherlands	1	(3)	--	--	--	(3)	1	1
Switzerland	--	--	3	(3)	--	(3)	3	(3)
United Kingdom	(3)	(3)	--	(3)	6	1	6	1
Other	2	1	(3)	(3)	(3)	1	2	2
Total[2]	3	80	4	(3)	9	11	16	92
Asia	1	2	--	(3)	3	2	6	4
Oceania	--	--	1	(3)	1	3	2	3
Middle East and Africa	--	(3)	--	(3)	--	1	1	1
Grand total[2]	7	83	2,291	2,179	115	114	2,413	2,378
Total value thousands	$1,884	$2,853	$14,837	$15,537	$6,300	$5,581	$23,021	$23,970

[1]Includes ground limestone.
[2]Data may not add to totals shown because of independent rounding.
[3]Less than 1/2 unit.

Table 5.—U.S. imports for consumption of crushed stone and calcium carbonate fines, by type

(Thousand short tons and thousand dollars)

Type	1983 Quantity	1983 Customs value	1984 Quantity	1984 Customs value
Crushed stone and chips:				
Limestone	1,367	7,952	1,645	10,646
Marble, breccia	29	310	2	181
Quartzite	r14	245	64	945
Slate	--	2	10	47
Other	869	2,200	1,202	3,251
Total	r2,279	10,709	2,923	[1]15,071
Calcium carbonate fines:[2]				
Natural aragonite[3]	375	943	275	710
Chalk, whiting	9	958	17	1,761
Total	r384	r1,901	292	2,471
Grand total[2]	r2,663	r12,610	3,215	[1]17,543

rRevised.
[1]Data do not add to total shown because of independent rounding.
[2]Excludes precipitated calcium carbonate.
[3]Includes some chalk and other calcareous materials.

WORLD REVIEW

The First International Aggregates Conference, AggPac '84, cosponsored by the National Crushed Stone Association, National Limestone Institute, and Pit & Quarry Publications Inc. and hosted by the Aggregates Association of New Zealand, was held in February in Auckland, New Zealand. The conference discussed new techniques and methods of aggregate production and usage, product specifications, and the need for acceptable economic solutions to problems facing the aggregates producers worldwide.[2]

The 1983 production of stone in Canada was 67.6 million tons valued at $315 million; about 95% of this output was crushed stone. The Province of Ontario was the largest producer of stone with 27.8 million tons valued at $122 million, followed closely by Quebec with 27.3 million tons valued at $121 million. Preliminary estimations for 1984 production of stone indicate an increase of about 5% to 71 million tons valued at $334 million, with the Province of Ontario accounting for about 42% of the total output.

TECHNOLOGY

The 67th annual convention of the National Crushed Stone Association was held between January 29 and February 2, 1984, in Chicago, IL, in conjunction with the biennial International Concrete & Aggregates Show. A major topic covered during the convention was computer applications in the crushed stone industry that included a review of the advantages of plant automation using programmable controllers, new ways to save energy through plant automation, and automating plant segments as a way to increase productivity and improve product quality.[3]

A Conference on Automation for the Crushed Stone Industry, cosponsored by the National Crushed Stone Association and the Bureau of Mines, was held in Arlington, VA. A wide range of subjects was covered, from computerized processing and plant control and automated equipment and energy management to strategic planning, market analysis, and office automation.[4] Rock Products magazine published two articles that described in detail how computer technology is being used by a crushed stone operation and a sand and gravel mining operation.[5] Several articles on crushed stone mining and processing, quarry automation, trends in the crushed stone industry, and the need for standard aggregate specifications were published.[6]

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[1]Physical scientist, Division of Industrial Minerals.

[2]Pit & Quarry. AggPac '84 Begins New Tradition. V. 76, No. 11, May 1984, p. 72.

[3]Herod, S., and S. Levine. NCSA's 67th Annual Convention Offers Comprehensive Program. Pit & Quarry, v. 76, No. 10, Apr. 1984, pp. 38-40.

[4]Robertson, J. L. Automation Meet Attracts 210. Rock Prod., v. 87, No. 11, Nov. 1984, pp. 47-50.

[5]Kuennen, T. Computer Logic Yields 550 TPH. Rock Prod., v. 87, No. 2, Feb. 1984, pp. 34-37.

[6]Borg, D. M/S Delay Blasting Systems. Rock Prod., v. 87, No. 6, June 1984, pp. 36-39.

Fowler, B. K. How To Develop Quarry Properly. Rock Prod., v. 87, No. 6, June 1984, pp. 40-42.

Kuennen, T. Rock Prod., v. 87, No. 8, Aug. 1984, pp. 35-37.

Mayville, R. L. High-Tech Engineering Adds 15 Years to Vulcan's Chattanooga Quarry. Pit & Quarry, v. 77, No. 8, Aug. 1984, pp. 90-102.

National Crushed Stone Association. Stone News, v. 9, No. 2, Apr. 1984, pp. RETS3-RETS4.

Robertson, J. L. Solving Quarry Problems. Rock Prod., v. 87, No. 8, Aug. 1984, pp. 31-34.

Rock Products. New Plant Ideas. V. 87, No. 7, July 1984, pp. 27-38.

Work cited in footnote 4.

Dimension Stone

By Harold A. Taylor, Jr.[1]

Production of dimension stone increased 6% to 1.16 million short tons valued at $155 million. More than one-half of the dimension stone produced was granite. Limestone, marble, sandstone, and slate were also produced.

Exports of dimension stone increased 24% in value to $26 million. The value of dimension stone imports increased 19% to $232 million, equivalent to 150% 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. The survey of dimension stone producers was not conducted in 1984, since it was an even-numbered year. The preliminary survey for 1984, which collected production information on a sample basis for the first 9 months only, was used to generate State annual preliminary estimates. Of the 402 dimension stone operations surveyed for 1983 and 1982, including those that were idle, 295, or 73%, responded, representing 91% of the total estimated value shown in table 1. The final 1982 data are based on previous year data from the 1983 survey and update 1982 preliminary data for the first 9 months only. 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)

	1980	1981	1982	1983	1984
Sold or used by producers[1]	1,315	1,331	[r] [e]1,089	[r]1,090	[e]1,157
Value[1]	$138,900	$150,463	[r] [e]$137,671	[r]$147,843	[e]$154,949
Exports (value)	$15,170	$20,698	$18,678	$21,185	$26,318
Imports for consumption (value)	$88,900	$132,904	$169,874	$195,378	$231,678

[e]Estimated. [r]Revised.
[1]Does not include Puerto Rico.

DOMESTIC PRODUCTION

Dimension stone was produced by 220 companies at 300 quarries in 32 States. Leading States, in order of tonnage, were Georgia, Indiana, and North Carolina. Notable was a 10% increase in Indiana. Of the total production, 55% was granite, 23% was limestone, 12% was sandstone, 11% was slate, 3% was marble, and the remaining 1% was miscellaneous stone, including argillite, schist, soapstone, and traprock (basalt). Leading producer companies were Rock of Ages Corp., principally in New Hampshire and Vermont, and Cold Spring Granite Co., principally in California, Minnesota, South Dakota, and Texas.

Granite.—Dimension granite, for statistical purposes, includes all coarse-grained igneous rocks. Production increased 6% to 638,000 tons and increased 8% in value to $95.0 million. Georgia continued to be the leading State producing 28% of the U.S. total, followed by Vermont and North Carolina. These three States together produced over one-half of the U.S. total.

Cold Spring Granite of Cold Spring, MN, announced a $5.0 million expansion that would involve construction of a new four-building facility for producing thin granite sheets, about 1 inch thick. The new facility near Cold Spring will have state-of-the-art equipment that will reduce production costs. This will enable the firm to compete better with the thin, low-cost foreign granites that have been imported in large quantities over the last 4 years. The existing operations that produce 3- to 4-inch-thick granite slabs and other products will continue to operate unchanged.

Granite Technologies Inc. announced the construction of an advanced Italian-equipped plant in Chicago to cut and polish imported rough granite and marble blocks to produce thin veneer for buildings.

Delano Granite Inc. of Delano, MN, filed for bankruptcy on March 26, 1984. This one-time major producer of granite monuments closed its plant late in 1983.

Coggins Granite Inc. sold its building stone division, which will leave it as a producer of rough blocks for monument manufacture in the Elberton, GA, area. The division was bought by an Atlanta individual and will continue to be operated as the Georgia Granite Co. Inc. and includes a plant and some almost-new cutting and polishing equipment, plus quarries in Georgia, Missouri, North Carolina, Oklahoma, South Carolina, South Dakota, and Virginia.

Limestone.—Dimension limestone includes bituminous, dolomitic, and siliceous limestones. Indiana, the leading State, produced 157,000 tons in 1984, compared with 142,680 tons in 1983 and 124,760 tons in 1982. Wisconsin, usually the third or fourth largest producer, totaled 21,270 tons valued at $870,000 in 1983 and 14,740 tons valued at $520,000 in 1982.

Table 2.—Dimension stone sold or used by producers in the United States, by State

State	1982[r, e]		1983		1984[e]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Alabama	4,312	$2,094	7,385	$2,661	7,585	$2,674
Arizona	45	1	45	1	20	([1])
Arkansas	8,919	574	9,114	573	--	--
California	19,700	2,727	20,321	2,839	22,240	2,990
Colorado	899	86	899	86	999	87
Connecticut	16,220	923	18,178	1,028	17,578	1,080
Georgia	182,131	19,375	[r]182,842	[r]21,019	202,030	20,007
Hawaii	396	4	330	3	--	--
Illinois	1,609	43	1,836	71	--	--
Indiana	126,558	11,626	144,478	11,015	159,126	14,269
Maryland	9,963	470	12,193	682	16,693	864
Massachusetts	54,884	11,399	50,780	10,488	56,982	11,657
Michigan	3,926	95	4,307	112	4,225	129
Minnesota	29,184	10,956	27,651	11,365	38,746	13,369
Missouri	210	13	W	W	W	W
New Hampshire	54,679	3,593	57,512	4,032	58,740	4,198
New Mexico	17,584	141	17,584	141	19,257	149
New York	22,441	3,952	23,552	4,310	14,859	4,271
North Carolina	165,461	8,457	86,736	8,267	W	W
Ohio	47,912	2,765	49,059	2,923	36,853	3,454
Oklahoma	8,414	589	9,935	737	12,074	771
Pennsylvania	42,404	5,033	53,400	5,799	44,376	6,001
South Carolina	17,099	1,164	17,113	1,165	16,130	1,092
South Dakota	39,418	14,805	[r]42,057	[r]15,794	59,597	18,642
Tennessee	8,312	1,238	7,373	1,161	7,021	1,097
Texas	40,674	7,702	50,484	11,071	46,937	11,236
Vermont	109,488	18,358	[r]115,714	19,995	116,005	20,462
Virginia	3,611	1,151	[r]15,584	[r]2,238	22,063	3,052
Washington	453	20	1,107	37	--	--
Wisconsin	17,721	2,815	24,218	2,884	24,028	2,863
Other[2]	34,019	5,504	38,603	5,347	152,458	10,534
Total[3]	1,088,646	137,671	[r]1,090,390	[r]147,843	1,156,622	154,949

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."

[1]Less than 1/2 unit.

[2]Includes Idaho, Iowa (1982-83), Kansas, Maine, Montana, New Jersey, Oregon (1982-83), Rhode Island, Utah (1982-83), and items indicated by symbol W.

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

Table 3.—Dimension granite sold or used by producers in the United States, by State

State	1982[r e]		1983		1984[e]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
California	5,400	$1,873	5,823	$1,975	W	W
Connecticut	8,395	592	9,773	662	W	W
Georgia	161,360	9,618	[r]161,816	[r]9,546	179,000	$9,500
Massachusetts	52,984	11,171	49,280	W	55,000	W
New Hampshire	54,679	3,592	57,512	4,032	58,700	4,200
North Carolina	159,606	7,431	80,096	7,187	W	W
Oklahoma	4,449	529	5,396	652	W	W
South Carolina	17,099	1,164	17,113	1,165	16,100	1,100
South Dakota	39,418	14,805	[r]42,057	[r]15,794	59,600	18,600
Texas	30,261	7,230	39,994	10,663	37,000	11,000
Vermont	81,895	11,454	W	W	W	W
Virginia	36	2	20	2	W	W
Wisconsin	2,978	2,291	2,945	2,016	W	W
Other[1]	37,686	9,304	128,815	34,402	232,600	50,600
Total	656,246	81,056	[r]600,640	[r]88,096	638,000	95,000

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Colorado, Maine, Maryland, Minnesota (1983), Missouri, New York, Pennsylvania, Rhode Island, Washington (1982-83), and items indicated by symbol W.

CONSUMPTION AND USES

Dimension stone was marketed over wide areas. Industry stockpiles were not monitored, and production during the year was assumed to equal consumption.

Consumption of domestic dimension stone increased slightly to 1.16 million tons valued at $155 million in 1984, compared with 1.09 million tons valued at $147.8 million in 1983 and 1.09 million tons valued at $137.7 million in 1982.

Consumption of domestic granite increased to 638,000 tons valued at $95.0 million in 1984, compared with 600,600 tons worth $88.1 million in 1983 and 656,200 tons worth $81.1 million in 1982.

Domestic limestone consumption was 270,100 tons valued at $24.0 million in 1984, compared with 245,000 tons valued at $19.1 million in 1983 and 214,600 tons valued at $19.2 million in 1982.

Domestic marble consumption, including travertine, totaled 26,500 tons valued at $15.2 million in 1984, compared with 30,750 tons valued at $18.6 million in 1983 and 31,630 tons valued at $17.8 million in 1982.

Consumption of domestic slate totaled 55,000 tons valued at $11.0 million in 1984, compared with 50,500 tons worth $11.7 million in 1983 and 41,100 tons worth $10.2 million in 1982.

A review of current industry practice indicated that use of dimension stone in building increased substantially in the 1980's because of its attractiveness, durability, superior insulation qualities, and because dimension stone has become less expensive relative to glass and steel, but particularly because of the advent of new installation techniques. Traditionally, stone slabs were lifted onto the building and then anchored in place. Now the slabs can be preassembled away from the building site into large panels backed by steel trusses, and then the whole panel is simply lifted into place at the building site. With this technique, the slabs can be thinner too, which uses less stone. Panels also can be assembled by casting a layer of concrete on the back of the rows of slabs. These practices conserve materials and allow work to be done at a more convenient location than on the side of a building. A technique just out of the experimental stage involves cementing thin marble tiles to the building with silicone adhesive. Another technique beginning to come into use involves installing slotted stone panels into a framework of aluminum, just like installing the glass panels in a glass curtain wall.[2]

Table 4.—Dimension stone sold or used by producers in the United States, by use

Use	1982[e]		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	261,473	$18,382	274,710	$22,300
Irregular-shaped stone[1]	139,915	4,988	157,313	5,956
Monumental	229,562	21,262	[r]232,232	[r]22,760
Other[2]	10,292	288	13,347	321
Dressed stone:				
Ashlars and partially squared pieces[3]	152,192	31,978	[r]134,730	[r]27,181
Slabs and blocks for building and construction	77,797	18,620	60,737	18,157
Monumental	31,573	17,045	[r]37,997	[r]21,832
Curbing	115,222	10,146	[r]95,937	[r]12,598
Flagging	36,892	4,408	[r]49,475	[r]4,956
Roofing slate	7,429	3,588	8,861	4,384
Structural and sanitary	2,893	1,685	3,581	1,817
Flooring slate	9,481	2,903	[r]10,631	[r]3,168
Other[4]	13,925	2,379	[r]10,839	[r]2,411
Total[5]	1,088,646	137,671	[r]1,090,390	[r]147,843

[e]Estimated. [r]Revised.
[1]Includes rubble.
[2]Includes flagging and uses not specified.
[3]Includes veneer.
[4]Includes paving block, blackboards, billiard table tops, slate used as lightweight aggregate, and uses not specified.
[5]Data may not add to totals shown because of independent rounding.

Table 5.—Dimension granite sold or used by producers in the United States, by use

Use	1982[e]		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	132,878	$12,674	132,035	$16,411
Irregular-shaped stone[1]	40,206	2,026	42,369	2,310
Monumental	229,562	21,262	[r]232,232	[r]22,760
Other[2]	116	15	180	16
Dressed stone:				
Ashlars and partially squared pieces	78,103	22,627	[r]52,120	[r]17,722
Slabs and blocks for building and construction	34,278	1,804	12,650	1,290
Monumental	21,868	10,095	[r]71,803	[r]18,266
Curbing	115,145	10,138	51,859	8,709
Other[3]	4,090	416	5,392	610
Total[4]	656,246	81,056	[r]600,640	[r]88,096

[e]Estimated. [r]Revised.
[1]Includes rubble.
[2]Includes flagging and uses not specified.
[3]Includes flagging and paving block.
[4]Data may not add to totals shown because of independent rounding.

Table 6.—Dimension limestone sold or used by producers in the United States, by use

Use	1982[e]		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	97,160	$4,408	110,564	$4,578
Irregular-shaped stone[1]	33,928	738	40,901	1,080
Other[2]	6,940	85	9,528	112
Dressed stone:				
Ashlars and partially squared pieces[3]	47,989	6,790	49,519	6,599
Slabs and blocks for building and construction	26,224	6,955	30,657	6,481
Curbing	38	2	38	2
Other[4]	2,287	195	3,877	270
Total	214,566	19,173	245,084	19,122

[e]Estimated.
[1]Includes rubble.
[2]Includes flagging.
[3]Includes veneer.
[4]Includes flagging and uses not specified.

Table 7.—Dimension sandstone sold or used by producers in the United States, by use

Use	1982[e]		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	25,120	$739	26,385	$810
Irregular-shaped stone[1]	58,858	1,981	67,185	2,323
Other[2]	2,225	149	2,292	150
Dressed stone:				
Ashlars and partially squared pieces[3]	23,407	1,939	30,305	2,261
Slabs and blocks for building and construction	9,812	1,415	10,341	1,491
Flagging	10,130	1,716	11,088	1,826
Other[4]	468	519	470	547
Total	130,020	8,458	148,066	[5]9,409

[e]Estimated.
[1]Includes rubble.
[2]Includes flagging.
[3]Includes veneer.
[4]Includes curbing and uses not specified.
[5]Data do not add to total shown because of independent rounding.

Table 8.—Dimension slate sold or used by producers in the United States, by use

Use	1982[e]		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Flagging	17,151	$1,923	[r]27,115	[r]$2,279
Roofing slate	7,429	3,588	8,861	4,384
Structural and sanitary	2,893	1,685	3,581	1,817
Flooring slate	9,481	2,903	[r]10,631	[r]3,168
Other[1]	4,174	120	291	40
Total	41,128	10,219	[r]50,479	[2]11,689

[e]Estimated. [r]Revised.
[1]Includes blackboards, billiard table tops, and uses not specified.
[2]Data do not add to total shown because of independent rounding.

Table 9.—Dimension marble sold or used by producers in the United States, by use

Use	1982[e]		1983	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	6,045	$554	5,476	$495
Dressed stone:				
Slabs and blocks for building and construction	7,482	8,446	7,089	8,894
Other[1]	18,105	8,849	18,188	9,213
Total	31,632	17,849	30,753	18,602

[e]Estimated.
[1]Includes rough irregular-shaped stone, dressed ashlars and partially squared pieces, monumental, flagging, and uses not specified.

PRICES

The average price for dimension stone was unchanged at abou. $134 per ton.

FOREIGN TRADE

Exports.—Exports of dimension stone, about 50% of which was granite, increased 24% in value to $26 million.

Imports.—Imports of dimension stone increased 19% in value to $232 million, mostly because of increases in marble imports.

While imports of rough and dressed granite decreased 8% by value, they about quadrupled in quantity. Imports of polished marble slabs, mostly from Italy, increased 45% to $61 million. Imports of other marble, n.s.p.f., increased 44% to $41 million, primarily because of a significant increase of material from Taiwan. Imports of slate increased 71% in value to $5.8 million. On a value basis, marble accounted for 45% of imports, followed by granite, 37%; travertine, 9%; and slate, 2%.

Table 10.—U.S. exports of dimension stone, by type

(Thousand short tons and thousand dollars unless otherwise specified)

Type	1983		1984		Major destination in 1984 (percent[1])
	Quantity	Value	Quantity	Value	
Granite, rough	75.7	8,068	79.7	8,895	Japan 37%; Federal Republic of Germany 25%.
Granite articles	NA	1,468	NA	4,878	Canada 52%.
Limestone, crude, not for building or monumental	9.3	156	5.9	105	Chile 85%.
Limestone, dressed, for building or monumental	1.5	227	.9	69	Canada 60%.
Limestone articles	30.4	584	34.1	1,593	India 57%.
Marble, breccia, onyx, rough or squared	18.6	540	13.6	346	Canada 80%.
Marble, breccia, onyx articles	NA	3,424	NA	991	Canada 21%.
Quartzite, rough and dressed	7.4	1,884	83.6	2,853	Netherlands 28%.
Slate building articles	NA	385	NA	177	Saudi Arabia 51%.
Slate building articles, other	NA	967	NA	960	Canada 51%.
Stone, rough, not for building or monumental	3.6	331	3.6	353	Canada 31%.
Stone, rough, for building or monumental	13.6	1,480	9.8	1,270	Japan 51%.
Stone, other, including alabaster or jet	NA	1,671	NA	3,828	Kuwait 17%.
Total	NA	21,185	NA	26,318	

NA Not available.
[1]By value.

Table 11.—U.S. imports for consumption of dimension granite, by country

(Thousand cubic feet and thousand dollars)

Country	Rough[1]		Dressed		Other n.s.p.f., undecorated[2] (value)
	Quantity	Value	Quantity	Value	
1982	771	4,252	1,228	71,637	4,076
1983:					
Brazil	10	31	108	2,821	66
Canada	198	3,598	209	10,698	3,135
India	17	256	25	874	3
Italy	43	72	1,357	61,422	1,077
Japan	--	--	16	85	29
Portugal	1	21	5	236	1
Saudi Arabia	--	--	--	--	--
South Africa, Republic of	73	938	16	269	56
Spain	--	--	27	2,180	90
Other	3	77	65	r1,373	r606
Total	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

rRevised.
[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.

Table 12.—U.S. imports for consumption of dimension marble and travertine, by country

Country	Marble, breccia, or onyx, polished slabs: Quantity (thousand square feet)	Marble, breccia, or onyx, polished slabs: Value (thousands)	Marble, breccia, or onyx, other n.s.p.f.[1]: Value (thousands)	Travertine dressed[2]: Quantity (short tons)	Travertine dressed[2]: Value (thousands)
1982	13,949	$34,211	$19,165	166,755	$20,787
1983:					
France	339	1,105	188	19	24
Germany, Federal Republic of	47	161	306	15	11
Greece	240	636	27	--	--
Italy	11,846	30,785	12,850	47,896	16,578
Mexico	695	933	1,564	17,584	1,355
Pakistan	40	181	467	--	--
Philippines	190	624	143	--	--
Portugal	798	2,108	461	536	190
Spain	2,243	3,401	487	1,044	133
Taiwan	384	789	11,005	17	9
Other	496	1,215	963	229	114
Total	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

[1]Quantity not reported. Does not include certain special kinds of rough marble, breccia, or onyx.
[2]Suitable for use as monumental, paving, or building stone. Does not include travertine articles.

Table 13.—U.S. imports for consumption of other dimension stone, by type

Type	1983: Quantity	1983: Value (thousands)	1984: Quantity	1984: Value (thousands)	Major source in 1984 (percent[1])
Granite, unmanufactured, nonmonumental short tons	1,679	$199	27,753	$554	Canada 79%.
Granite, n.s.p.f., decorated	--	175	--	620	Italy 48%.
Alabaster and jet articles	--	1,922	--	3,300	Italy 96%.
Limestone, crude, not for building, monumental short tons	271,291	1,349	885,472	4,215	Bahamas 60%.
Limestone, dressed, hewn do	8,883	343	4,855	612	France 47%.
Marble and breccia, rough cubic feet	44,336	243	57,629	397	Italy 47%.
Onyx, rough do	1,596	32	11,855	68	Mexico 86%.
Marble, breccia, onyx, slab and tiles, unpolished square feet	644,351	1,432	1,413,100	1,625	Italy 54%.
Quartzite short tons	13,533	245	57,019	945	Canada 68%.
Slate, roofing square feet	298,259	82	1,008,911	597	United Kingdom 63%.
Slate, other, n.s.p.f	--	3,296	--	5,178	Italy 67%.
Travertine articles, undecorated	--	2,671	--	3,999	Italy 89%.
Travertine articles, decorated	--	715	--	1,489	Italy 90%.
Stone, unmanufactured short tons	42,357	472	161,258	825	Canada 52%.
Stone, dressed, building do	2,385	405	12,039	659	Mexico 48%.
Stone, other n.s.p.f., undecorated	--	1,613	--	1,869	Mexico 28%.
Stone, other n.s.p.f., decorated	--	1,357	--	2,519	Taiwan 23%.

[1]By value.

WORLD REVIEW

Dimension stone is produced in many countries of the world; production of it is more widespread than that of almost any other mineral commodity. Italy continued to produce about one-half of the world total.

A recent study of the world dimension stone market indicated that it continues to be relatively stable except for some local fluctuations such as a production decline in the United Kingdom caused by the conversion of a number of quarries from dimension stone to crushed stone production. A production increase in more finished and higher cost stone in India was caused by the installation of modern equipment.[3]

Belgium.—Southern Belgium is noted for production of two very hard limestones, petit granit and rouge de flandres, both of which take a good polish and are therefore considered to be marbles by the dimension stone trade. SA Carrières du Hainaut was the largest producer of petit granit and had a capacity of 1.69 million cubic feet per year; the stone was made into flooring, cladding, and tombstones. SA Carrières du Clypot was the second largest producer of petit granit and had a capacity of 490,000 cubic feet per year; the stone was made into tiles, cladding, paving, and curbing. SA Carrières Gauthier & Wincqz was the other major producer of petit granit and had a capacity of 280,000 cubic feet per year; the stone was made into paving, building stone for exteriors, monuments and associated items, and stone used in the interiors of buildings. SA Comarbel was the major producer of rouge de flandres and had a capacity of 18,000 tons per year; 90% of the stone was exported as tiling and paving.[4]

Canada.—The Ontario Ministry of Natural Resources issued a study of the potential for dimension stone production in northwestern Ontario. The study covered stone for both buildings and monuments, mainly granite. An expansion of the industry in northwestern Ontario was deemed feasible, starting with an expansion of sales of rough granite slabs to the building and monumental markets, then moving to local manufacture of curbing, crazy-work and pavers, flagging, and bases for memorials, and finally to an expansion of sales of high-value polished granite items, particularly monuments. The strong markets for colored granites, particularly deep red and black, result in higher prices for these stones. This makes exploration for them especially attractive, and therefore, a search for them is recommended. Governmental assistance for expanding the dimension stone industry was recommended, particularly in exploration, in providing financial assistance, and in setting an example by using the local building stones themselves.[5]

China.—A marble slab plant with a capacity of 65,000 square feet per year came on-stream at Urumqi, Xinjiang Province, in western China. The marble is fine grained and suitable for making 0.6-inch-thick slabs. Reserves are estimated to be over 1 billion tons and are located in the Central Tian Shan Mountains.

Greece.—Last year, a 5-year development plan went into effect that would triple primary quarry production of marble and increase marble exports by a factor of 10 by 1988. Marble exports are now at roughly the 100,000-ton-per-year level, mostly worked and finished, and mostly going to Middle Eastern markets. The exporters find the United States and Canadian markets particularly attractive, but the industry is being hampered by the stringent application of environmental restrictions on quarry development. The only Greek marble now exported in significant quantities is Pentelikon, the marble used to build the Parthenon.[6]

Portugal.—Exports of unpolished marble totaled 77,480 tons in 1983, compared with 54,940 tons in 1982 and 77,900 tons in 1981. Exports of sawn and worked marble totaled 41,000 tons in 1983, compared with 35,420 tons in 1982 and 54,480 tons in 1981. Exports of granite setts and paving and curbing stone totaled 185,080 tons in 1983, compared with 123,220 tons in 1982 and 154,810 tons in 1981. Low productivity and undercapitalization will make it difficult for the dimension stone industry to compete when Portugal enters the European Economic Community.[7]

South Africa, Republic of.—Production of granite and gabbro totaled 219,320 tons in 1983, of which 188,490 tons was exported. The largest granite-producing company by far is Keeley Granite (Pty.) Ltd.[8]

Sweden.—The Swedish market for dimension stone has declined markedly in the last 5 years, although the red, brown, and black granites that Sweden is known for continue to be produced on a large scale. The total demand for Swedish dimension stone in 1982 included building stone, 57%; tombstones, 24%; paving stones, 17%; and the balance, for other uses.[9]

TECHNOLOGY

A new diamond bead was developed for the diamond wire saw. This is the first change in the bead since the diamond wire saw went into use 5 years ago at Carrara, Italy, and one that could allow the cutting of harder, more abrasive stones. The new bead is diamond impregnated and has the diamond grit distributed evenly throughout the impregnated annular volume, allowing uniform cutting ability over the life of the bead, unlike the old electroplated bead. According to the manufacturer, the new impregnated bead saws about 20% more slowly than the old bead, but costs roughly one-third less per square yard and has over a 50% longer service life.[10]

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[1]Physical scientist, Division of Industrial Minerals.
[2]Engineering News Record. Buildings Are Turning to Stone. V. 212, No. 10, Mar. 8, 1984, pp. 26-28.
[3]Allison, P. Dimension Stone—A Rock Steady Market. Ind. Miner. (London), No. 202, July 1984, pp. 19-35.
[4]Work cited in footnote 3.
[5]Les Consultants Sogir Inc. Market Study for Stone in Northwestern Ontario. Ont. Geol. Surv. Open File Rep. 5493, 1984, 110 pp.
[6]Stone Industries. Greece Plans for Export Growth. V. 19, No. 2, Mar. 1984, pp. 26-27.
[7]———. Time for Investment in Portugal. V. 19, No. 4, May 1984, pp. 33-34.
[8]Work cited in footnote 3.
[9]Work cited in footnote 3.
[10]Thoreau, B. Diamond Impregnated Wire for Hard Stones. Stone Ind., v. 19, No. 3, Apr. 1984, pp. 28-29.

Sulfur

By David E. Morse[1]

Stimulated by marked increase in demand, domestic production of sulfur in all forms increased 15%. Output from Frasch mines was up 31%, whereas production of recovered elemental sulfur from petroleum refineries and natural gas-processing plants increased to an alltime high exceeding 5 million metric tons for the first time. Shipments of sulfur in all forms increased 11% and exceeded sulfur output by 8%. Prices for all elemental sulfur increased, regaining 1982 levels by yearend 1984. Notwithstanding its position as the world's largest producer, U.S. sulfur demand continued to exceed domestic production. The United States continued to be a net sulfur importer despite a decrease of nearly 0.8 million tons in producers' stocks of elemental sulfur.

World sulfur production increased after 3 consecutive years of decline. World demand exceeded output, requiring a drawdown of world stocks by over 4 million tons.

Table 1.—Salient sulfur statistics

(Thousand metric tons, sulfur content, and thousand dollars unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production:					
Frasch	6,390	6,348	4,210	3,202	4,193
Recovered[1]	4,073	4,259	4,404	4,955	5,214
Other forms	1,403	1,538	1,173	1,133	1,245
Total	11,866	12,145	9,787	9,290	10,652
Shipments:					
Frasch	7,400	5,910	3,598	4,111	5,001
Recovered[1]	4,115	4,207	4,344	5,041	5,210
Other forms	1,403	1,538	1,173	1,133	1,245
Total	12,918	11,655	9,115	10,285	11,456
Imports, elemental	2,523	2,522	1,905	1,695	2,557
Exports, elemental[2]	1,673	1,392	961	992	1,334
Consumption, apparent, all forms[3]	13,659	12,785	10,059	10,988	12,679
Stocks, Dec. 31: Producer, Frasch and recovered	3,094	3,634	4,202	3,218	2,434
Value:					
Shipments, f.o.b. mine or plant:					
Frasch	$720,511	$715,683	$434,660	r$414,210	$546,106
Recovered[1]	305,046	412,115	425,217	384,214	416,878
Other forms	84,332	140,618	122,177	116,255	121,692
Total	1,109,889	1,268,416	982,054	r914,679	1,084,676
Imports, elemental[4]	$138,852	$209,766	$164,885	$129,110	$200,189
Exports, elemental[5]	$185,866	$187,407	$122,143	$109,298	$156,067
Price, elemental, dollars per metric ton, f.o.b. mine or plant	$89.06	$111.48	$108.27	r$87.24	$94.31
World: Production, all forms (including pyrites)	r54,983	r53,372	50,753	p50,315	e51,884

eEstimated. pPreliminary. rRevised.
[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes exports from the Virgin Islands to foreign countries in 1981-84.
[3]Measured by shipments, plus imports, minus exports.
[4]Declared customs valuation.
[5]Includes value of exports from the Virgin Islands to foreign countries in 1981-84.

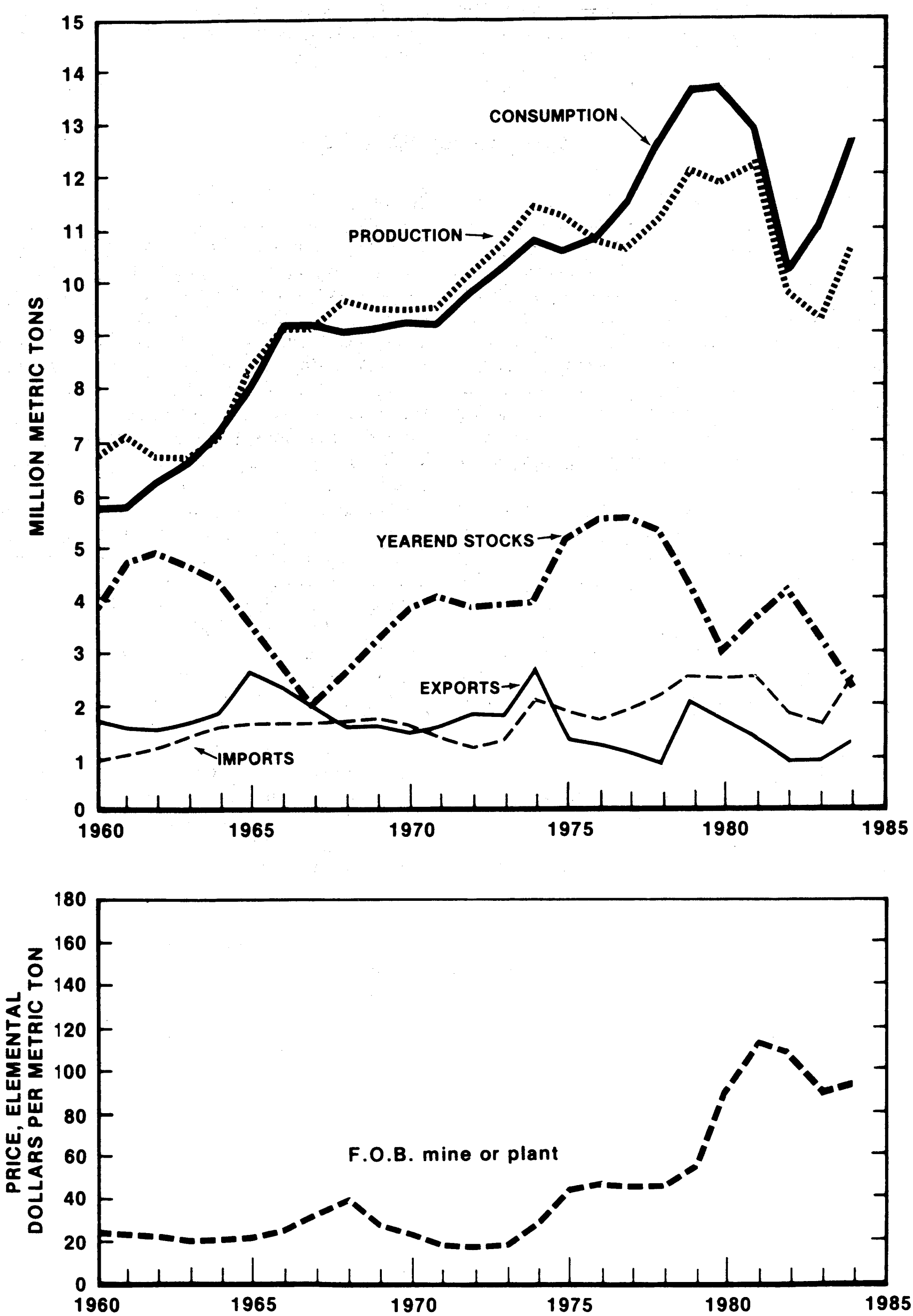

Figure 1.—Trends in the sulfur industry in the United States.

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 192 operations to which a survey request was sent, all responded, representing 100% of the total production shown in tables 1 and 2.

DOMESTIC PRODUCTION

Frasch.—In January, six Frasch mines were operating in Louisiana and Texas. Mines in Louisiana were Freeport Minerals Co. at Garden Island Bay, Grand Isle, and Caillou Island. Mines in Texas were Farmland Industries Inc. at Fort Stockton; Duval Corp. at Culberson; and Texasgulf Inc. at Boling Dome. Freeport closed the Caillou Island facility because of unfavorable economics caused by poor thermal efficiencies and production difficulties. At yearend, the remaining five mines were operating at about 86% of capacity.

Frasch sulfur output increased nearly 1.0 million tons over the depressed quantity produced in 1983. Shipments increased by 0.9 million tons and exceeded output by 800,000 tons. Frasch sulfur accounted for about 39% of domestic production in 1984, compared with 35% in 1983. Approximately 82% of Frasch sulfur shipments was for domestic consumption, and 18%, for export. The total value of Frasch sulfur shipments increased 32%.

Recovered.—Production of recovered elemental sulfur, a nondiscretionary byproduct from natural gas and petroleum refineries, and coking plants, accounted for 49% of the total domestic output of sulfur in all forms, compared with 53% in 1983. Production and shipments reached alltime highs of over 5.0 million tons in 1984 and surpassed Frasch output and shipments for the third consecutive year. This type of sulfur was produced by 58 companies at 155 plants in 26 States, 1 plant in the Virgin Islands, and 1 plant in Puerto Rico. Most of these plants were of relatively small size, with only 10 reporting an annual production exceeding 100,000 tons. By source, 54% was produced by 43 companies at 85 refineries or satellite plants treating refinery gases and 3 coking plants, and 46% was produced by 27 companies at 67 natural gas treatment plants. The five largest recovered elemental sulfur producers were Chevron U.S.A. Inc., Exxon Co. U.S.A., Getty Oil Co., Shell Oil Co., and Standard Oil Co. of Indiana. These companies' 45 plants accounted for 59% of recovered elemental sulfur output.

The leading States in production of recovered elemental sulfur were Alabama, California, Mississippi, Texas, and Wyoming. These five States contributed 71% of the total output; shipments from Texas accounted for 27% of total shipments. The total value of shipments of recovered elemental sulfur increased 9%.

Table 2.—Production of sulfur and sulfur-containing raw materials in the United States

(Thousand metric tons)

	1983		1984	
	Gross weight	Sulfur content	Gross weight	Sulfur content
Frasch sulfur	3,202	3,202	4,193	4,193
Recovered sulfur[1]	4,955	4,955	5,214	5,214
Byproduct sulfuric acid (100% basis) produced at copper, lead, molybdenum, and zinc plants	2,541	831	2,942	962
Pyrites	W	W	W	W
Other forms[2]	741	302	723	283
Total	XX	9,290	XX	10,652

W Withheld to avoid disclosing company proprietary data; included with "Other forms." XX Not applicable.
[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes hydrogen sulfide, liquid sulfur dioxide, and data indicated by symbol W.

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]
1980	4,081	2,309	6,390	7,400	720,511
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	[r]414,210
1984	2,257	1,937	4,193	5,001	546,106

[r]Revised.
[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]
1980	1,757	2,316	4,073	4,115	305,046
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

[1]Includes Puerto Rico and the Virgin Islands.
[2]Includes a small quantity from coking operations and utility plants in 1980-82; includes only a small quantity from coking operations in 1983-84.
[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	1983			1984		
	Production (quantity)	Shipments		Production (quantity)	Shipments	
		Quantity	Value		Quantity	Value
Alabama	401	401	36,319	380	380	34,492
California	480	505	24,978	516	516	28,695
Florida	142	142	W	111	111	W
Illinois	224	225	20,557	182	181	15,838
Louisiana	261	261	24,122	320	318	29,901
Michigan and Minnesota	118	119	8,054	139	139	9,627
Mississippi	690	722	67,860	745	754	74,382
New Jersey	73	73	8,029	58	59	6,636
New Mexico	60	60	3,827	63	63	4,245
North Dakota	101	102	4,904	112	112	5,572
Ohio	38	39	3,837	39	39	3,983
Pennsylvania	52	53	4,507	53	52	4,487
Texas	1,394	1,407	109,061	1,417	1,413	121,447
Wisconsin	2	2	114	2	2	108
Wyoming	504	489	16,903	626	624	23,280
Other[1]	415	442	51,139	453	447	54,185
Total[2]	4,955	5,041	384,214	5,214	5,210	416,878

W Withheld to avoid disclosing company proprietary data; included with "Other."
[1]Includes Arkansas, Colorado, Delaware, Indiana, Kansas, Kentucky, Montana, Oklahoma (1983), 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	1983		1984	
	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	235	237	228	228
Natural gas	142	141	110	111
Total[1]	377	379	339	339
PAD 2:				
Petroleum and coke	498	500	504	500
Natural gas	105	107	114	114
Total[1]	604	607	618	615
PAD 3:[2]				
Petroleum	1,255	1,259	1,440	1,443
Natural gas	1,627	1,681	1,565	1,563
Total[1]	2,882	2,940	3,006	3,007
PAD 4 and 5:				
Petroleum	594	631	633	633
Natural gas	496	481	616	613
Total[1]	1,091	1,112	1,250	1,247
Grand total[1]	4,955	5,041	5,214	5,210

[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 9% of the total domestic production of sulfur in all forms. Eleven acid plants operated in conjunction with copper smelters, and 11 plants were accessories to lead, molybdenum, and zinc roasting and smelting operations. The five largest acid plants accounted for 57% 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' 14 plants produced 84% 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
1980	686	183	134	1,003	55,897
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

[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 pyrites, hydrogen sulfide, and sulfur dioxide was 3% of the total domestic production of sulfur in all forms. The total sulfur content in these products was 6% less than that of 1983. The three largest producers of these products were Asarco (sulfur dioxide), Stauffer Chemical Co. (sulfur dioxide), and Tennessee Chemical Co. (pyrites and sulfur dioxide). These companies' one mine and five plants accounted for 96% of the total contained sulfur produced 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
1980	322	36	42	400	28,435
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

W Withheld to avoid disclosing company proprietary data; included in "Total."

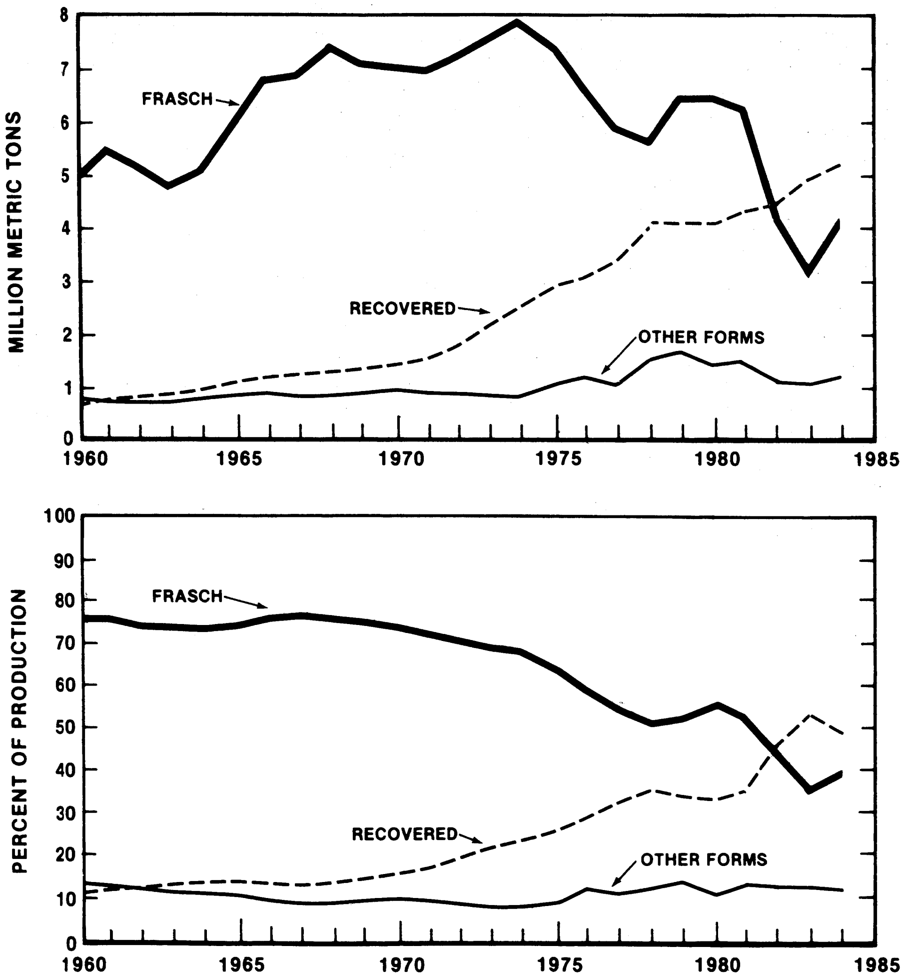

Figure 2.—Trends in the production of sulfur in the United States.

CONSUMPTION AND USES

Apparent domestic consumption of sulfur in all forms increased 15%. The sources of supply were domestic recovered elemental sulfur, 38%; domestic Frasch sulfur, 32%; and combined domestic byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide, 10%. The remaining 20% 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 64 companies, and shipments by end use of sulfuric acid were reported by 61 companies. Eleven companies reported shipments of both elemental sulfur and sulfuric acid.

The largest sulfur end use, sulfuric acid production, 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."

Led by a 21% increase in sulfuric acid consumption for phosphatic fertilizers, the largest single end use, shipments of 100% sulfuric acid increased 15%. Shipments of sulfuric acid for petroleum refining and other petroleum and coal products, the second largest end use, remained about the same. Usage of sulfuric acid for copper ore leaching increased 95%.

According to the 1984 canvass reports, company receipts of spent sulfuric acid for reclaiming totaled 2.8 million tons. The largest source of spent acid, from petroleum refining and coal products, accounted for 52% of the total returned. The petroleum refining industry was a net user of about 600,000 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 phosphatic fertilizers, soap and detergents, steel, industrial organic chemicals, other inorganic chemicals, storage batteries, other chemical products, and some unidentified sources.

The largest use of sulfur in all forms, for agricultural purposes, totaled 9.2 million tons, an increase of 18%. Industrial use increased about 7%.

Table 9.—Apparent consumption of sulfur[1] in the United States

(Thousand metric tons)

	1980	1981	1982	1983	1984
Frasch:					
Shipments	7,400	5,910	3,598	4,111	5,001
Imports	990	856	690	604	722
Exports	1,673	1,216	731	601	888
Total	6,717	5,550	3,557	4,114	4,835
Recovered:					
Shipments[2]	4,115	4,207	4,344	5,041	5,210
Imports	1,533	1,666	1,215	1,091	1,835
Exports	109	176	230	391	446
Total	5,539	5,697	5,329	5,741	6,599
Pyrites, shipments	322	307	265	W	W
Byproduct sulfuric acid, shipments	1,003	1,159	828	831	962
Other forms, shipments[3]	78	72	80	302	283
Total, all forms	13,659	12,785	10,059	10,988	12,679

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	1983	1984
20	Food and kindred products	W	W
26, 261	Pulp and paper products	14	29
282, 2822, 2823	Synthetic rubber, cellulosic fibers, other plastic products	34	65
287	Agricultural chemicals	[illegible]	480
28, 285, 286	Paints and allied products, industrial organic chemicals, other chemical products.	115	127
284	Soaps and detergents	23	14
29, 291	Petroleum refining and petroleum and coal products	142	278
281	Other industrial inorganic chemicals	250	285
30	Rubber and miscellaneous plastic products	W	W
	Sulfuric acid:		
	Domestic sulfur	6,558	6,909
	Imported sulfur	1,675	2,425
	Total	8,233	9,334
	Unidentified	801	734
	Total domestic uses	10,175	11,346
	Exports	645	1,289
	Grand total	10,820	12,635

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

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 1983	Quantity 1984
102	Copper ores	534	1,043
1094	Uranium and vanadium ores	250	163
10	Other ores	138	194
261	Pulpmills	607	700
26	Other paper products	152	114
285, 2816	Inorganic pigments and paints and allied products	382	332
281	Other inorganic chemicals	965	1,160
282, 2822	Synthetic rubber and other plastic materials and synthetics	965	959
2823	Cellulosic fibers including rayon	294	155
283	Drugs	87	74
284	Soaps and detergents	320	254
286	Industrial organic chemicals	1,124	938
2873	Nitrogenous fertilizers	160	261
2874	Phosphatic fertilizers	21,759	26,373
2879	Pesticides	84	70
287	Other agricultural chemicals	184	47
2892	Explosives	62	118
2899	Water-treating compounds	398	213
28	Other chemical products	204	405
29, 291	Petroleum refining and other petroleum and coal products	2,071	2,067
30	Rubber and miscellaneous plastic products	96	W
331	Steel pickling	288	270
333	Nonferrous metals	32	50
33	Other primary metals	19	113
3691	Storage batteries (acid)	177	177
	Unidentified	1,305	1,584
	Total domestic	32,657	37,834
	Exports	169	61
	Grand total	32,826	37,895

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] 1983	Elemental sulfur[1] 1984	Sulfuric acid (sulfur equivalent) 1983	Sulfuric acid (sulfur equivalent) 1984	Total 1983	Total 1984
102	Copper ores	--	--	175	341	175	341
1094	Uranium and vanadium ores	--	--	82	53	82	53
10	Other ores	--	--	45	63	45	63
20	Food and kindred products	W	W	--	--	W	W
26, 261	Pulpmills and paper products	14	29	248	266	262	295
28, 285, 286, 2816	Inorganic pigments, paints and allied products, industrial organic chemicals, other chemical products.	115	127	125	109	240	236
281	Other inorganic chemicals	250	285	316	379	566	664
282, 2822	Synthetic rubber and other plastic materials and synthetics.	[2]34	[2]65	315	314	[2]349	[2]379
2823	Cellulosic fibers, including rayon	([3])	([3])	96	51	96	51
283	Drugs	--	--	28	24	28	24
284	Soaps and detergents	23	14	104	83	127	97
286	Industrial organic chemicals	--	--	367	307	367	307
2873	Nitrogenous fertilizers	--	--	52	85	52	85
2874	Phosphatic fertilizers	--	--	7,113	8,621	7,113	8,621
2879	Pesticides	--	--	28	23	28	23
287	Other agricultural chemicals	563	480	60	15	623	495
2892	Explosives	--	--	20	39	20	39
2899	Water-treating compounds	--	--	130	70	130	70
28	Other chemical products	--	--	67	132	67	132
29, 291	Petroleum refining and other petroleum and coal products.	142	278	677	676	819	954
30	Rubber and miscellaneous plastic products	W	W	31	W	31	W
331	Steel pickling	--	--	94	88	94	88
333	Nonferrous metals	--	--	11	16	11	16
33	Other primary metals	--	--	6	37	6	37
3691	Storage batteries (acid)	--	--	58	58	58	58
	Exported sulfuric acid	--	--	55	20	55	20
	Total identified	1,141	1,278	10,303	11,870	11,444	13,148
	Unidentified	801	734	427	518	1,228	1,252
	Grand total	1,942	2,012	10,730	12,388	12,672	14,400

W Withheld to avoid disclosing company proprietary data; included with "Unidentified."
[1]Does not include elemental sulfur used for production of sulfuric acid.
[2]Includes elemental sulfur used in cellulosic fibers.
[3]Included with "Synthetic rubber and other plastic materials and synthetics."

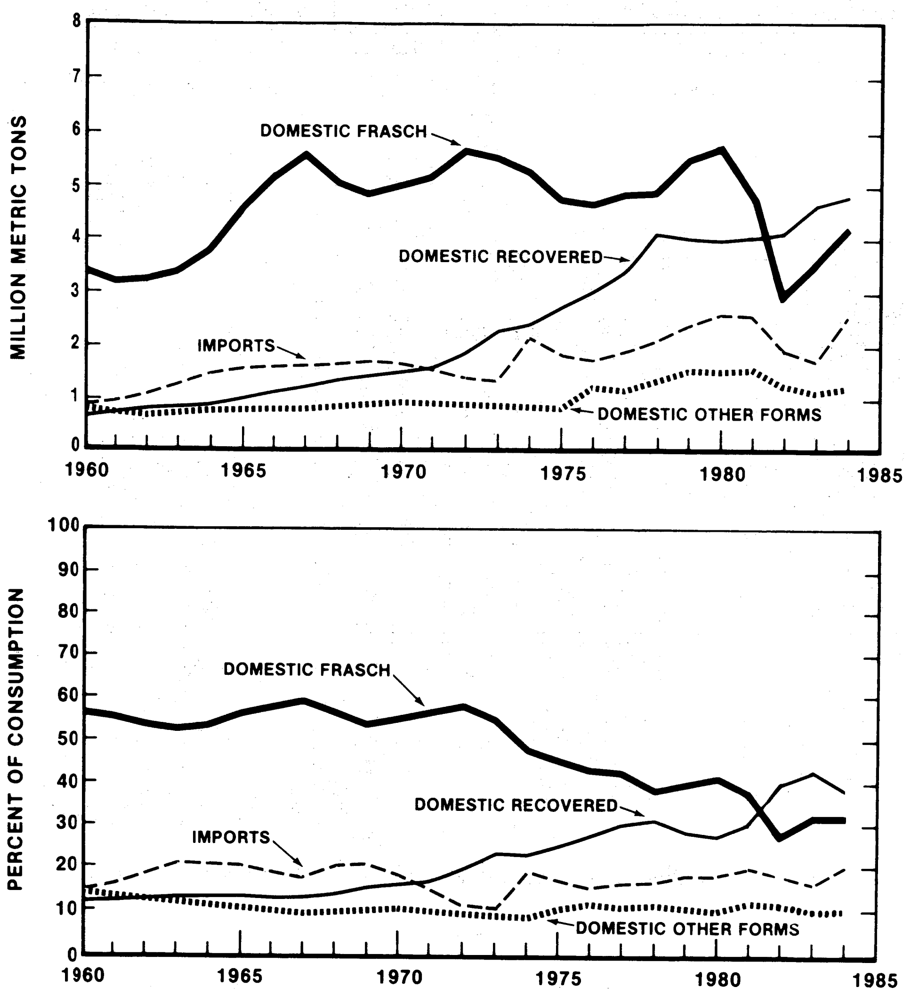

Figure 3.—Trends in the consumption of sulfur in the United States.

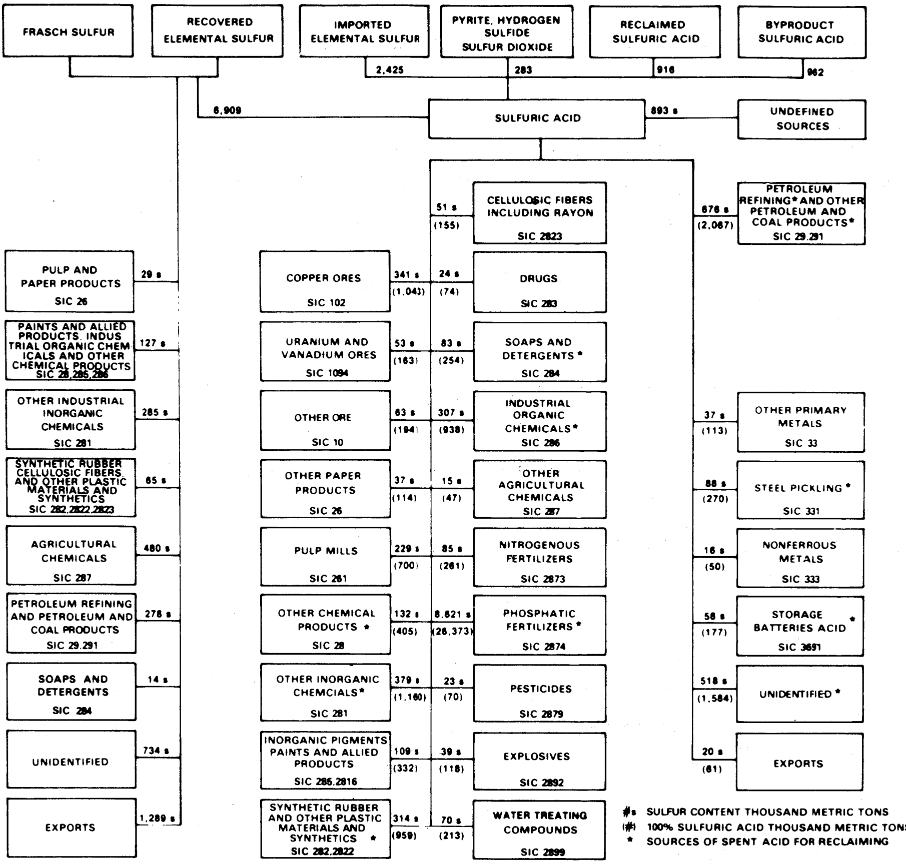

Figure 4.—Sulfur-sulfuric acid supply and end-use relationship in 1984.

STOCKS

Inventories held by Frasch producers were reduced by 26%. Combined yearend stocks amounted to approximately a 2-1/2-month supply compared with a 4-month supply in 1983, based on domestic and export demands for Frasch and recovered elemental sulfur.

Table 13.—Yearend sulfur stocks of U.S. producers

(Thousand metric tons)

Year	Frasch	Recovered	Total
1980	2,954	140	3,094
1981	3,442	192	3,634
1982	3,964	238	4,202
1983	3,065	153	3,218
1984	2,279	155	2,434

PRICES

The posted price for liquid sulfur ex-terminal Tampa, FL, increased three times in 1984. Price discounting, which began in April 1983, continued throughout 1984. International prices for solid sulfur increased substantially. The following table indicates pricing changes instituted during the year.

Table 14.—Sulfur price, 1984

Month	U.S. liquid sulfur[1] (per long ton)	Export (spot)[2] (per metric ton)
January	$132.50	$86.25
February	--	88.50
March	--	91.00
April	--	99.40
May	140.00	102.63
June	--	106.00
July	--	107.50
August	--	$115-140
September	147.50	130-141
October	--	--
November	--	--
December	157.50	135-145
Yearend 1984	157.50	135-151

[1]F.o.b. terminal, Tampa, FL. Discounts for volume customers up to $10 per long ton.
[2]F.o.b. Vancouver, British Columbia, Canada.

Source: Green Markets. V. 8, No. 1-51.

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 8%. The average value, f.o.b. plant, for shipments of recovered elemental sulfur varied widely by geographic region: lowest in the Rocky Mountain States and on the west coast, somewhat higher in 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 in 1984.

Table 15.—Reported sales values of shipments of sulfur, f.o.b. mine or plant

(Dollars per metric ton)

Year	Frasch	Recovered	Average
1980	97.36	74.13	89.06
1981	121.11	97.97	111.48
1982	120.79	97.89	108.27
1983	[r]100.76	76.22	[r]87.24
1984	109.20	80.02	94.31

[r]Revised.

FOREIGN TRADE

Exports of elemental sulfur from the United States, including the Virgin Islands, increased 34% in quantity and 43% in value. Exports of sulfur from the west coast were nearly 250,000 tons or 18% of total U.S. exports.

The United States continued to be a net importer of sulfur. Frasch sulfur from Mexico and recovered elemental sulfur from Canada continued to supply nearly all U.S. sulfur import requirements. Total imports of elemental sulfur increased 51% in quantity and 55% in value.

The United States also had significant international trade in sulfuric acid in 1984. Canada and Mexico were the United States' most important sulfuric acid trade partners.

Table 16.—U.S. exports[1] of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1983		1984	
	Quantity	Value	Quantity	Value
Argentina	1	334	1	512
Australia	(2)	339	1	688
Belgium-Luxembourg	337	44,072	397	46,983
Brazil	99	11,810	205	23,903
Canada	6	380	2	124
Chile	(2)	84	3	532
Egypt	69	7,544	132	17,535
France	(2)	8	20	1,913
Germany, Federal Republic of	2	1,319	1	455
Greece	(2)	2	--	--
India	46	3,707	127	14,334
Indonesia	3	225	18	2,278
Italy	44	3,974	16	1,470
Mexico	43	2,339	54	2,955
Morocco	24	2,505	162	21,973

See footnotes at end of table.

Table 16.—U.S. exports[1] of elemental sulfur, by country —Continued

(Thousand metric tons and thousand dollars)

Country	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Netherlands	(2)	7	13	1,399
Nigeria	5	415	--	--
Romania	31	3,819	21	2,400
Senegal	29	2,272	11	909
Sweden	5	433	(2)	1
Taiwan	80	7,041	43	4,566
Thailand	6	469	(2)	12
Tunisia	132	11,948	40	1,918
Turkey	--	--	21	2,383
United Kingdom	16	1,388	(2)	25
Uruguay	(2)	3	10	980
Yugoslavia	--	--	16	1,963
Other	r15	r2,864	19	3,856
Total[3]	992	109,298	1,334	156,067

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.

Table 17.—U.S. exports of sulfuric acid (100% H_2SO_4), by country

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Brazil	59	$16	26,831	$1,012
Canada	105,835	5,270	33,798	1,510
Chile	399	19	10,355	343
Dominican Republic	129	20	2,966	299
Ecuador	2,218	98	6,198	330
France	580	39	1,424	50
Guyana	598	30	1,539	224
Jamaica	122	9	1,665	114
Korea, Republic of	1,422	188	658	399
Mexico	25,077	950	6,815	293
Netherlands	6,407	173	32	4
Netherlands Antilles	15,184	1,017	6,295	331
Panama	1,249	96	2,500	126
Saudi Arabia	1,239	691	1,239	252
Trinidad and Tobago	190	7	2,379	136
Venezuela	389	51	6,182	308
Other	r9,905	r1,415	8,441	1,042
Total	171,002	10,089	119,317	6,773

rRevised.

Table 18.—U.S. imports of elemental sulfur, by country

(Thousand metric tons and thousand dollars)

Country	1983 Quantity	1983 Value[1]	1984 Quantity	1984 Value[1]
Canada	1,091	62,505	1,812	117,776
Mexico	604	66,556	722	79,756
Venezuela	--	--	22	2,531
Other[2]	(3)	r49	1	126
Total	1,695	129,110	2,557	200,189

rRevised.
[1]Declared customs valuation.
[2]Includes France, the Federal Republic of Germany, and Japan in 1983 and Belgium, China, the Federal Republic of Germany, Italy, Japan, and Netherland Antilles in 1984.
[3]Less than 1/2 unit.

Table 19.—U.S. imports of sulfuric acid (100% H_2SO_4), by country

Country	1983 Quantity (metric tons)	1983 Value[1] (thousands)	1984 Quantity (metric tons)	1984 Value[1] (thousands)
Canada	300,342	$9,261	356,484	$15,175
Germany, Federal Republic of	35	21	13,672	929
Japan	110,786	4,853	--	--
Mexico	665	52	15,105	784
Norway	13,967	494	6,464	568
Spain	10,424	573	18,468	1,323
Sweden	8,340	310	(2)	5
Switzerland	(2)	(2)	15,513	595
United Kingdom	900	152	2	4
Other	8	19	1	9
Total	445,467	15,735	425,709	[3]19,391

[1]Declared c.i.f. valuation.
[2]Less than 1/2 unit.
[3]Data do not add to total shown because of independent rounding.

WORLD REVIEW

World production of sulfur increased substantially after 3 consecutive years of declining output. Elemental sulfur production increased nearly 1.6 million tons while output of sulfur in other forms was essentially unchanged. Nevertheless, world consumption continued to outplace production requiring a drawdown of about 4.5 million tons in world elemental sulfur stocks. Canada reduced inventories by more than 2.6 million tons; the United States and Saudi Arabia each reduced stocks by about 800,000 tons. Stock levels also decreased in Mexico and Iraq while stocks were built slightly at the Lacq sour-gas facilities in France.

International trade in elemental sulfur increased sharply with about 17.5 million tons traded during the year compared with 15.3 million tons in 1983. Canada continued as the world's leading exporter, followed by Poland, Saudi Arabia, the United States, and Mexico. The United States was the largest importer. Other nations importing significant quantities of sulfur, in decreasing order of quantity, were Morocco, the U.S.S.R., Brazil, India, Tunisia, and the United Kingdom.

International sulfur prices escalated, reaching 1981 record-high levels by yearend. Vancouver, Canada, export prices, spot basis, increased by nearly $60 per ton or 68%; Saudi Arabian export settlements jumped nearly $30 per ton in August and were up over 50% between January and December.

Canada.—Shipments of sulfur in all forms were about 9.3 million tons, 2.6 million tons greater than output, and 27% above 1983 shipments. Exports increased nearly 36% to 7.6 million tons. Sulfur exported through the Port of Vancouver, British Columbia, increased to a record-high volume of 5.8 million tons, 26% higher than in 1983. Exports to the United States increased from 1.1 to 1.8 million tons; new contractural supply arrangements for Texasgulf Chemicals Co.'s North Carolina fertilizer complex from Canterra Energy Ltd.'s Alberta gas-processing facilities were responsible for most of the increase.

Canadian Occidental Petroleum Ltd. planned to construct a sour-gas processing plant at Mezeppa near Calgary, Alberta. Approval for the facility, which was to include a 200,000-ton-per-year sulfur recovery unit, was received in 1984. Husky Oil Co. announced plans to construct a multibillion-dollar heavy oil upgrading plant in Saskatchewan that included a 250-ton-per-day sulfur recovery unit.

Contractors were chosen by the Canadian Pacific Railroad to complete a new tunnel at Rogers Pass, British Columbia, by 1988. The 9-mile-long tunnel was to be completed at an altitude below the existing tunnel, which would permit westbound trains to move greater tonnages without increasing engine horsepower. When completed, the new tunnel would benefit shippers of sulfur to Vancouver for export.

Iran.—A small quantity of sulfur was exported from Bandar Khomeini in November. Total exports for the year were estimated at 40,000 tons and were believed to be collected from petroleum refineries and represented several years of output. The first sulfur recovery unit at the Khangira gas-processing plant near Sarrakha in northeast Iran was completed early in the year with the second unit scheduled for completion by yearend. Planned sulfur capacity at the facility was about 450,000 tons per year.

Iraq.—Sulfur exports overland through Kuwait, Jordan, and Turkey were about the same, 450,000 tons, as in 1983. The overland routes were necessitated by the destruction of domestic export facilities during the ongoing war with neighboring Iran. The newly completed 528,000-ton-per-year sulfur recovery unit processing associated gas from the Kirkuk Oilfield was believed to be operating at less than one-fifth of capacity. A 90,000-ton-per-year recovery plant was scheduled to come on-stream at the Baiji petroleum refinery during the year.

Kuwait.—New sulfur production capacity, 535 tons per day, was completed at Kuwait National Petroleum Co.'s Mina Al-Ahmadi petroleum refinery. Sulfur storage, handling, and export facilities were also completed. A second recovery unit of equal capacity was scheduled for completion at the refinery in 1986. In 1984, the company's Mina Abdulla refinery was in the midst of an upgrading project that included three 270-ton-per-day sulfur recovery units. This project was scheduled to be completed during the first half of 1986.

Mexico.—Frasch and recovered sulfur output both increased, reversing the trend of the previous 4 years. The additional Frasch production reflects the startup of the Petapa Mine adjacent to the Jaltiplan Dome. The Jaltiplan plant was utilized to supply hot water and steam for the Petapa deposit. Recovered output from Petróleos Mexicanos operations, up 22%, as well as Frasch production was marketed by Azufrera Panamericana S.A., a state-owned company.

Poland.—A project to establish a new Frasch mine at Osiek, about 13 miles south of Tarnobrzeg, was approved. The new operation would replace the Grzybow operation, which was nearing reserve depletion. Startup of the new 1.2- to 1.5-million-ton-per-year mine was dependent on financing.

Saudi Arabia.—Sulfur exports declined from 1.7 to 1.5 million tons. Exports exceeded output by nearly 800,000 tons exhausting vated stocks that had accumulated prior to June 1982 when exports began. A detailed article was published describing all aspects of the sulfur industry in Saudi Arabia.[2]

In October, a fire severely damaged the export-oriented prilling, materials handling, and warehouse facilities at Jubail. The General Petroleum and Mineral Organization, a Government agency and owner of the facility, contracted with the Saudi Sulfur Co. to prill sulfur at Berri while damage to the Jubail facility was assessed. Saudi Sulfur had prilling facilities on-line by mid-November. The prills were trucked from Beri to Jubail for export.

Table 20.—Sulfur: World production in all forms, by country and source[1]

(Thousand metric tons)

Country[2] and source[3]	1980	1981	1982	1983[p]	1984[e]
Algeria: Byproduct, petroleum and natural gas	14	15	[e]10	15	20
Argentina:[e]					
Native (from caliche)	--	10	--	--	NA
Byproduct, all sources	NA	NA	--	--	NA
Total	NA	10	--	--	NA
Australia:					
Byproduct:					
Metallurgy	167	171	157	140	140
Petroleum	13	[r]14	17	13	13
Total	[r]180	[r]185	174	153	153
Austria:					
Byproduct:					
Metallurgy	9	9	10	9	9
Petroleum and natural gas	19	28	38	31	30
Gypsum	24	25	27	26	26
Total	52	62	75	66	65
Bahamas: Byproduct, petroleum[e]	5	5	5	5	5
Bahrain: Byproduct, petroleum	33	[e]36	34	49	50
Belgium: Byproduct, all sources[e]	270	270	[r]270	250	240
Bolivia: Native	11	10	6	3	2
Brazil:					
Frasch	--	--	--	1	NA
Pyrites	25	44	54	55	NA
Byproduct:					
Metallurgy	--	17	30	150	NA
Petroleum	131	102	100	110	NA
Total	156	163	184	316	NA
Bulgaria:[e]					
Pyrites	300	200	200	200	200
Byproduct, all sources	70	70	70	70	70
Total	370	270	270	270	270
Canada:					
Pyrites[e] [4]	12	10	9	5	7
Byproduct:					
Metallurgy	903	783	627	678	875
Natural gas	5,899	5,599	5,226	5,390	5,260
Petroleum[e]	160	160	160	170	165
Tar sands	286	247	259	330	302
Total	7,260	6,799	6,281	6,573	6,609
Chile:					
Native:					
Refined	14	5	7	16	15
From caliche	74	110	98	83	80
Byproduct, metallurgy	27	[e]28	32	[e]32	32
Total	115	143	137	131	127
China:[e]					
Native	200	200	200	200	200
Pyrites	1,700	1,800	1,800	[r]2,300	2,100
Byproduct, all sources	300	300	300	[r]350	350
Total	2,200	2,300	2,300	[r]2,850	2,650
Colombia:					
Native	26	26	33	31	30
Byproduct, petroleum	1	2	2	[e]3	3
Total	27	28	35	34	33
Cuba:[e]					
Pyrites	22	14	20	20	20
Byproduct, petroleum	8	8	8	8	8
Total	30	22	28	28	28

See footnotes at end of table.

Table 20.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1980	1981	1982	1983[p]	1984[e]
Cyprus:[5] Pyrites	25	[r]9	[e]26	21	20
Czechoslovakia:[e]					
Native	5	5	5	5	5
Pyrites	60	60	60	60	60
Byproduct, all sources	10	10	10	10	10
Total	75	75	75	75	75
Denmark: Byproduct, petroleum	8	6	[e]6	[e]6	6
Ecuador:[e]					
Native	[r]4	[r]2	5	5	5
Byproduct:					
Natural gas	5	5	5	5	5
Petroleum	5	5	5	5	5
Total	[r]14	[r]12	15	15	15
Egypt: Byproduct, petroleum and natural gas	3	2	2	1	2
Finland:					
Pyrites	144	184	177	224	230
Byproduct:					
Metallurgy	247	234	270	265	260
Petroleum[e]	30	30	10	10	10
Total	421	448	457	499	500
France:					
Byproduct:					
Natural gas	1,840	1,701	1,668	1,654	1,630
Petroleum	226	221	[e]283	157	160
Unspecified[e]	150	120	110	120	110
Total	2,216	2,042	2,061	1,931	1,900
German Democratic Republic:[e]					
Pyrites	10	10	--	--	--
Byproduct, all sources	350	350	360	360	350
Total	360	360	360	360	350
Germany, Federal Republic of:					
Pyrites	222	213	229	([6])	--
Byproduct:					
Metallurgy[7]	450	400	400	400	350
Natural gas	814	834	872	632	860
Petroleum[e]	220	190	220	195	190
Unspecified[e]	93	95	100	95	90
Total[e]	1,799	1,732	1,821	[r]1,322	1,490
Greece:					
Pyrites[e]	[8]61	60	60	60	60
Byproduct:					
Natural gas	--	4	97	[e]115	120
Petroleum[e]	4	7	8	[r]5	5
Total[e]	65	71	165	[r]180	185
Hungary:[e]					
Pyrites	3	3	3	3	2
Byproduct, all sources	[8]9	9	9	9	9
Total	12	12	12	12	11
India:					
Pyrites	34	23	22	25	27
Byproduct:					
Metallurgy[e]	115	92	100	110	115
Petroleum	5	4	5	4	5
Total[e]	154	119	[r]127	[r]139	147
Indonesia:[5] Native	([9])	1	1	3	4

See footnotes at end of table.

Table 20.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1980	1981	1982	1983[p]	1984[e]
Iran:[e]					
Native	70	50	[r]10	[r]20	30
Byproduct, petroleum and natural gas	150	6	10	[r]25	30
Total	220	56	[r]20	[r]45	60
Iraq:[e]					
Frasch	[8]700	[8]200	300	300	500
Byproduct, petroleum and natural gas	[8]40	[8]40	40	40	70
Total	[8]740	[8]240	340	340	570
Ireland: Pyrites[e]	11	11	11	11	11
Israel: Byproduct, petroleum and natural gas[e]	10	10	10	10	10
Italy:					
Native	23	20	10	5	[8]8
Pyrites	331	261	269	192	282
Byproduct, all sources[e 10]	250	230	210	210	200
Total	604	511	489	407	490
Japan:					
Pyrites	311	293	276	272	260
Byproduct:					
Metallurgy	1,300	1,236	1,268	1,239	1,172
Petroleum	1,173	1,080	1,051	1,102	1,140
Total	2,784	2,609	2,595	2,613	2,572
Korea, North:[e]					
Pyrites	250	225	200	200	200
Byproduct, metallurgy	30	30	30	30	30
Total	280	255	230	230	230
Korea, Republic of:					
Pyrites	([9])	--	--	([9])	([9])
Byproduct:[e]					
Metallurgy	54	54	54	54	54
Petroleum	36	36	36	36	36
Total[e]	90	90	90	90	90
Kuwait: Byproduct, petroleum and natural gas[e]	120	97	141	145	220
Libya: Byproduct, petroleum and natural gas[e]	22	16	20	20	20
Mexico:					
Frasch	1,700	1,652	1,391	1,225	1,364
Byproduct:					
Metallurgy[e]	115	100	100	100	100
Petroleum and natural gas	402	426	425	377	461
Total[e]	2,217	2,178	1,916	[r]1,702	1,925
Morocco: Pyrites	36	[r]22	--	--	--
Namibia: Pyrites	4	8	58	81	[8]104
Netherlands:[e]					
Byproduct:					
Metallurgy	90	90	100	100	90
Petroleum	52	55	65	[r]105	105
Total	142	145	165	[r]205	195
Netherlands Antilles: Byproduct, petroleum[e]	91	90	90	[r]87	90
New Zealand: Byproduct, all sources	([9])	([9])	([9])	1	1
Norway:					
Pyrites	193	[r]210	216	220	200
Byproduct:[e]					
Metallurgy	40	40	40	40	40
Petroleum	6	6	6	10	10
Total[e]	239	[r]256	[r]262	[r]270	250
Pakistan:					
Native	1	([9])	1	1	1
Byproduct, all sources[e]	14	[r]14	19	[r]26	26
Total	15	[r]14	20	27	27

See footnotes at end of table.

Table 20.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1980	1981	1982	1983[p]	1984[e]
Peru:					
Native	(9)	(9)	(9)	(9)	(9)
Byproduct, all sources[e]	20	20	58	65	70
Total	20	20	58	65	70
Philippines:					
Pyrites	54	46	30	29	30
Byproduct, metallurgy	--	--	--	57	130
Total	54	46	30	86	160
Poland:[11]					
Frasch[e]	4,667	4,295	4,441	[r]4,499	4,500
Native[e]	518	478	494	[r]500	500
Byproduct:[e]					
Metallurgy	300	300	300	300	300
Petroleum	30	30	30	30	30
Gypsum[e]	20	20	20	20	20
Total	5,535	5,123	5,285	5,349	5,350
Portugal:					
Pyrites	155	135	116	124	105
Byproduct, all sources	2	2	2	[e]5	5
Total	157	137	118	129	110
Romania:[e]					
Pyrites	350	300	200	200	200
Byproduct, all sources	140	150	150	150	150
Total	490	450	350	350	350
Saudi Arabia:[e]					
Native	1	NA	--	--	--
Byproduct, petroleum and natural gas	460	600	900	[r]695	720
Total	461	600	900	[r]695	720
Singapore: Byproduct, petroleum	12	(9)	15	4	5
South Africa, Republic of:					
Pyrites	493	502	465	474	440
Byproduct:[e]					
Metallurgy	100	100	135	125	120
Petroleum	25	27	25	32	30
Total	618	629	625	631	590
Spain:					
Pyrites	1,096	1,118	1,029	1,073	1,100
Byproduct:					
Coal (lignite) gasification[e]	3	3	3	3	3
Metallurgy	125	135	[e]125	[e]120	120
Petroleum	12	12	[e]10	[e]8	7
Total[e]	1,236	1,268	1,167	[r]1,204	1,230
Sweden:					
Pyrites	[r]249	[r]202	204	206	200
Byproduct:					
Metallurgy[e]	130	130	130	130	130
Unspecified	37	38	23	30	30
Total	[r]416	[r]370	357	366	360
Switzerland: Byproduct, petroleum	3	3	3	3	3
Syria: Byproduct, petroleum and natural gas	5	6	22	[e]30	35
Taiwan:					
Pyrites	(9)	(9)	--	--	--
Byproduct, all sources	8	10	20	27	29
Total	8	10	20	27	29
Trinidad and Tobago: Byproduct, petroleum	57	44	13	10	7

See footnotes at end of table.

Table 20.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1980	1981	1982	1983[p]	1984[e]
Turkey:					
Native	23	28	29	[e]31	35
Pyrites	33	29	30	[e]25	30
Byproduct, all sources	70	120	126	132	130
Total	126	177	185	188	195
U.S.S.R.:[e]					
Frasch	800	800	800	800	800
Native	2,000	2,000	1,900	1,800	1,800
Pyrites	3,550	3,600	[r]3,500	[r]3,400	3,300
Byproduct:					
Coal	40	40	40	40	40
Metallurgy	[r]800	[r]800	[r]800	[r]800	800
Natural gas	[r]2,200	[r]2,250	[r]2,300	[r]2,350	2,400
Petroleum	200	200	200	200	200
Total	9,590	9,690	[r]9,540	[r]9,390	9,340
United Kingdom:					
Byproduct:					
Metallurgy[e]	50	50	50	50	50
Of petroleum refinery	80	75	59	55	60
Spent oxides	4	4	4	4	4
Total[e]	134	129	[r]113	[r]109	114
United States:					
Frasch	6,390	6,348	4,210	3,202	[8]4,193
Pyrites	322	307	265	W	W
Byproduct:					
Metallurgy	1,003	1,159	828	831	[8]962
Natural gas	1,757	1,971	1,960	2,371	[8]2,407
Petroleum	2,316	2,288	2,444	2,584	[8]2,807
Unspecified	78	72	80	302	[8]283
Total	11,866	12,145	9,787	9,290	[8]10,652
Uruguay: Byproduct, petroleum[e]	2	2	2	2	2
Venezuela: Byproduct, petroleum and natural gas[e]	85	85	85	85	86
Yugoslavia:					
Pyrites	252	274	340	357	320
Byproduct:[e]					
Metallurgy	200	200	200	180	160
Petroleum	5	4	4	3	3
Total[e]	457	478	[r]544	[r]540	483
Zaire: Byproduct, metallurgy[e]	25	25	25	[r]36	36
Zambia:					
Pyrites	[r]1	[r]([9])	1	25	25
Byproduct, all sources	[r]91	90	84	[r] [e]80	80
Total	[r]92	[r]90	85	105	105
Zimbabwe:					
Pyrites	29	25	25	25	25
Byproduct, all sources[e]	5	5	5	5	5
Total	34	30	30	30	30
Grand total	[r]54,983	[r]53,372	50,753	50,315	51,884

See footnotes at end of table.

Table 20.—Sulfur: World production in all forms, by country and source[1] —Continued

(Thousand metric tons)

Country[2] and source[3]	1980	1981	1982	1983[p]	1984[e]
Grand total—Continued					
Of which:					
Frasch	14,257	13,295	11,142	10,027	11,357
Native	[r]2,970	[r]2,945	2,799	2,703	2,715
Pyrites	[r]10,338	[r]10,198	9,895	9,887	9,558
Byproduct:					
Coal and coal gasification	43	43	43	43	43
Metallurgy	[r]6,280	[r]6,183	5,811	5,976	6,075
Natural gas	[r]12,515	[r]12,364	12,128	12,517	12,682
Petroleum	[r]4,949	[r]4,742	4,916	5,011	5,160
Petroleum and natural gas, undifferentiated	1,330	1,331	1,703	1,474	1,704
Spent oxides	4	4	4	4	4
Tar sands	286	247	259	330	302
Unspecified sources	[r]1,967	[r]1,975	2,006	2,297	2,238
Gypsum	44	45	47	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 May 28, 1985.

[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 Yemen (Aden). 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]Byproduct pyrite and pyrrhotite from the processing of metallic sulfide ores.

[5]In addition, may produce limited quantities of byproduct sulfur from oil refining.

[6]Revised to zero.

[7]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."

[8]Reported figure.

[9]Less than 1/2 unit.

[10]Includes recovery from gypsum, if any.

[11]Official Polish sources report total mined elemental sulfur output annually; this figure has been divided between Frasch and other native sulfur on the basis of information obtained from supplementary sources. Therefore, although both numbers are estimates, the total is not an estimate.

TECHNOLOGY

At an international conference, Sulphur—84, presentation of 103 papers included 4 major topic areas: sulfur trade and transportation, production and engineering aspects of recovered sulfur, new product applications, and agricultural uses of sulfur.[3]

[1]Physical scientist, Division of Industrial Minerals.

[2]British Sulphur Corp. Ltd. (London). Sulphur. Saudi Arabia: A New Phase of Sulphur Exports Begins. No. 173, July-Aug. 1984, pp. 20-23.

[3]The Sulphur Development Institute of Canada. Proceedings of Sulphur—84. An International Conference (Calgary, Alberta, Canada, June 3-6, 1984). June 1985, 847 pp.

Talc and Pyrophyllite

By Robert A. Clifton[1]

Total domestic production of talc and pyrophyllite combined increased 10% in 1984, and sales increased 4%. Exports of talc increased 17% in tonnage and 25% in value.

Domestic Data Coverage.—Domestic production data for talc and pyrophyllite are developed by the Bureau of Mines from a voluntary survey of U.S. operating mines. Of the 39 mines to which a survey request was sent, 34 responded, representing 87% of 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)

	1980	1981	1982	1983	1984
United States:					
Mine production, crude:					
Talc	1,127	1,236	1,049	980	1,085
Pyrophyllite	113	107	87	87	85
Total[1]	1,240	1,343	1,135	1,066	1,170
Value:					
Talc	$18,600	$21,600	$19,540	$18,998	$23,333
Pyrophyllite	837	1,016	1,131	1,282	1,412
Total	19,437	22,616	20,671	20,280	24,745
Sold by producers, crude and processed:					
Talc	1,173	1,115	915	1,038	1,115
Pyrophyllite	158	106	110	125	97
Total	1,331	1,221	1,025	1,163	1,212
Value:					
Talc	$84,523	$95,354	$82,104	$104,739	$112,829
Pyrophyllite	4,254	3,454	3,557	4,057	3,578
Total	88,777	98,808	85,661	108,796	116,407
Exports[2] (talc)	275	311	232	218	256
Value	$14,963	$15,095	$12,957	$12,916	$16,162
Imports for consumption (talc)	21	27	27	44	45
Value	$3,720	$5,834	$6,264	$7,691	$9,156
Apparent consumption[3]	1,077	937	820	989	1,009
World: Production	[r]8,307	[r]8,018	7,761	[p]7,800	[e]7,967

[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]Production plus imports minus exports adjusted for changes in stocks.

Legislation and Government Programs.—The National Defense Stockpile inventory of talc, block or lump, was 1,081 short tons at yearend, far exceeding the goal of 28 tons. The inventory of ground talc, for which no goal had been established, remained at 1,809 tons.

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, 3.8% 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 about 11% in tonnage and 23% in value. Talc, including soapstone, was produced at 39 mines in 11 States. California led all States in the number of producing mines with 12. Montana, New York, Texas, and Vermont accounted for 91% of domestic talc production. Montana continued to lead all States in the value of talc produced.

The six 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; Southern Clay Products Inc. and Texas Talc Co., in Texas; R. T. Vanderbilt Co. Inc., in New York; and Windsor Minerals Inc., in Vermont and California.

Acqui-Tal Inc., a newly formed Vermont corporation, recently bought the Johnson Talc Mill and the land around it from the Eastern Magnesia Talc Co. Acqui-Tal has a service contract with the Vermont Talc Co., whose increased demand for processed talc was a driving force behind the creation of Acqui-Tal and the purchase of the mill. Vermont Talc will send ore mined at its Chester mine to Johnson Talc, where Acqui-Tal will process it according to Vermont Talc's specifications. Vermont Talc will then market the finished product.

In a related event, Vermont Talc asked the State for permission to start site preparation to double its Chester plant's capacity.

Nicor Mineral Ventures, a Colorado mining company, described plans for a $10 million talc mine near Ennis and a processing plant near Three Forks, both in Montana. Nicor, the operator, has Meridian Land and Minerals Co. as a partner. The mine and processing plant, expected to open in 1985, would employ 39 people initially and eventually as many as 89 workers.

The open pit mine will be located in the Madison River Valley, about 20 miles south of Ennis and adjacent to Cyprus Industrial Minerals' Yellowstone talc mine.

The minesite has an identified reserve of 1 million tons of talc. Nicor officials have estimated the lifespan of the mine to be 13 years and said the mine would produce 13.8 million tons of waste during its lifetime. The entire project will occupy about 200 acres. The surface area already has been stripped, and mining will begin after a hard-rock mining permit is issued by the State.

The mill would be a separate facility located at the junction of highways 287 and 10, 15 miles southwest of Three Forks. Talc will be shipped from the mine to the mill by trucks.

Pyrophyllite.—Pyrophyllite was produced by four companies operating seven mines in California and North Carolina. Total production decreased slightly.

Table 2.—Crude talc and pyrophyllite produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1983 Quantity	1983 Value	1984 Quantity	1984 Value
California	71	1,289	74	1,642
Georgia (talc)	14	101	15	104
North Carolina	89	1,452	87	1,587
Oregon (talc)	W	W	(1)	66
Texas (talc)	250	3,933	283	5,703
Other[2] (talc)	642	13,505	711	15,643
Total	1,066	20,280	1,170	24,745

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

[1]Less than 1/2 unit.

[2]Includes Arkansas, Montana, New York, Vermont, Virginia, Washington, and State indicated by symbol W.

CONSUMPTION AND USES

Apparent domestic consumption of crude and processed talc and pyrophyllite increased 2%. Sales of talc and pyrophyllite increased 4% in tonnage and 7% in value.

End-use distribution of ground talc was ceramics, 37%; paint, 19%; paper, 10%; roofing, 9%; plastics, 7%; cosmetics, 5%; rubber, 3%; insecticides, 1%; and the remainder went to a variety of miscellaneous uses.

The largest portion, 35%, of domestically produced ground pyrophyllite was used in ceramics, 25% in refractories, 17% in insecticides, 7% in roofing, and the remainder in other uses. A significant portion of pyrophyllite was imported and ground for use in the ceramics industry.

Table 3.—End uses for ground talc and pyrophyllite

(Thousand short tons)

Use	1983			1984		
	Talc	Pyrophyllite	Total	Talc	Pyrophyllite	Total
Ceramics	319	27	346	358	29	387
Cosmetics[1]	50	--	50	44	--	44
Insecticides	5	12	17	8	14	22
Paint	166	1	167	189	1	190
Paper	81	--	81	100	--	100
Plastics	57	1	58	67	1	68
Refractories	2	23	25	4	21	25
Roofing	98	7	105	86	6	92
Rubber	28	--	28	29	--	29
Other[2]	95	13	108	85	11	96
Total	901	84	985	970	83	1,053

[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 the quality and degree and method of processing. In general, yearend reported prices remained steady except for minor increases and foreign exchange fluctuation. These prices, however, did not reflect the midyear reports of a paint publication. In the first of these, it was reported that talc demand was strong and that a 5% across-the-board increase in talc prices was imminent.[2] The next week a $20 per ton increase for micronized Montana talc from one producer was reported.[3]

At yearend, the same publication discussing paint extenders indicated that only talc seemed to be immune from discounting during 1984.[4] Prices, quoted by Engineering and Mining Journal, December 1984, per short ton of domestic ground talc, in carload lots, f.o.b. mine or mill, including containers, were as follows:

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- 70.00
98% to 99.25% through 325 mesh	78.00- 80.00
100% through 325 mesh, fluid-energy ground	160.00
California:	
Standard	69.50
Fractionated	37.00- 71.00
Micronized	62.00-104.00
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

American Paint & Coatings Journal, December 24, 1984, listed the following prices per short ton for paint-grade talc in carload lots:

California:	
Bags, mill:	
White, Hegman No. 3-3-1/2	$103.00
Hegman No. 4-5	129.00
Canada: Fine micron, Hegman No. 6	176.00
Montana: Ultrafine grind, Hegman No. 6	145.00
New York:	
Nonfibrous, bags, mill:	
98% through 325 mesh	78.00
99.6% through 325 mesh	91.00
Trace retained on 325 mesh	146.00

Approximate equivalents, in dollars per short ton, of price ranges quoted in Industrial Minerals (London), December 1984, for talc, c.i.f. main European ports, were as follows:

Australian, cosmetic (ex store)	$180-$193
Norwegian:	
Ground (ex store)	124- 138
Micronized (ex store)	138- 193
French, fine-ground	124- 235
Italian, cosmetic-grade	228
Chinese, normal (ex store):	
UK 200 mesh	174
UK 325 mesh	186
New York, paint, minimum 20-ton lot	242

FOREIGN TRADE

Exports.—Talc exports increased 17% while the average price of these exports increased 7% to $63 per ton. These prices varied from $35 per ton for material shipped to Mexico to more than $500 per ton for material sent to several smaller countries.

Mexico remained the major importer of U.S. talc, accounting for 42% of the tonnage shipped, followed by Canada, 30%; Japan, 9%; and Belgium-Luxembourg, 4%. Canada, however, continued to lead in value of imports with 33% of the total compared with Mexico's 23%. A total of 51 countries were recipients of U.S. talc.

Imports.—U.S. imports for consumption of talc increased 2%. Crude from Australia disappeared from the market. Imports from Canada increased by 38%. Canada, which supplied 56% of total imports, remained the leading source of imported talc, followed by Italy with 21%. These two countries were also first and second in value of 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
1980	24	1,412	68	4,960	13	957	161	3,648	9	3,986	275	14,963
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

[1]Excludes powders—talcum (in package), face, and compact.
[2]Probably includes shipments in transit through Canadian ports.
[3]Includes 47 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)
1982	9,103	$1,734	16,169	$2,495	1,231	$986	$1,049	26,503	$6,264
1983:									
Australia	11,007	951	--	--	--	--	--	11,007	951
Brazil	41	7	41	7	905	324	7	987	345
Canada	5	2	17,848	2,433	164	240	26	18,017	2,701
China	--	--	19	2	34	34	338	53	374
India	1	3	88	21	6	6	377	95	407
Italy	7,225	1,295	188	56	--	--	8	7,413	1,359
Korea, Republic of	--	--	2,000	426	116	57	--	2,116	483
Other[1]	2,643	13	1,517	670	146	192	196	4,306	1,071
Total	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[2]	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

NA Not available.
[1]Includes 23 countries.
[2]Includes 25 countries.

WORLD REVIEW

The United States remained the world's largest talc producer, and Japan remained the largest pyrophyllite producer. Together, they accounted for 35% of the world's talc and pyrophyllite production.

A discussion of the latest (1984) Roskill talc and pyrophyllite economic report in a British chemical magazine revealed that, without final data, 1984 was seen to be a market recovery year for world talc demand in all major end-use markets.[5] An interesting trend in the article indicated that since the mid-1970's, rising transportation costs have coincided with rising Third World demand for talc to feed the indigenous ceramics, paint, and paper industries, particularly in Brazil, North Korea, and Taiwan. As a result, closer sources are being developed, especially in Brazil and China.

Australia.—The Three Springs Mine of Western Mining Corp. and its partner, Kalgoorlie Southern Gold Mines NL, responded to a surging demand by adding a second shift. Production in the second half of the year doubled over that in the first half as sales nearly quadrupled.

Included in the sale of Steetley Industries Ltd. to Anglo American Corp. of South Africa Ltd. was Steetley Industries' talc mine in South Australia.

Canada.—An information service release gave some details about the Canadian talc industry.[6] The report stated that the nameplate production capacity of the four talc operations at 80,000 tons per year and the pyrophyllite operation at 50,000 tons per year remained unchanged from 1976 through 1982. The domestic demand never exceeded the record high 51% of production in 1979, and exports were roughly double domestic demand throughout the period.

The ongoing expansion of the two talc mines in Ontario was reported.[7] The article indicated that Canada Talc Ltd. was in the early stages of a more than Can$3 million investment program, augmented by a Can$825,000 grant from Ontario's Ministry of Natural Resources, to expand its talc and dolomite mines at Madoc and to construct new processing facilities at Marmora, 17 kilometers to the west. The delineation of two new ore bodies by Canada Talc has provided added impetus to increase output of products for paint, tile, rubber, plastics, and other filler applications.

Steetley Talc Ltd., a division of Steetley

Industries, produces ultrafine grades of white talc at its Timmins processing plant. Since acquiring the talc operations in 1978, Steetley Talc has made numerous modifications at the mine and concentrator in Penhorwood Township as well as at the Timmins facilities. Steetley Talc is also engaged in a multimillion dollar expansion program that will provide greater flexibility to meet increased market demand for its products by the cosmetics, paper, paint, and plastics industries.

The article also disclosed that in British Columbia the International Marble and Stone Co. Ltd. is initiating trial shipments from its property west of Creston. The product is a relatively low-quality ground talc for applications such as filler and dusting components in asphalt trades.

Japan.—A breakdown of Japanese production data for both talc and pyrophyllite from 1978 through 1981 revealed that talc production averaged only 11% of the total for that period.

Korea, Republic of.—Industrial Minerals (London) summarized the talc industry in the Republic of Korea.[8] Total talc production was 189,000 tons in 1983, a substantial increase over the 138,000 tons in 1982 but still below the 198,000 tons produced in 1981. There are 10 mines, but more than 110,000 tons of the 1983 total came from a single mine operated by Ilshin Industrial Co. Ltd. The company's sole operating mine, with a capacity of about 220,000 tons per year of crude ore, is at Dong Yang, roughly in the middle of the country. Reserves of good-quality talc are estimated at about 6.6 million tons, and the company nominally estimates its total reserves from all sources as 550 million tons. The talc is very pure, although at the contact surfaces there may be some actinolite, calcite, or tremolite.

A substantial portion of the output of talc from the company is exported. Most of the exports are to other Asian countries, with Japan taking about one-half of the total. The company estimates that 60% to 65% of its output is used in the paper industry, with the rest consumed in cosmetics, paint, and insecticides. Government figures for 1981 show that 81% of the Republic of Korea's total talc consumption (excluding exports) was used in the paper industry compared with 56.3% in 1978. Talc is an important paper filler in the Republic of Korea because domestic kaolin production is not paper-grade quality, and most of the requirements are met by imports. Because of the lack of other paper fillers, the Republic of Korea has concentrated on the main domestic filler material available, in a similar way to Finland. Some talc also is used as a pitch control in paper.

Because of talc's fine grain, it can be used for some very high-value applications. Lumps of talc are used as a carving medium, and Ilshin has a section that produces and sells talc carvings. Also, talc sticks are produced for use in the iron and steel industry for marking hot metal and by welders for marking welding areas on metal. These products have both domestic and international markets. Although the talc from Ilshin is used as a white filler, it cannot normally be used in ceramics.

Table 6.—Talc and related materials: World production, by country[1]

(Short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Argentina (talc, steatite, pyrophyllite)	36,080	39,925	31,849	32,729	32,500
Australia	188,455	[r]91,476	168,424	[r e]165,000	165,000
Austria (unground talc)	128,648	128,336	129,072	134,623	136,000
Brazil (talc and pyrophyllite)[3]	455,316	555,184	446,731	[r e]500,000	500,000
Burma	367	141	141	141	150
Canada (shipments)	95,901	98,106	[e]79,000	[e]107,000	139,000
Chile	1,256	733	312	702	550
China[e]	1,010,000	990,000	[r]1,050,000	[r]1,050,000	1,050,000
Colombia	6,504	6,669	6,878	7,318	7,400
Egypt	4,417	6,309	9,139	4,981	6,600
Finland	350,425	339,418	358,251	351,009	342,000
France (ground talc)	332,435	340,911	304,723	315,591	320,000
Germany, Federal Republic of (marketable)	17,085	17,021	16,789	15,773	15,000
Greece (steatite)[e]	[4]1,609	1,500	1,600	[4]1,666	1,700
Hungary[e]	19,300	19,300	18,700	18,700	19,300
India	407,366	405,175	379,129	389,162	400,000
Italy (talc and steatite)	182,879	180,106	180,746	175,239	165,000
Japan[5]	1,927,718	1,703,125	1,644,982	1,615,791	1,666,000
Korea, North[e]	185,000	185,000	185,000	185,000	185,000

See footnotes at end of table.

Table 6.—Talc and related materials: World production, by country[1] —Continued

(Short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Korea, Republic of (talc and pyrophyllite)	792,752	622,383	651,594	696,810	660,000
Mexico	11,120	15,178	13,525	16,636	16,500
Nepal[6]	1,609	78	3,310	16,825	22,000
Norway	96,601	[r]93,981	[r e]94,000	[r e]96,000	94,000
Pakistan (pyrophyllite)	33,069	27,554	24,877	17,593	22,000
Paraguay	276	165	165	130	140
Peru (talc and pyrophyllite)[e]	[4]9,474	10,000	9,500	9,500	9,000
Philippines	951	492	1,111	968	1,100
Portugal	2,864	7,014	5,445	6,018	5,300
Romania[e]	66,000	66,000	66,000	66,000	72,000
South Africa, Republic of[7]	15,836	16,674	15,226	12,337	15,700
Spain (steatite)	81,515	76,134	69,099	76,574	77,000
Sweden	17,478	17,175	19,569	[e]17,000	17,000
Taiwan	10,925	27,309	33,798	29,821	21,000
Thailand (talc and pyrophyllite)	12,926	13,266	24,249	22,209	24,000
U.S.S.R.[e]	540,000	550,000	560,000	560,000	570,000
United Kingdom	19,000	19,800	21,000	17,600	17,600
United States (talc and pyrophyllite)	1,240,427	1,342,916	1,135,415	1,066,000	[4]1,170,000
Uruguay	2,432	[e]1,900	1,262	1,323	1,300
Zambia	284	1,015	299	[e]275	275
Zimbabwe	503	425	298	[e]300	275
Total	[r]8,306,803	[r]8,017,894	7,761,208	7,800,344	7,967,390

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through May 14, 1985. Data represent total production of talc and all related materials unless otherwise specified.
[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 utility of continuous mining machines (CMM) in the production of a salable product was described at the 1984 Society of Mining Engineers-American Institute of Mining, Metallurgical, and Petroleum Engineers Fall Meeting. The presentation indicated that the CMM's had proven to be extremely useful with their capability to selectively mine open pit and underground ore bodies, to avoid unmarketable low grade, to limit stress to mine pit walls, to minimize support requirements underground, to supply essentially precrushed ore to the mills, and most importantly, to provide a safe working environment for workers and machines. The Rainbow Pit Mine operated for 51 months without a lost-time accident.[9]

The versatility of tremolitic talc in the ceramics industry was described in a British journal.[10] The successful application of tremolitic talc in whitewares (semivitreous ware and vitreous ware), glazes, and refractories was discussed. Typical semivitreous bodies include wall tile, art pottery, and dinnerware. Tremolitic talc has been found to be an ideal raw material because it produces high-thermal expansion bodies through the formation of enstatite, which tends to prevent crazing; it produces low-moisture expansion bodies, resulting in good resistance to delayed crazing; it contains 30% to 50% prismatic tremolite, which aids dry pressing; it permits faster wet pressing; it eliminates lamination; and it improves product density.

It is especially suitable for high-talc, low-temperature casting bodies through control of specific resistance on certain grades, and low-firing temperatures and fast-firing schedules are possible, which conserve energy and, in many cases, reduce cost.

Current and potential uses of talc in the paper industry were discussed in the literature.[11] It was noted that the mineral most frequently used in the paper is kaolin, both as a filler and as a coating pigment, and that calcium carbonate has also gained ground during the past few years. However, talc is important as a filling agent in the paper industry in Finland, France, and Japan. As a coating pigment, talc is still rather unusual; however, research, particularly in Finland, indicates that this kind of application will spread in the future. Unlike other minerals, talc is also commonly used for the elimination of pitch problems in the pulp and paper industry.

Talc meets the requirements of softness and chemical inertness set by the paper industry for the minerals used in the manufacturing process and has acceptable optical properties. In the production of some paper grades, the platy shape of talc particles enhances some properties, but the surface chemical characteristics of talc have both advantages and disadvantages. Since minerals must be dispersed with water before application, talc can cause problems, especially in coating, because of its water-repellent surface.

Many species of trees contain fatty and resinaceous acids and their compounds, which remain in the pulp after processing. These compounds, when agglomerated, can cause serious problems with economic consequences by adhering to machinery and equipment in the pulpmaking and papermaking process. A finely ground material capable of adsorbing pitch onto its surface is needed to prevent agglomeration and adhesion of pitch particles. With its organophilic character, talc is a suitable medium. A significant advantage of talc compared with other pitch control materials is that pitch is incorporated in the end product and leaves the process. In this way, it also acts as a filler and prevents concentrated pitch from accumulating in the process, thus reducing the effluent load.

The requirements the paper industry sets on the minerals it uses for fillers are strict. In general, low density, freedom from impurities, low abrasiveness, and insolubility are desirable properties. A good optical effect is also an asset, although the requirements on brightness and opacity are often conflicting. By adsorbing pitch and other organics, talc will cleanse the water and pulp systems of paper machines. Talc repels water and adsorbs organic matter also in finished paper. The water adsorption of paper is reduced, and talc binds printing inks preventing them from penetrating into the structure of paper. The softness of talc is of great economic importance in papermaking, because its abrasive effect on machinery is low. This is particularly clear in the prolonged life of wires used for removal of water from the pulp.

The largest problem area of talc in coating applications is its surface chemistry. The small particle size of talc used in coating adds to the problem. To achieve the desired paper technical properties, talc must be micronized to a particle size below 10 micrometers. Without suitable alteration in the surface chemical properties, wetting of coating talc with water is extremely slow, and reaching a sufficiently high solids content is impossible.

Studies in Finland have shown that by using pelletized talc, a special mixer, and a suitable combination of chemicals, it is now possible to disperse talc less than 10 micrometers to a stable, liquid slurry of almost 70% solids content. The slurry is suitable for use with other common constituents incorporated in the coating mixture. The properties of this mixture are almost identical with the corresponding kaolin mixture and is an acceptable substitute.

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[1]Physical scientist, Division of Industrial Minerals.

[2]American Paint & Coatings Journal. The Market. V. 68, No. 52, June 11, 1984, p. 26.

[3]———. The Market. V. 68, No. 53, June 18, 1984, p. 21.

[4]———. Calcined Clay Headed for Paper Industry, Distributor's Directory. Dec. 31, 1984, pp. 13-14.

[5]Manufacturing Chemist (London). Recovery Seen in World Talc Demand. V. 55, No. 10, Oct. 1984, p. 23.

[6]Corpus Information Services. Talc. Oct. 31, 1983, p. 2.

[7]Industrial Minerals (London). Ontario, Industrial Minerals in Canada. No. 200, May 1984, pp. 83-89.

[8]Dickson, T. Korean Industrial Minerals—A Brief Summary. Ind. Miner. (London), No. 202, July 1984, pp. 57-61.

[9]Miller, R. N. Talc Mining in Vermont: The Application of Continuous Mining Machines. Pres. at Soc. Min. Eng. AIME Fall Meeting, Denver, CO, Oct. 24-26, 1984. Soc. Min. Eng. preprint 84-358, p. 3.

[10]Johnson, R. L. Talc. Ceram. Bull. (London), v. 36, No. 5, May 1984, pp. 687-688.

[11]Huuskonen, J., and P. Ahonen. Talc as a Raw Material in the Paper Industry. Paper in Raw Materials for the Pulp and Paper Industry. Met. Bull., 1984, pp. 65-68.

Thorium

By James B. Hedrick[1]

Domestic mine production of monazite, the principal source of thorium, increased in 1984. Associated Minerals Ltd. Inc. was the only domestic monazite producer. Domestically mined monazite was exported, and all thorium products used in the United States were imported or produced in the United States from either imported materials or from existing company stocks. W. R. Grace & Co. and Rhône-Poulenc Inc., a subsidiary of Rhône-Poulenc S.A. of France, were the principal processors of thorium-containing ores and compounds in the United States.

Major nonenergy end uses were in aerospace alloys, mantles for incandescent lanterns, welding rods, 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 monazite containing thorium are developed by the Bureau of Mines from one voluntary survey of U.S. operations. This is 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 are withheld to avoid disclosing company proprietary data.

Table 1.—Salient U.S. thorium statistics

(Metric tons of ThO_2, unless otherwise specified)

	1980	1981	1982	1983	1984
Exports: Ores and metals	2	6	4	4	11
Imports: Compounds and gas mantles	24	33	23	46	45
Shipments from Government stockpile excesses	3	3	--	--	--
Apparent consumption, nonenergy applications[e] [1]	25	30	19	42	34
Prices, yearend, dollars per kilogram, ThO_2:					
Nitrate, mantle-grade	$8.40	$9.50	$10.60	$10.60	$10.10
Oxide, 99% grade	$16.00	$21.20	$24.50	$31.00	$37.65

[e]Estimated.

[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 recently been used to produce thorium products.

Legislation and Government Programs.—On October 19, 1984, the President signed Public Law 98-525, the Defense Authorization Act, 1985, terminating all previous authorization for disposals of thorium nitrate from the National Defense Stockpile (NDS), effective September 30, 1984. Section 902 of the new law, effective October 1, 1984, authorized the disposal of 22,680 kilograms (50,000 pounds) of thorium nitrate from the NDS that had previously been declared excess to goal.

DOMESTIC PRODUCTION

Associated Minerals, a subsidiary of the Australian-owned firm Associated Minerals Consolidated Ltd. (AMC), was the only commercial minerals sands operation in the United States to produce monazite during the year. The company produced monazite as a byproduct of minerals sands mined for titanium and zirconium minerals at Green Cove Springs, FL.

Marathon Gold Corp. continued development of its gold-rare-earth-thorium deposit near Craig, Moffat County, CO. Marathon's deposit contains monazite and xenotime that may be produced as byproducts of processing placer gold. Development of the deposit was a joint venture between Marathon, Centennial Gold Corp., which owns 54% of Marathon, and Hampton Gold Mining Areas PLC. Rhône-Poulenc reportedly entered an agreement to purchase 4,000 to 8,000 metric tons of monazite and xenotime per year when the deposit begins commercial operation.[2] Rhône-Poulenc reportedly would initially process the monazite at its rare-earth and thorium processing plant in La Rochelle, France, and at a future date begin processing it at the company's rare-earth and thorium plant in Freeport, TX.

Williams Strategic Metals Inc. (WSM), a subsidiary of Williams Resources Inc., continued its plans to recover rare-earth- and thorium-bearing apatite from 16 million tons of iron ore tailings near Mineville, NY. WSM worked with Hazen Research Inc., of Golden, CO, to optimize a process that would yield magnetite, yttrium, and rare earths as coproducts, and phosphoric acid as a byproduct. WSM planned to start up a pilot plant, with a capacity of 10 tons of tailings per day, in 1985.[3]

Table 2.—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 Casting Corp	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.
General Atomic Co	San Diego, CA	Nuclear fuels.
W. R. Grace & Co	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	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	Lewistown, ME	Produces thoriated welding rods.
Rhône-Poulenc Inc	Freeport, TX	Produces thorium nitrate from an intermediate compound of monazite.
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.

A joint effort by the Kerr-McGee Chemical Corp., Oklahoma City, OK, and the city council of West Chicago, IL, was underway to pinpoint and remove radioactive thorium from about 80 low-level radioactive sites in West Chicago. Most of the identified sites were within a few blocks of a chemical plant operated over the years by several firms, including Kerr-McGee. Kerr-McGee operated the plant, which processed monazite to produce rare-earth and thorium products, from 1967 to 1973. None of the radioactive sites that were identified were found to present an immediate health hazard. Kerr-McGee offered to locate and remove the radioactive materials from the sites and restore the affected areas. The thorium-containing materials reportedly were to be removed to the closed plantsite by yearend 1985. Several proposals for safely storing the thorium-containing materials, including radioactive materials already at the plantsite, were being studied by Kerr-McGee, several Federal agencies, the Illinois Nuclear Safety Commission, and the city council of West Chicago.

CONSUMPTION AND USES

Domestic thorium processors consumed an estimated 51 tons of thorium oxide equivalent in 1984, an increase of 4 tons above the 1983 level. Energy uses accounted for about 6 tons of the total, and nonenergy uses accounted for the remainder. The distribution of thorium consumption in the nonenergy uses was estimated as follows: refractory applications, 60%; lamp mantles, 17%; aerospace alloys, 8%; welding rods, 3%; and other applications, including ceramics and lighting, 12%.

Most of the thorium used in metallurgical applications was alloyed with magnesium. Magnesium-thorium alloys possess high-strength and excellent creep resistance at elevated temperatures, properties that are useful in aerospace applications. Small quantities of thorium were used in dispersion-hardened alloys for high-strength, high-temperature applications.

Thorium oxide (thoria), which has the highest melting point of all the oxides, 3,000° C, was used in several refractory applications, including high-strength and high-temperature ceramics, investment molds, crucibles, and experimental stage, heat-dissipative, core-retention beds for nuclear reactors.

Thorium nitrate was used in the manufacture of mantles for incandescent "camping" lanterns and 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 applications.

Thorium was used also in electron tubes, in lighting airport runways, in 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.

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 3,234,936 kilograms (equivalent to 1,547,043 kilograms of thorium oxide) on December 31, 1984. The NDS goal at yearend was 272,155 kilograms of thorium nitrate (equivalent to 130,153 kilograms of thorium oxide); remaining stocks have been declared excess to goal. Effective October 1, 1984, Public Law 98-525, the Defense Authorization Act, 1985, authorized for disposal 22,680 kilograms (50,000 pounds) that had previously been declared excess to goal.

The U.S. Department of Energy's inventory at yearend contained 1,237,277 kilograms of thorium oxide equivalent contained in ore, metal, and various compounds.

PRICES

The average declared value of imported monazite increased during 1984 to $389 per ton, up $12 from the 1983 value. The price range of Australian monazite (minimum 55% rare-earth oxide including thoria, f.o.b-f.i.d.),[4] as quoted in Metal Bulletin (London), decreased from A$410-A$450 per ton at yearend 1983 to A$410-A$440 per ton by yearend 1984. Changes in the foreign exchange rate in 1984, resulting from the economic strength of the U.S. dollar against foreign currencies, caused the corresponding U.S. price range to fall from US$369-US$405 in 1983[5] to US$340-US$365 in 1984.[6]

The yearend price for monazite, based on a thorium oxide content of 7%, was approximately $4.86 to $5.21 per kilogram of thorium oxide contained.

Rhône-Poulenc quoted thorium product prices per kilogram, net 30 days, f.o.b. Freeport, TX, or duty paid at point of entry, effective August 15, 1984, as follows: thorium oxide, 99% purity, $37.65; 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.

FOREIGN TRADE

For the fifth 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 monazite containing thorium since 1977. However, the monazite has been imported solely for its rare-earth content, and no thorium products have been produced from it. Thorium products processed and manufactured domestically in 1984 were all derived from imported materials, primarily thorium-containing compounds 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)

	1982		1983		1984		Principal destinations and sources, 1984
	Quantity	Value	Quantity	Value	Quantity	Value	
EXPORTS							
Thorium ore, monazite	91,508	$103,356	57,139	$51,678	229,983	$157,608	All to France.
Metals[1]	301	17,690	937	48,882	890	46,905	Switzerland 430; Canada 173; Japan 133; other 154.
IMPORTS							
Ore and concentrate:							
Thorium ore, monazite metric tons	7,203	3,070,006	4,028	1,517,299	5,661	2,202,377	Australia 5,610; Republic of South Africa 51.
ThO_2 content	510,240	XX	284,980	XX	395,760	XX	
Compounds:							
Nitrate	15,202	160,243	17,438	191,871	17,957	220,360	France 16,157; Canada 1,800.
Oxide	13,787	307,058	35,844	825,393	35,026	299,994	France 31,130; Netherlands 3,849; United Kingdom 47.
Oxide equivalent, in gas mantles[e] [2]	1,846	731,233	1,193	505,589	1,169	426,230	Malta 937; Hong Kong 86; Canada 84; other 62.
Other	326	75,593	428	100,793	588	195,111	United Kingdom 470; Switzerland 118.
Metals and alloys	[r]4,082	NA	[r]30,016	NA	79,990	NA	All from United Kingdom.

[e]Estimated. [r]Revised. NA Not available. XX Not applicable.
[1]Unwrought, wrought, waste, and scrap.
[2]Based on the manufacture of 2,205 gas mantles per kilogram ThO_2.

WORLD REVIEW

The principal world source of thorium is monazite, a rare-earth phosphate mineral. Monazite is recovered as a byproduct of processing minerals sands for titanium and zirconium in many countries and as a byproduct of processing minerals sands for tin in Malaysia and Thailand. Thorium is a byproduct and its availability depends on demand for the rare-earth elements contained in monazite, and to a lesser extent, demand for titanium and zirconium minerals. As a result of the large demand for rare earths in relation to thorium, a large overcapacity exists for thorium. Large stocks of thorium-containing compounds and residues are stored in Brazil, France, India, and the United States. Australia was the world's principal producer of monazite in 1984. Australia exported monazite concentrate primarily to France and the United States where it was processed mainly for its rare-earth content. Byproduct thorium compounds, produced in France and the United States, were marketed worldwide. Monazite and other thorium-containing materials produced in Brazil and India were Government-controlled and, because of thorium's potential use as a nuclear fuel, were not exported.

World thorium reserves were estimated by the Bureau of Mines at 1,140 tons of equivalent thorium oxide, of which 96% is in market economy countries. India had the largest share of world reserves, with 30% of the total.

In Australia new investment interest was prompted in 1984 by the increased demand for rare earths, and thus for minerals sands, including monazite. Allied Eneabba Ltd. was studying a plan to build a A$60 million processing plant to treat monazite and produce rare-earth compounds.[7] The plant reportedly would also treat monazite from other producers in Western Australia, which supplies nearly one-half of the world's supply of monazite.[8] Monazite accounted for 3% of the minerals sands Allied produced in 1983.[9] Allied's output in 1983 and 1984, from minerals sands mining and wet-processing operations at Eneabba and dry plant operations at Narngulu, was reduced because hard-rock material, a cemented sandstone, was encountered during mining. Modifications to both mine and plant equipment to deal with the rock were started. Allied planned to recover the heavy minerals contained in the rock.[10]

An agreement was reached between Consolidated Rutile Ltd. (CRL) and AMC for the acquisition of assets on North Stradbroke Island owned by AMC and its subsidiary, Titanium and Zirconium Industries Pty. Ltd. (TAZI). The assets CRL was to acquire in the first quarter of 1985 included housing, heavy minerals sands processing plants, a 1,400-ton-per-hour dredge that was already operating on CRL's leases near Amity on the north side of North Stradbroke Island, and stocks of ilmenite. The agreement may have been prompted by AMC's failure to receive export approval for minerals from its leases on Moreton Island. AMC's leases on Moreton Island will, however, reportedly not be relinquished because the heavy mineral reserves were the last known extensive deposit on the east coast.[11]

CRL announced that it would commit A$31 million to the development of its Gordon heavy minerals leases on the southern end of North Stradbroke Island. A new dredge and plant there reportedly will have a capacity of 2,800 tons per hour, similar to the capacity of CRL's mine at Bayside on the western side of the island. Mining was scheduled to begin at the Gordon leases in the first half of 1985.[12]

Cable Sands Pty. Ltd. reported that 1983 had been a record year for production. About 600 tons of monazite and 30 tons of xenotime had been produced at Cable's Bunbury plant. In 1984, the company was in the process of moving its mining and wet-processing operations from Capel to an area 4 kilometers north of Capel. A second smaller plant was planned, to start production at the end of 1984 at a site 40 miles north of Bunbury. Cable planned to make a more substantial move in a few years, from its new Capel location to a coastal site, where it expected to switch to a dredge-type operation.[13]

Rutile & Zircon Mines (Newcastle) Ltd. (RZM) reportedly planned to move, over the next 2 years, to new minerals sands leases located 4 to 5 kilometers north of the current Hunter River workings. RZM currently was operating two dredge-concentrator units, one at Tomago and the other at a site north of the Hunter River, that supplied RZM's dry plant in Tomago, near Newcastle, New South Wales.[14]

In return for surrender of heavy minerals sands leases on Moreton Island, Bribie Island, Curtis Island, and along the central coast of Queensland, the State Government reportedly offered the companies involved development leases at Inskip Point, Queensland. The companies, Murphyores Holdings Ltd. and Mineral Deposits Ltd., were prohibited from mining along the coastal areas of Queensland in order to allow for the expansion of national park, port, and industrial sites.[15]

Table 4.—Monazite concentrate: World production, by country[1]

(Metric tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Australia	14,079	[r]13,282	9,562	[r][e]15,000	15,000
Brazil	2,532	2,100	1,768	5,256	6,000
India[3]	3,395	3,704	[e]4,000	[e]4,000	4,000
Malaysia (exports)	347	320	582	1,051	1,000
Sri Lanka	63	60	304	[e]300	300
Thailand	152	107	162	277	250
United States	W	W	W	W	W
Zaire	51	[r]35	32	8	5
Total	20,619	[r]19,608	16,410	25,892	26,555

[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. 23, 1985.

[2]In addition to the countries listed, China, Indonesia, North Korea, the Republic of Korea, and Nigeria 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.

TECHNOLOGY

Researchers at Dow Chemical Co. in Freeport, TX, reportedly developed a high-purity corrosion-resistant magnesium sand-casting alloy that does not contain thorium. The new alloy, temporarily designated AZ91C/HP, was developed for use in military aircraft exposed to highly corrosive saltwater environments. Acceptance of this alloy by aircraft producers could replace several magnesium-thorium alloys presently used in lightweight aircraft parts.[16]

Scientists at Israel's Tel Aviv and Ben Gurion Universities reportedly developed a process, based on thorium, for generating nuclear power. The new process uses thorium to produce energy in situ in the reactor, lessening the uranium required and eliminating the possibility of reprocessing the thorium fuel to remove uranium-233, a potential nuclear weapons material. Testing of the process in an existing light-water reactor was planned.[17]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Industrial Minerals (London). New Rare-Earth Source for Rhône. Aug. 1984, pp. 15-16.

[3]Chemical Engineering. An Abandoned Iron-Ore Mine May Supply About Half the U.S.'s Need for Yttrium. Nov. 26, 1984, pp. 18-19.

[4]Free on board-free into container depot.

[5]Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the rate of A$1.1117=US$1.00 based on yearend 1983 foreign exchange rates from the Wall Street Journal.

[6]Values have been converted from Australian dollars (A$) to U.S. dollars (US$) at the rate of A$1.2070=US$1.00 based on yearend 1984 foreign exchange rates from the Wall Street Journal.

[7]Industrial Minerals (London). World of Minerals. Proposed Processing Ventures. Sept. 1984, p. 15.

[8]———. World of Minerals. Decisions Shortly-On Mineral Sands. Nov. 1984, p. 9.

[9]———. Annual Report Highlights. Allied Eneabba Limited. May 1984, p. 27.

[10]Coope, B. M. Developments in Australia's Industrial Minerals. Ind. Miner. (London), Nov. 1984, pp. 61-67.

[11]Industrial Minerals (London). World of Minerals. Agreement on Stradbroke Reached. Oct. 1984, pp. 9-10.

[12]Mining Journal (London). Consolidated Rutile: Island Mining. V. 303, No. 7782, Oct. 12, 1984, pp. 262.

[13]Work cited in footnote 10.

[14]Work cited in footnote 10.

[15]Mining Journal (London). Industry in Action. Leases for Murphyores. Apr. 20, 1984, pp. 270-271.

[16]Crisafulli, T. Anti-Corrosive Magnesium Alloy Bows. Am. Met. Mark., v. 92, No. 235, Dec. 5, 1984, p. 5.

[17]Chemical & Engineering News. Science/Technology Concentrates. Thorium for Nonproliferative Nuclear Process. Apr. 16, 1984, p. 25.

Tin

By James F. Carlin, Jr.[1]

For the fourth consecutive year, world tin supply exceeded demand, although world mine production declined and world consumption rose during the year. The International Tin Council (ITC) continued imposition of export controls on member producer countries.

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 four mines to which a survey form was sent, all responded. Domestic production data were withheld to avoid disclosing company proprietary data.

Table 1.—Salient tin statistics

(Metric tons unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production:					
Mine	W	W	W	W	W
Smelter	3,000	2,000	3,500	2,500	4,000
Secondary	18,638	15,438	14,293	r14,205	15,417
Exports[1]	595	2,361	5,769	1,340	1,429
Imports for consumption:					
Metal	45,982	45,874	27,939	34,048	41,224
Ore (tin content)	840	232	1,961	969	3,272
Consumption:					
Primary	44,342	40,229	33,019	34,301	37,819
Secondary	12,020	14,144	13,276	11,246	11,622
Stocks, yearend U.S. industry	12,101	11,131	10,251	9,859	9,977
Prices, average cents per pound:					
New York market	773.44	648.40	586.85	601.28	567.80
New York composite	846.00	733.05	653.91	654.78	623.80
London	761.99	649.53	580.50	589.19	556.55
Penang	745.56	637.85	587.29	590.78	564.95
World: Production:					
Mine	r244,726	r251,939	236,052	p210,653	e207,842
Smelter	r250,594	r249,918	234,741	p211,756	e209,049

eEstimated. pPreliminary. rRevised. W Withheld to avoid disclosing company proprietary data.
[1]Exports (excluding reexports).

Legislation and Government Programs.—The General Services Administration (GSA) continued its daily fixed-price tin sale program. A total of 2,397 metric tons was sold in 1984; of that amount, 2,032 tons represented payment material for GSA's Ferroalloy Upgrading Program, which started April 11, 1984. A Memorandum of Understanding, signed by the U.S. Department of State, GSA, and the Association of Southeast Asian Nations to limit GSA tin disposals to about 3,000 tons per year, was in effect through December 31.

At yearend, the National Defense Stockpile inventory was 188,355 tons; the stockpile goal was 42,674 tons.

The depletion allowance for tin remained at 22% for domestic deposits and 14% for foreign deposits.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.—Three mines, operating in Alaska, Arizona, 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 sole domestic tin smelter, located in Texas City, TX, and owned by Gulf Chemical & Metallurgical Corp., a subsidiary of Associated Metals & Minerals Corp., increased tin metal output to an estimated 4,000 tons. The smelter treated imported and domestic concentrates, secondary tin-bearing materials, and its own stockpile of tin residues and slags.

SECONDARY TIN

The United States was believed to be the world's largest producer of secondary tin. Secondary tin 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

	1983	1984
Tinplate scrap treated ____ metric tons	486,543	492,825
Tin recovered in the form of:		
Metal ____ do	928	824
Compounds (tin content) ____ do	182	301
Total[1] ____ do	1,110	1,125
Weight of tin compounds produced ____ do	1,284	1,498
Average quantity of tin recovered per metric ton of tinplate scrap used ____ kilograms	1.98	2.24
Average delivered cost of tinplate scrap ____ per metric ton	$60.60	$68.01

[1]Recovery from tinplate scrap treated only. In addition, detinners recovered 278 metric tons of tin as metal and in compounds from tin-base scrap and residues in 1984.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery

(Metric tons unless otherwise specified)

Form of recovery	1983	1984
Tin metal:		
At detinning plants	1,170	1,097
At other plants	10	10
Total	1,180	1,107
Bronze and brass:		
From copper-base scrap	r8,429	9,071
From lead- and tin-base scrap	88	75
Total	r8,517	9,146
Solder	3,072	3,653
Type metal	172	142
Babbitt	185	123
Antimonial lead	803	894
Chemical compounds	182	301
Miscellaneous[1]	94	51
Total	4,508	5,164
Grand total	r14,205	15,417
Value (thousands)	r$188,301	$192,987

rRevised.
[1]Includes foil and terne metal.

Table 4.—U.S. stocks, receipts, and consumption of new and old scrap and tin recovered in 1984, by type of scrap and class of consumer

(Metric tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered[e]		
	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31			
			New	Old	Total		New	Old	Total
Copper-base scrap:									
Secondary smelters:									
Automobile radiators (unsweated)	3,544	70,321	2,020	67,858	69,878	3,987	68	3,309	3,377
Brass, composition or red	2,643	48,152	11,504	36,740	48,244	2,551	388	1,326	1,714
Brass, low (silicon bronze)	350	2,052	684	971	1,655	747	--	--	--
Brass, yellow	3,681	52,930	18,214	33,092	51,306	5,305	3	190	193
Bronze	1,535	19,098	2,132	16,654	18,786	1,847	167	1,310	1,477
Low-grade scrap and residues	4,379	87,487	60,829	24,097	84,926	6,940	4	--	4
Nickel silver	632	2,277	692	1,718	2,410	499	7	15	22
Railroad-car boxes	108	624	--	722	722	10	--	34	34
Total	16,872	282,941	96,075	181,852	277,927	21,886	637	6,184	6,821
Brass mills:[1]									
Brass, low (silicon bronze)	3,044	14,447	14,447	--	14,447	2,813	--	--	--
Brass, yellow	16,196	307,493	307,493	--	307,493	18,730	--	--	--
Bronze	1,178	4,880	4,880	--	4,880	1,248	232	--	232
Nickel silver	4,428	19,245	19,214	31	19,245	4,214	--	--	--
Total	24,846	346,065	346,034	31	346,065	27,005	232	--	232
Foundries and other plants:[2]									
Automobile radiators (unsweated)	1,085	5,445	889	4,673	5,562	968	--	210	210
Brass, composition or red	621	10,559	6,003	4,741	10,744	436	286	225	511
Brass, low (silicon bronze)	56	1,384	692	698	1,390	50	--	--	--
Brass, yellow	550	10,971	5,869	5,005	10,874	647	17	24	41
Bronze	854	924	314	613	927	851	24	48	72
Low-grade scrap and residues	--	3	--	3	3	--	--	--	--
Nickel silver	23	160	2	154	156	27	--	--	--
Railroad-car boxes	745	5,548	--	4,786	4,786	1,507	--	227	227
Total	3,934	34,994	13,769	20,673	34,442	4,486	327	734	1,061
Total tin from copper-base scrap	XX	XX	XX	XX	XX	XX	1,196	6,918	8,114
Lead-base scrap:									
Smelters, refiners, others:									
Babbitt	130	1,956	--	1,801	1,801	285	--	87	87
Battery lead plates	42,411	596,790	--	609,434	609,434	29,767	--	1,262	1,262
Drosses and residues	5,706	66,017	63,917	--	63,917	7,806	1,677	--	1,677
Solder and tinny lead	997	17,105	--	15,993	15,993	2,109	--	2,560	2,560
Type metal	591	4,181	--	4,270	4,270	502	--	182	182
Total	49,835	686,049	63,917	631,498	695,415	40,469	1,677	4,091	5,768
Tin-base scrap:									
Smelters, refiners, others:									
Babbitt	3	71	--	70	70	4	--	57	57
Block-tin pipe	8	72	--	76	76	4	--	75	75
Drosses and residues	12	410	409	--	409	13	23	--	23
Pewter	1	--	--	--	--	1	--	--	--
Total	24	553	409	146	555	22	23	132	155
Tinplate and other scrap:									
Detinning plants	--	--	484,392	--	484,392	--	1,380	--	1,380
Grand total	XX	XX	XX	XX	XX	XX	4,276	11,141	15,417

[e]Estimated; tin recovered new and old from copper-base scrap, brass mills, and foundries. XX Not applicable.
[1]Brass-mill stocks include home scrap, and purchased-scrap consumption is assumed equal to receipts; therefore, lines and total in brass-mill section do not balance.
[2]Omits "machine-shop scrap."

CONSUMPTION AND USES

Primary tin consumption rose for the third consecutive year, but remained well below the levels of the 1970's. In 1984, 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 97.8 billion metal cans shipped, tinplated steel and tin-free steel accounted for 35% and aluminum accounted for 65%, compared with 92.4 billion metal cans shipped in 1983, when steel accounted for 37% and aluminum, 63%.[2]

Table 5.—U.S. consumption of primary and secondary tin

(Metric tons)

	1980	1981	1982	1983	1984
Stocks, Jan. 1[1]	7,075	8,835	8,717	7,549	7,740
Net receipts during year:					
Primary	43,545	41,162	35,843	36,494	39,388
Secondary	2,461	5,692	6,507	5,412	6,096
Scrap	7,709	8,050	7,830	7,435	7,323
Total receipts	53,715	54,904	50,180	49,341	52,807
Total available	60,790	63,739	58,897	56,890	60,547
Tin consumed in manufactured products:					
Primary	44,342	40,229	33,019	34,301	37,819
Secondary	12,020	14,144	13,276	11,246	11,622
Total	56,362	54,373	46,295	45,547	49,441
Intercompany transactions in scrap	835	726	274	245	318
Total processed	57,197	55,099	46,569	45,792	49,759
Stocks, Dec. 31 (total available less total processed)	3,593	8,640	12,328	11,098	10,788

[1]Includes tin in transit in the United States.

Table 6.—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)	Tinplate (all forms): Tin content[1] (metric tons)	Tinplate (all forms): Tin per metric ton of plate (kilograms)
1980	311,770	3,699,920	16,346	4.4
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

[1]Includes small tonnage of secondary tin and tin acquired in chemicals.

Table 7.—U.S. consumption of tin, by finished product

(Metric tons of contained tin)

Product	1983			1984		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)[1]	W	W	W	W	W	W
Babbitt	2,563	318	2,881	2,343	341	2,684
Bar tin	654	W	654	522	4	526
Bronze and brass	1,395	3,188	4,583	1,686	3,312	4,998
Chemicals	W	W	W	W	W	W
Collapsible tubes and foil	W	W	W	W	W	W
Solder	10,087	4,033	14,120	13,450	3,799	17,249
Tinning	1,759	W	1,759	1,748	W	1,748
Tinplate[2]	9,328	134	9,462	8,659	166	8,825
Tin powder	793	W	793	1,057	W	1,057
Type metal	W	W	W	W	W	W
White metal[3]	856	81	937	881	77	958
Other	6,866	3,492	10,358	7,473	3,923	11,396
Total	34,301	11,246	45,547	37,819	11,622	49,441

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 8.—U.S. industry yearend tin stocks

(Metric tons)

	1980	1981	1982	1983	1984
Plant raw materials:					
Pig tin:					
Virgin[1]	7,359	6,857	6,269	6,326	5,480
Secondary	229	411	265	732	1,562
In process[2]	1,247	1,449	1,015	682	1,164
Total	8,835	8,717	7,549	7,740	8,206
Additional pig tin:					
Jobbers-importers	564	1,943	1,386	608	761
Afloat to United States	2,702	471	1,316	1,511	1,010
Total	3,266	2,414	2,702	2,119	1,771
Grand total	12,101	11,131	10,251	9,859	9,977

[1]Includes tin in transit in the United States.
[2]Data represent scrap only, tin content.

PRICES

The price of tin metal throughout 1984 showed little fluctuation. However, the price generally weakened, and the average tin price was slightly lower than in 1983.

Table 9.—Monthly composite price of Straits tin for delivery in New York

(Cents per pound)

Month	1983 High	1983 Low	1983 Average	1984 High	1984 Low	1984 Average
January	633.16	618.40	624.43	625.60	622.20	623.74
February	661.65	634.10	650.69	634.77	622.13	627.88
March	677.84	654.54	667.72	644.90	627.36	626.65
April	698.69	676.45	687.59	638.71	633.65	636.50
May	686.77	673.49	680.00	641.05	632.36	636.32
June	677.72	658.85	667.07	640.12	635.21	638.25
July	671.20	648.68	659.68	635.10	624.86	629.89
August	653.19	642.94	648.38	632.50	619.23	626.00
September	653.22	638.05	645.10	623.70	607.27	618.08
October	653.31	634.25	646.83	607.49	597.45	603.61
November	652.75	646.49	649.02	615.98	600.82	609.94
December	645.40	620.30	630.80	604.30	591.88	598.76
Average	XX	XX	654.78	XX	XX	623.80

XX Not applicable.

Source: Metals Week.

FOREIGN TRADE

Imports of tin concentrates in 1984 rebounded to a level consistent with those of the late 1970's. Peru remained the major source of tin concentrates.

Imports of tin metal increased, in line with the domestic consumption increase. Brazil emerged as the major source of tin metal, followed by Thailand, Malaysia, Bolivia, and Indonesia.

Imports of tin in all forms (ore and concentrate, metal, and waste and scrap) remained free of U.S. duty.

Table 10.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and tin manufactures: Imports: Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f.: Value (thousands)	Imports: Dross, skimmings, scrap, residues, tin alloys, n.s.p.f.: Quantity (metric tons)	Imports: Dross, skimmings, scrap, residues, tin alloys, n.s.p.f.: Value (thousands)	Exports: Tin scrap and other tin-bearing material, except tinplate scrap: Value (thousands)	Tin compounds: Imports: Quantity (metric tons)	Tin compounds: Imports: Value (thousands)
1982	$12,288	3,068	$4,364	$13,566	321	$2,667
1983	10,728	1,193	1,219	8,972	642	4,120
1984	3,292	1,211	1,318	12,494	838	5,301

Table 11.—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: Exports: Quantity (metric tons)	Ingots, pigs, bars: Exports: Value (thousands)	Tinplate and terneplate: Exports[1]: Quantity (metric tons)	Tinplate and terneplate: Exports[1]: Value (thousands)	Tinplate and terneplate: Imports: Quantity (metric tons)	Tinplate and terneplate: Imports: Value (thousands)	Tinplate scrap: Imports: Quantity (metric tons)	Tinplate scrap: Imports: Value (thousands)
1982	5,769	$84,454	217,840	$118,870	198,123	$134,718	5,530	$454
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

[1]Tinplate circles, strips, and cobbles are included with exports of tinplate and terneplate.

Table 12.—U.S. imports for consumption of tin, by country

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Concentrates (tin content):				
Bolivia	257	$2,812	271	$1,782
Canada	--	--	1	1
Mexico	--	--	17	78
Peru	341	3,474	2,502	14,308
Singapore	101	887	46	475
South Africa, Republic of	270	2,376	3	28
Thailand	--	--	403	3,883
Zaire	--	--	29	306
Total[1]	969	9,549	3,272	20,862
Metal:[2]				
Australia	390	4,879	288	4,179
Belgium-Luxembourg	45	592	137	1,688
Bolivia	5,739	73,798	5,438	67,742
Brazil	5,604	70,885	10,220	126,190
Burma	56	754	64	776
Canada	2	41	8	66
Chile	71	905	218	3,713
China	1,938	23,617	1,640	20,596
Denmark	--	--	40	489
Germany, Federal Republic of	181	2,335	1	11
Indonesia	6,004	77,354	4,985	62,224
Japan	--	--	20	242
Malaysia	4,704	62,396	6,622	80,546
Mauritania	18	223	--	--
Netherlands	9	117	140	1,743
Nigeria	265	3,529	60	788
Paraguay	--	--	1	6
Philippines	--	--	20	256
Rwanda	--	--	30	367
Singapore	1,029	13,701	781	4,128
South Africa, Republic of	18	228	10	121
Taiwan	135	1,705	--	--
Thailand	7,436	95,768	9,531	104,657
United Kingdom	18	268	583	7,253
Zaire	10	126	89	787
Zimbabwe	376	4,931	296	3,462
Total[1]	34,048	438,154	41,224	492,030

[1]Data may not add to totals shown because of independent rounding.
[2]Bars, blocks, pigs, or granulated.

WORLD REVIEW

International Tin Agreement.—The Sixth International Tin Agreement (ITA), which commenced July 1, 1982, continued in effect throughout 1984. The United States was not a member of the agreement. The ITC continued stringent tin export controls on member producer countries as a method of reducing the world tin surplus. Controls on tin exports under the sixth ITA started on July 1, 1982, at 36% of precontrol levels and continued into the second quarter of 1983. The export cutback rate was tightened further to 39.6% in the third quarter of 1983 and remained at that level through the end of 1984. Industry sources estimated the world tin surplus at about 70,000 tons compared with a surplus of about 80,000 tons reported in 1983.

Several new efforts to eliminate tin smuggling in Southeast Asia were made, and some results were achieved. Tin concentrate smuggling was estimated by the ITC to have declined to 11,000 tons from 16,000 tons in 1983. Tin smuggling was counterproductive to export control measures and was viewed as a significant factor in contributing to the world tin surplus. Industry sources estimated that Singapore continued to be the destination for considerable tonnage of smuggled tin concentrates from Indonesia, Malaysia, and Thailand.

The ITC buffer stock manager continued tin price support actions in the Kuala Lumpur Tin Market (KLTM) in Malaysia during the year by buying tin for the ITC stockpile to defend the ITC's floor price. The ITC retained the same buffer stock floor price of 29.15 Malaysian dollars (M$) per kilogram and ceiling price of M$37.89 that were in effect since October 17, 1981.

The Association of Tin Producing Countries (ATPC), comprised of seven major producer nations—Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand, and Zaire—completed its first full year as an organization. ATPC viewed itself as being complimentary to and supportive of the activities of the ITA. Two meetings were held by ATPC, and the organization attempted to influence non-ITA member countries to restrain tin production.

Argentina.—The Government of Argentina announced plans to develop a vein-type underground sulfide tin deposit at Antofalla.

Australia.—Australian Southern Ventures NL completed a feasibility study on the viability of a small mining operation on the tin-bearing alluvial gravels at the China Camp tin project in Queensland, and planned to proceed with development.

Metals Exploration Ltd. announced startup of the Gibsonvale tin tailings operation near West Wyalong, New South Wales. The firm had previously produced tin at the site during 1968-74.

Bolivia.—In 1984, 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 a number of mining cooperatives. The three largest mines were the Huanuni, the La Palca, and the Catavi. Bolivia remained a relatively 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 concentrates produced were beneficiated in mills adjoining the mines.

Throughout the year, Bolivian tin production was hampered by a series of strikes. Workers protested Government austerity programs and sought a large wage increase to keep pace with the country's high rate of inflation. COMIBOL announced plans to expand its Bolivar Mine.

The country's smelting industry comprised the Vinto smelter near Oruro, the Karachipampa smelter near Potosí, and the La Palca tin volatilization plant, also near Potosí. Vinto was operated by Empresa Nacional de Fundiciones (ENAF); Karachipampa was operated jointly by ENAF and COMIBOL; and La Palca was run by COMIBOL. ENAF announced an $8 million loan from the Federal Republic of Germany to modernize its Vinto smelters.

Brazil.—Brazil was not a member of the ITA and therefore not bound by the ITA's export controls, and Brazilian tin mines sharply increased their output. Brazil ranked as the world's sixth largest tin producer. The three largest private tin mining companies in Brazil—Paranapanema S.A. Mineração, Indústria e Construção; Brascan Recursos Naturais S.A. (BRN); and Mineração Brumadinho S.A.—all sharply increased output.

The leading producer, Paranapanema, accounted for more than one-half the total country 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 firm shipped the entire output of its mines to its Mamoré smelter, near São Paulo, for conversion to refined metal. The Mamoré smelter was expanded to about 12,000 tons per year of refined tin capacity.

BRN, jointly owned by Brascan Ltd. and BP Mineração Ltd., was Brazil's second leading tin producer. It operated several alluvial tin 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 had several exploration 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. was reported to be near startup at its Mocambo tin project, which will produce tin from an alluvial deposit situated near São Felix in the Xingu River area of Pará State. This was the first major investment in a metal mining venture by Mineração San Jose Ltd., St. Joe's mining subsidiary in Brazil.

There were at least 10 tin smelters in Brazil, but none, except Mamoré, had sufficient feed to operate at designed capacity.

Canada.—Rio Algom Ltd. proceeded with construction of its substantial open pit tin mine at East Kemptville, Nova Scotia, with startup planned for late 1985. The operation was expected to produce about 4,500 tons per year of tin in concentrate form, to cost $150 million, and to be the largest tin mine in North America. Rio Algom arranged for all the tin concentrates to be shipped to the Capper Pass smelter in North Ferriby, United Kingdom.

Indonesia.—Most of this country's tin deposits are offshore. The national mining organization, P.T. Tambang Timah, remained the major producer in 1984. P.T. Koba Tin was the country's second largest tin producer, with its largest mine situated on Banka Island. Koba was jointly owned by Kajaura Mining Corp. (Pty.) Ltd., an Australian company, and by Tambang Timah.

Japan.—The largest of the two tin mines was in the southwestern part of Honshu Island and was owned and operated by the Akenobe Mining Co. Ltd., a subsidiary of Mitsubishi Metal Corp. The other mine was the Suzutama Mine, situated in the southwestern part of Kyusha Island and owned by Kyowa Mining Co. Both mines shipped their entire output of tin concentrates to Mitsubishi's Ikuno tin smelter.

Malaysia.—Although Malaysia remained the world's leading tin producer, its tin mining activities continued the pattern of decline of recent years. There were 474 mines in 1984, compared with 852 mines in 1980. The number of dredges declined to 30, the number of gravel pump mines declined to 379, and the total labor force declined to 24,000 people.

Two large smelters continued operating at Penang, refining all of Malaysia's tin concentrates and considerable amounts of imported concentrates.

On October 1, the KLTM began operations. It replaced the 95-year-old Penang tin market. The KLTM, like the Penang market, traded exclusively in refined Malaysian tin metal. Unlike the Penang market, the KLTM's price setting mechanism was more attuned to a broader base of supply and demand. The KLTM balanced all bids and offers received to give a single price, which represented the day's tin spot price.

The Malaysia Mining Corp. (MMC) opened a sales office in New York, NY, to handle tin exports to the United States. Previously, MMC's exports to the United States were handled by independent importers.

Namibia.—Most tin production came from the Uis Mine, in the Brandberg area. The Uis Mine was owned by Industrial Minerals Mining Corp. (Pty.) Ltd., a wholly owned subsidiary of South African Iron and Steel Industrial Corp. Ltd. (Iscor). The Uis tin deposits occurred as low-grade, 0.11% to 0.15% tin, cassiterite mineralization. The tin concentrates were shipped directly to the Vanderbijlpark steelworks in the Republic of South Africa, where they provided a large part of Iscor's tin needs for use in the making of electrolytic tinplate.

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 concentrates were smelted by Makeri Smelting Co. Ltd.

Peru.—Tin mine output continued a steady increase. The San Rafael Mine, owned by Minsur S.A., was the only tin mine. Situated near Juliaca, the mine is within the northern extension of the Bolivian tin belt. The mine reported tin grades of 1.8%.

South Africa, Republic of.—Rooiberg Tin Ltd., owned by Gold Fields of South Africa Ltd., continued to be the largest producer. Zaaiplaats Tin Mining Co. Ltd. was the second leading producer. Union Tin Mines Ltd., also owned by Gold Fields, was the smallest of the three producers. Although not a member of the ITA and thus not bound by export controls, tin production in the Republic of South Africa continued to decline, largely owing to lower tin recovery grades.

Thailand.—Throughout the year, Thai miners complained about ITC export controls and the Government's tin royalty or tax system. Miners called for Thailand to withdraw from the ITA. The royalty problems and the export controls reportedly led to worsening of the serious smuggling situation. Industry sources estimated that 5,000 tons of tin concentrate was smuggled out of Thailand.

Siam Charoen Tin Smelting Co. applied to Thailand's Industry Ministry to build a 360-ton-per-year tin smelter near Bangkok. The smelter would sell its output to local users, in line with the Industry Ministry's policy of encouraging local demand by promoting new domestic smelters as a source of cheaper tin supplies.

U.S.S.R.—The U.S.S.R. ranked as the world's second leading tin ore producer. However, it was a net importer of tin. The major Soviet tin producing areas were the Soviet Far East, Yakutia, and Transbaykal. About 25% of total output was from placer deposits, mostly located in the Soviet North East.

United Kingdom.—Not bound by the ITC's export controls, the United Kingdom's tin mine output expanded. Carnon Consolidated Tin Mines Ltd., a subsidiary of Rio Tinto Zinc Corp. Ltd. (RTZ), was the biggest producer with an output of 1,900 tons of tin concentrates, with an average tin grade of 0.88% and a 74% recovery rate. RTZ purchased the United Kingdom's second largest tin mine, South Crofty, and announced plans to invest substantially to modernize and expand the mine's main shaft. Another producer, Geevor Tin Mines Ltd., which operated an underground tin mine near Lands End, Cornwall, applied for planning permission to prospect for minerals in the alluvium of the Hayle River in the Godolphin Bridge area in West Cornwall.

Vietnam.—Reports indicate that three tin mines were operated in Vietnam. The Tinh Tuc Mine in Cao Bang Province continued as the main producer. The second major producer was the Son Duong Mine in Ha Tuyen Province, and the smallest and newest mine was the Quy Hop Mine in Nghe Tinh Province.

Zaire.—The major producer was Société Minière et Industrielle de Kivu (Sominki) in Kivu. The firm was 28% state owned and 72% owned by Empain-Schneider Group of France. Its concession area was about 9,800 square kilometers. Tin output by Sominki suffered from depletion of secondary deposits and a deteriorating infrastructure. Sominki was reportedly consolidating its operations, closing distant minesites. Tin concentrate output was shipped to Europe for smelting.

Table 13.—Tin: World mine production, by country[1]

(Metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Argentina	351	413	304	291	300
Australia	11,588	12,267	12,126	[2]9,275	9,300
Bolivia	27,291	29,830	26,773	25,278	21,100
Brazil	[r]6,377	[r]8,253	9,293	13,418	[3]16,021
Burma	1,290	1,438	1,681	1,642	[3]2,028
Cameroon	15	19	[e]14	([4])	--
Canada	[r]243	239	135	141	[3]217
China[e]	14,600	15,000	15,000	15,000	15,000
Czechoslovakia[e]	322	433	[r]400	400	400
German Democratic Republic[e]	1,800	1,600	1,700	[r]1,800	1,800
Indonesia	32,527	35,392	33,806	26,553	21,530
Japan	549	561	529	600	[3]485
Korea, Republic of	8	--	--	--	--
Laos[e]	290	200	225	[r]265	315
Malaysia	61,404	59,938	52,342	41,367	[3]41,307
Mexico	60	28	27	50	50
Namibia	1,070	1,228	1,326	[e]1,400	1,400
Niger	64	55	36	40	40
Nigeria	2,569	[r]3,172	2,355	1,560	1,700
Peru	1,077	1,519	1,672	2,368	2,990
Portugal	274	506	410	347	350
Rwanda	2,069	1,790	1,655	1,520	1,100
South Africa, Republic of	2,913	2,811	3,035	2,668	2,200
Spain	437	564	518	444	450
Tanzania	12	[r]9	9	6	5
Thailand	33,685	31,474	26,109	19,943	[3]21,920
Uganda[e]	30	30	30	30	30
U.S.S.R.[e]	[r]34,000	[r]34,000	[r]35,000	[r]35,000	36,000
United Kingdom	2,982	3,869	4,208	4,025	4,600
United States	W	W	W	W	W
Vietnam	370	380	[e]580	550	500
Zaire	3,159	3,321	3,144	[r e]3,000	3,000
Zambia[e]	([5])	--	10	22	[3]4
Zimbabwe[e]	1,300	1,600	1,600	1,650	1,700
Total	[r]244,726	[r]251,939	236,052	210,653	207,842

[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 11, 1985.

[2]Excludes tin content of copper-tin cathodes.

[3]Reported figure.

[4]Revised to zero.

[5]Less than 1/2 unit.

The second largest producer was Société Zairetain, with 50% state ownership and 50% ownership by Geomines Cie. of Belgium. Its operations reportedly declined sharply in recent decades owing to lack of reinvestment in plant and equipment. Zairetain reported a small output of refined tin from its smelter at Manono.

The third largest producer was Société Minière de Goma (SMDG), with 20% state ownership and 80% ownership by the Bureau de Recherches Géologiques et Minières, which is funded by the French Government. SMDG operated the small Kalimbi Mine in northern Kivu Province. Several other new tin mining ventures were planned by other organizations.

Zimbabwe.—Production was centered at the Kamativi Mine-concentrator-smelter complex in the northwest area near Hawange. The tin occurred as cassiterite, along with tantalite, lithium, and beryllium.

Table 14.—Tin: World smelter production, by country[1]

(Metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Argentina[e]	300	200	200	150	150
Australia	4,819	4,286	3,105	2,913	[2]2,941
Belgium	2,822	65	--	--	--
Bolivia	18,191	20,005	19,032	14,174	16,400
Brazil	8,792	[r]7,789	9,298	12,741	[2]18,100
China[e]	14,600	15,000	15,000	15,000	15,000
German Democratic Republic	1,800	1,800	2,000	2,000	2,000
Germany, Federal Republic of	2,262	1,815	608	417	400
Indonesia	30,465	[r]32,519	29,755	28,390	22,500
Japan	1,319	1,315	1,296	1,260	[2]1,354
Malaysia[3]	71,318	70,326	62,836	53,338	46,500
Mexico[4]	1,322	838	944	1,216	1,200
Netherlands	1,100	[r]3,500	2,800	5,400	6,000
Nigeria	2,678	2,486	2,754	1,190	1,300
Portugal	938	900	[e]400	200	180
Rwanda	--	--	908	1,110	1,100
South Africa, Republic of	1,100	[r]2,602	2,884	2,685	1,500
Spain	4,100	4,400	3,700	2,200	2,000
Thailand	34,689	32,626	25,497	18,467	[2]19,979
U.S.S.R.[e]	[r]38,000	[r]37,000	[r]38,000	[r]38,000	38,500
United Kingdom	5,829	6,839	8,200	6,500	6,100
United States[5]	3,000	2,000	3,500	2,500	4,000
Vietnam	--	--	[e]475	520	475
Zaire	[r]216	450	352	[e]150	150
Zimbabwe	934	1,157	1,197	1,235	1,220
Total	[r]250,594	[r]249,918	234,741	211,756	209,049

[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 11, 1985.
[2]Reported figure.
[3]Includes small production of tin from smelter in Singapore.
[4]Primarily from imported tin concentrate; minor amounts of refined tin from domestic ores were as follows, in metric tons: 1980—60; 1981—28; 1982—27; 1983—50 (estimated); and 1984—50 (estimated).
[5]Includes tin content of alloys made directly from ores.

TECHNOLOGY

The International Tin Research Institute reported investigation of applications of mono-organotins to fabric as a water repellent agent. Early results showed some success with cotton fabrics thus treated.[3]

A low-cost methyltin heat stabilizer was developed for rigid polyvinylchloride compounds to be used for potable water pipes.[4]

A new manufacturing method, surface mount technology, was developed that utilizes solder pastes or creams to attach electronic chip resistors, chip capacitors, and other electronic components directly to silicon chips using only metallized pads. The process reportedly can be operated at high volume at low cost.[5]

The electric utility industry developed a new use for organotin antifouling coatings in the circulating water systems of electric powerplants. These coatings have long been used to coat the hulls of seagoing vessels, where they are effective toxicants to barnacles, sea grass, mollusks, and sponges. The Electric Power Research Institute started a 3-year study to evaluate the ability of organotin coatings to control powerplant fouling.[6]

A new technique for efficiently making flat glass in smaller plants in developing countries was introduced by a U.S. company, AFG Corp. of Tennessee. The process was an adaptation of the Pilkington process of producing flat glass by floating molten glass on a bath of molten tin. The average float glass plant has an economic production level of 500 to 650 tons per day. The new minifloat system was reportedly effective at 120 tons per day and therefore suitable for smaller markets.[7]

The International Tin Research Institute developed electrodeposition techniques to apply tin coatings that contain nonmetallic inclusions such as silicon carbide and molybdenum disulfide. These composite coatings were expected to combine the beneficial effects of tin with other properties like improved abrasion resistance and better antifriction characteristics.[8]

The Third International Tinplate Conference was held October 15-19, 1984, in London, England. Forty-four papers were presented by representatives of the tinplate, canmaking, and canning industries of 13 countries. Numerous new tinplating technical innovations were presented.[9]

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[1]Physical scientist, Division of Nonferrous Metals.
[2]Can Manufacturers Institute. Metal Can Shipments Report 1984. Washington, DC, 1984, p. 3.
[3]Tin International. V. 57, No. 3, Mar. 1984, p. 80.
[4]Work cited in footnote 3.
[5]Tin and Its Uses. No. 143, 1985, pp. 13-17.
[6]———. No. 141, 1984, p. 14.
[7]Tin International. V. 57, No. 5, May 1984, pp. 145-146.
[8]Tin News. Tin-Novations. V. 33, No. 12, Dec. 15, 1984, p. 3.
[9]Pages 1-8 of work cited in footnote 5.

Titanium

By Langtry E. Lynd[1] and Ruth A. Hough[2]

Domestic consumption of titanium concentrates increased in 1984, and production and consumption of titanium dioxide (TiO_2) pigment reached new record-high levels, reflecting continued recovery in the U.S. economy. Production of ilmenite, rutile, and synthetic rutile also increased. Domestic consumption of titanium sponge metal rebounded sharply from the low point reached in 1983 mainly because of substantial improvement in the commercial aircraft market. Prices of titanium concentrates, particularly rutile, increased because of the high demand for TiO_2 pigment. Titanium sponge metal list prices were unchanged and were discounted heavily early in the year, but recovered somewhat by yearend. Titanium dioxide pigment prices increased in the third quarter, but were still below published list prices at 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 an estimated 89% 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)

	1980	1981	1982	1983	1984
United States:					
Ilmenite concentrate:					
Mine shipments	593,704	523,681	233,063	W	W
Value thousands	$32,041	$37,013	$19,093	W	W
Imports for consumption	357,488	236,217	348,366	259,328	409,605
Consumption	848,607	856,116	583,250	730,578	783,391
Titanium slag:					
Imports for consumption	194,994	268,825	247,845	138,708	209,839
Consumption	181,582	252,826	225,541	166,401	200,858
Rutile concentrate, natural and synthetic:					
Imports for consumption	281,605	202,373	163,325	111,578	180,508
Consumption	297,582	285,371	238,937	265,558	317,902
Sponge metal:					
Imports for consumption	4,777	6,490	1,354	1,199	[1]2,667
Consumption	26,943	[e]31,599	[e]17,328	[e]16,072	[e]24,713
Price, Dec. 31, per pound	$7.02	$7.65	$5.55	$5.55	$5.55
Titanium dioxide pigment:					
Production	727,245	761,190	[r]659,710	[r]760,385	798,978
Imports for consumption	97,590	124,906	138,922	174,857	193,501
Consumption, apparent[2]	753,480	806,040	[r]741,065	[r]853,008	880,287
Price, Dec. 31, cents per pound:					
Anatase	57.0	69.0	69.0	69.0	69.0
Rutile	63.0	75.0	75.0	75.0	75.0
World: Production:					
Ilmenite concentrate	[r]4,106,829	[r]4,022,884	3,340,339	[p] [3]2,966,857	[e] [3]3,183,495
Rutile concentrate, natural[3]	480,472	[r]398,709	374,450	[p]350,915	391,483
Titaniferous slag	[r]1,313,439	1,244,864	1,157,445	[p]1,160,000	[e]1,260,000

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Excludes sponge imported by 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 included 21,604 tons of specification metal and 10,866 tons of nonspecification material. Most of the 4,500 tons of sponge contracted for by the General Services Administration (GSA) in 1983 was delivered by yearend 1984, but was not yet included in inventory totals.

The Government stockpile goal for rutile was unchanged at 106,000 tons. The total rutile stockpile inventory at yearend was 39,186 tons.

The U.S. International Trade Commission (ITC) in a three to two decision on October 29 ruled that imports of titanium sponge by the GSA for the stockpile from three Japanese producers had caused material injury to domestic titanium producers. The ITC also determined by a five to zero vote that imports of titanium from Deeside Titanium Ltd., United Kingdom, had not caused material injury.[4] The International Trade Administration (ITA) of the U.S. Department of Commerce set final dumping margins on the products of Japanese titanium sponge producers as follows: Osaka Titanium Co. Ltd., 15.09%; Toho Titanium Co. Ltd., 34.25%; and Nippon Soda Co. Ltd., 56.37%. The ITA also decided that imports to fulfill the 1983 purchase contracts of titanium for the stockpile will not be subject to duties.

DOMESTIC PRODUCTION

Concentrates.—U.S. producers of ilmenite were Associated Minerals (U.S.A.) Ltd. Inc. (AMU) at Green Cove Springs, FL, and E. I. du Pont de Nemours & Co. Inc. at Starke and Highland, FL. NL Industries Inc. ceased ilmenite production at Tahawus, NY, but continued to produce magnetite concentrate for heavy-media applications.

As in 1983, AMU was the only U.S. 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 A. Johnson Metals Corp. (formerly the Industrial Metals Div. of A. Johnson & Co. Inc.), Lionville, PA; Reactive Metals and Alloys Corp., West Pittsburg, PA; and Shieldalloy Corp., Newfield, NJ. Most of the production consisted of the 70% titanium grades. A. Johnson Metals discontinued production of ferrotitanium in late 1984 reportedly because of the large volume of low-priced material being imported from overseas, but plans to continue to be a supplier of titanium scrap.

Metal.—Domestic production of titanium sponge metal was 74% above the depressed level of 1983. Sponge production capacity was unchanged from that of 1983. The increased titanium production resulted mainly from increased demand for commercial and military aircraft, including the B-1B bomber.

At yearend, negotiations were begun for a leveraged buyout of the Timet Div. of Titanium Metals Corp. of America by a group of investors including Timet's top management and Kelso & Co., a New York management consulting firm. Allegheny International Inc. and NL have been 50-50 joint owners of Timet and were to each retain a 5% share of Timet. Kelso was to arrange financing and was expected to obtain a 20% to 30% share in Timet. The Standard Steel Div. of Titanium Metals was excluded from the sale.

A. Johnson announced the first commercial production of as-cast titanium slab in the United States. The slabs were produced at the company's electron beam furnace facility in Morgantown, PA, and were successfully converted to flat-rolled mill products by several specialty metal companies. The casting process reportedly reduced processing costs and increased yields in the production of commercially pure mill products.

Albany Titanium Inc. (ALTi), Albany, OR, was constructing two pilot plants to develop a newly patented process, licensed from Occidental Petroleum Corp., for producing titanium sponge and powder from domestic ilmenite. Development of the process was expedited by a $4 million grant made jointly by the Army, Navy, Air Force, and Defense Research Projects Agency. Under a 30-month contract retroactive to May 1, the Air Force will receive 5 tons of titanium sponge and 1 ton of powder for analysis and evaluation. Construction of a production facility with a capacity of 5,000 tons of powder or sponge per year was planned for completion in 1986. ALTi claimed that cost savings of 50% compared with current commercial processes could be achieved.

Martin Marietta Corp., Bethesda, MD, announced it had signed an agreement in principle with Nippon Kokan K.K., Japan, to establish a joint venture to produce and market aluminum and titanium fabricated products. The two firms were to form a new corporation, owned 60% by Martin Marietta and 40% by Nippon Kokan, that will include the Torrance, CA, extrusion and forging plant of Martin Marietta Aluminum Inc., and will use the latest metal processing technology of both firms. Reportedly, Nippon Kokan was investing $45 million in the new corporation.

Viking Metallurgical Corp. completed the first phase of approval by Pratt & Whitney Aircraft Group for use of Viking's electron-beam-melted (EBM) electrodes made from titanium alloy turning for manufacture of rotor-grade ingot. This phase was a verification of the effectiveness of Viking's EBM process for removal of carbide tool particles from titanium turnings. The second phase of approval was to involve processing of five rotor-grade ingots made from EBM electrodes.

Table 2.—Production and mine shipments of ilmenite concentrates[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)
1980	556,646	593,704	358,181	$32,041
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

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 1984

Company	Ownership	Plant location	Capacity (short tons): Sponge	Capacity (short tons): Ingot
Howmet Corp., Alloy Div	Pechiney, France	Whitehall, MI	--	5,000
International Titanium Inc	Wyman-Gordon Co., 42.5%; Ishizuka Research Institute and Mitsui & Co. Ltd., Japan; other U.S. and Japanese interests.	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	--	1,000
Martin Marietta Aluminum Inc	do	Torrance, CA	--	5,000
Oregon Metallurgical Corp	Armco Inc., 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	--	12,000
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	15,000	17,000
Viking Metallurgical Corp	Quanex Corp	Verdi, NV	--	[1]5,000
Western Zirconium Co	Westinghouse Electric Corp	Ogden, UT	500	500
Total			33,500	60,000

[1]Single melt only, commercially pure ingot and slab.

Pigment.—Kerr-McGee completed in May the expansion of its Hamilton, MS, pigment plant to 63,000 tons per year capacity, and in October had begun a further expansion to 72,000 tons per year. The $8 million project was to be completed by mid-1986.

In October 1984, NL reportedly signed an agreement to buy the U.S. TiO_2 pigment business of American Cyanamid Co. for about $95 million. American Cyanamid's TiO_2 pigment business, with chloride and sulfate process plants at Savannah, GA, had annual sales of $135 million and 110,000 tons per year of production capacity. However, NL later announced that it would not pursue this acquisition because of opposition by the Federal Trade Commission.

Table 4.—Components of U.S. titanium metal supply and demand

(Short tons)

Component	1980	1981	1982	1983	1984
Production:					
Sponge	[1]22,500	[1]26,400	[1]15,600	13,966	24,326
Ingot	42,864	46,236	26,536	26,439	39,964
Exports:					
Sponge	113	58	36	39	171
Other unwrought	344	257	173	258	204
Scrap	3,300	3,280	4,287	5,379	4,109
Ingot, slab, sheet bar, etc	3,278	4,203	2,196	1,371	2,071
Other wrought	1,845	1,846	1,404	783	778
Total	8,880	9,644	8,096	7,830	7,333
Imports:					
Sponge	4,777	6,490	1,354	1,199	[2]2,667
Scrap	4,138	3,787	1,277	1,572	1,850
Ingot and billet	191	244	212	81	176
Mill products	946	1,116	870	935	840
Total	10,052	11,637	3,713	[3]3,788	5,533
Stocks, yearend:					
Government: Sponge (total inventory)	32,331	32,331	32,331	32,331	32,470
Industry:					
Sponge	2,381	[e]3,720	[e]3,350	[e]3,136	[e]3,147
Scrap	8,641	[e]10,484	[e]11,073	[e]12,635	[e]12,489
Ingot	1,860	3,592	2,534	[r]3,273	4,526
Other	2	7	3	22	18
Total industry	12,884	17,803	16,960	[r]19,066	20,180
Reported consumption:					
Sponge	26,943	[e]31,599	[e]17,328	[e]16,072	[e]24,713
Scrap	15,406	[e]14,795	[e]8,528	[e]10,467	[e]15,549
Ingot	43,360	43,592	27,580	[r]26,232	39,062
Mill products (net shipments)[4]	27,133	25,492	18,281	15,949	22,808
Castings (shipments)[4]	191	209	260	240	268

[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 GSA for the national stockpile.
[3]Data do not add to total 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, 1984

Company and plant location	Pigment capacity (short tons per year)	
	Sulfate process	Chloride process
American Cyanamid Co., Savannah, GA	64,000	46,000
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
Kerr-McGee Chemical Corp., Hamilton, MS	--	63,000
SCM Corp., Glidden Pigments Group:		
Ashtabula, OH	--	86,000
Baltimore, MD	66,000	46,000
Total	130,000	764,000

Table 6.—Components of U.S. titanium dioxide pigment supply and demand

(Short tons unless otherwise specified)

Component	1980 (gross weight)	1981 (gross weight)	1982 Gross weight	1982 TiO_2 content	1983 Gross weight	1983 TiO_2 content	1984 Gross weight	1984 TiO_2 content
Production	727,245	761,190	r659,710	r613,530	r760,385	r707,158	798,978	743,849
Shipments:[1]								
Quantity	731,546	778,116	707,075	662,487	813,958	762,818	905,383	844,901
Value thousands	$795,734	$947,881	$927,517	$927,517	$950,515	$950,515	$1,106,898	$1,106,898
Exports	42,126	61,104	72,823	66,280	91,702	r83,372	106,124	96,740
Imports for consumption	97,590	124,906	138,922	e130,309	174,857	e164,191	193,501	e181,891
Stocks, yearend	83,237	102,189	86,933	e81,543	77,465	e72,740	83,533	e78,521
Consumption, apparent[2]	753,480	806,040	r741,065	e692,074	r853,008	e796,780	880,287	e823,219

eEstimated. rRevised.
[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 titanium in concentrates consumed domestically increased about 10%, mainly because of higher TiO_2 pigment production. About one-half of the increase in consumption was in the form of rutile.

Metal.—Demand for titanium sponge improved appreciably, mainly because of increased orders for commercial and military aircraft, including the B-1B bomber. Mill product shipments were 56% in the form of billet; 31% sheet, strip, plate, tubing, pipe, extrusions, and other; and 13% rod and bar.

Bar and billet were the major forms used for aircraft engines and airframe forgings, 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. An important new factor in promoting new uses and expansion of established applications for titanium was the Titanium Development Association (TDA), which completed its first full year of operation in December. TDA accomplishments during the year included its first exhibit at the Society of Automotive Engineers Aerospace Congress and Exposition; development of an Information Service Hotline to quickly notify members of product and process inquiries; marketing and professional association surveys; and preparation of the first annual "Buyers Guide" on titanium.

Current use of titanium in large commercial transports represents 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 cases on various engines.[5] Major nonaerospace industrial uses are those requiring superior resistance to corrosion, such as surface condensers in powerplants, heat exchangers, and chemical industry equipment.

RMI Co. was investigating the possible use of titanium for valve trains in automobile engines and reported that much interest had been shown by U.S. and Japanese automobile manufacturers in this application. The company estimated that automotive valve trains could consume more than 500 tons of titanium per year. In a previous project, RMI had demonstrated that titanium suspension springs were 70% lighter than steel springs and performed just as well.

Pigment.—Consumption of TiO_2 pigments rose to a new peak for the second consecutive year, because of continued economic expansion and increased demand from the homebuilding industry. Notable changes were the increases in consumption for paints and plastics and the sharp decrease in consumption in paper. The latter has been attributed partly to increased use of calcined clay and calcium carbonate instead of TiO_2 by the paper industry.

Ferrotitanium.—Consumption of ferrotitanium scrap in steel and other alloys increased, mainly because of higher steel production.

Table 7.—U.S. consumption of titanium concentrates

(Short tons)

Year	Ilmenite[1]		Titanium slag		Rutile (natural and synthetic)	
	Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]	Gross weight	TiO_2 content[e]
1980	848,607	513,315	181,582	133,933	297,582	277,882
1981	856,116	511,022	252,826	186,020	[2]285,371	[2]266,596
1982	583,250	352,393	225,541	168,433	[2]238,937	[2]225,113
1983:						
Alloys and carbide	(3)	(3)	(4)	(4)	--	--
Pigments	723,044	468,279	166,401	127,267	[2]223,210	[2]210,949
Welding-rod coatings and fluxes	(3)	(3)	--	--	3,892	3,649
Miscellaneous[5]	7,534	6,006	--	--	38,456	35,820
Total	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	[2]245,927	[2]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

[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	1980	1981	1982	1983	1984
Paints, varnishes, lacquers	44.1	43.4	43.3	43.3	47.6
Paper	24.3	23.8	24.6	24.2	17.3
Plastics (except floor covering and vinyl-coated fabrics and textiles)	10.6	11.4	11.4	11.7	13.4
Rubber	2.1	2.2	2.3	1.6	1.7
Printing ink	2.8	1.3	.9	1.0	1.0
Ceramics	1.7	1.4	1.1	1.0	.9
Other	8.2	8.6	6.4	5.9	5.1
Exports	6.2	7.9	10.0	11.3	13.0
Total	100.0	100.0	100.0	100.0	100.0

Table 9.—U.S. consumption of titanium products[1] in steel and other alloys

(Short tons)

	1980	1981	1982	1983	1984
Carbon steel	423	641	420	744	659
Stainless and heat-resisting steel	1,620	1,552	1,289	1,748	1,851
Other alloy steel (includes HSLA)	848	903	664	749	677
Tool steel	W	W	W	W	W
Total steel[2]	2,891	3,096	2,373	3,241	3,187
Cast irons	102	63	47	38	62
Superalloys	1,053	645	409	535	622
Alloys, other than above	272	254	200	252	473
Miscellaneous and unspecified	13	26	10	12	18
Total consumption	4,331	4,084	3,039	4,078	4,362

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 decreased 34% from the yearend 1983 level, mainly because of a 128,000-ton reduction in ilmenite stocks. The high usage from stocks occurred despite increases in domestic production and imports of concentrates, reflecting the substantial increase in consumption.

Table 10.—U.S. stocks of titanium concentrates and pigment, December 31

(Short tons)

	Gross weight	TiO_2 content[e]
Ilmenite:[1]		
1982	742,644	470,776
1983[r]	398,884	254,237
1984	197,593	126,305
Titanium slag:[1]		
1982	135,765	103,667
1983	78,378	61,026
1984	83,281	64,842
Rutile:[1]		
1982	176,079	165,762
1983[r]	130,035	122,189
1984	104,724	98,648
Titanium pigment:[2]		
1982	86,993	NA
1983	77,465	NA
1984	83,533	NA

[e]Estimated. [r]Revised. NA Not available.
[1]Producer, consumer, and dealer stocks.
[2]Bureau of the Census. Producer stocks only.

PRICES

Concentrates.—Prices of titanium concentrates increased during the year because of the high demand for TiO_2 pigment.

Metal.—Titanium sponge list prices were unchanged but were discounted rather heavily early in the year, recovering appreciably by yearend.

Pigment.—Titanium dioxide pigment sale prices increased 5 cents per pound in the third quarter but were still about 5 cents per pound below published list prices at yearend.

Table 11.—Published prices of titanium concentrates and products

		1983[1]	1984[1]
Concentrates:			
Ilmenite, f.o.b. eastern U.S. ports	per long ton	$70.00-$75.00	$70.00-$75.00
Ilmenite, f.o.b. Australian ports	do	30.00- 34.00	36.00- 38.00
Ilmenite, large lots, bulk, f.o.b. Titen, FL	do	44.00- 45.00	44.00- 45.00
Rutile, f.o.b. eastern U.S. ports	per short ton	400.00-430.00	460.00-490.00
Rutile, bagged, f.o.b. Australian ports	do	267.00-284.00	339.00-359.00
Rutile, bulk, f.o.b. Australian ports	do	259.00-275.00	319.00-335.00
Rutile, large lots, bulk, f.o.b. Titen, FL	do	310.00	320.00-340.00
Synthetic rutile, f.o.b. Mobile, AL	do	350.00	350.00
Titanium slag, 74% TiO_2, f.o.b. Sorel, Quebec[2]	per long ton	162.00	--
Titanium, slag, 80% TiO_2, f.o.b. Sorel, Quebec	per metric ton	--	185.00
Titanium slag, 85% TiO_2, f.o.b. Richards Bay, Republic of South Africa[e]	do	[r]187.00-198.00	200.00
Metal:			
Sponge, reported sales	per pound	--	4.00- 4.25
Sponge, domestic, f.o.b. plant	do	5.55- 5.85	5.55- 5.85
Sponge, Japanese, under contract, c.i.f. U.S. ports, including import duty	do	No quotation	No quotation
Sponge, imported, spot price	do	No quotation	No quotation
Mill products:			
Bar	do	18.00	18.00
Billet	do	13.00	13.00
Plate	do	16.00	16.00
Sheet	do	18.00	18.00
Strip	do	17.00	17.00
Pigment:			
Titanium dioxide pigment, f.o.b. U.S. plants, anatase	do	.69	.69
Titanium dioxide pigment, f.o.b. U.S. plants, rutile	do	.75	.75

[e]Estimated. [r]Revised.
[1]Yearend.
[2]Slag from Sorel contained 74% and 80% TiO_2 in 1983 and 80% TiO_2 in 1984. Price shown is for 74% TiO_2 product in 1983 and 80% TiO_2 product in 1984.

FOREIGN TRADE

The upward trend in TiO_2 pigment exports and imports that began in 1981 continued in 1984. Substantial increases in imports of concentrates and most titanium metal categories occurred, following decreases in 1983.

Table 12.—U.S. exports of titanium products, by class

Class	1982		1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Concentrates:						
Ilmenite	19,230	$618	865	$26	3,807	$151
Rutile	2,452	661	3,526	980	4,844	1,784
Total[1]	21,682	1,280	4,391	1,006	8,651	1,936
Metal:						
Sponge	36	256	39	203	171	967
Other unwrought	173	1,218	258	1,896	204	1,224
Scrap	4,287	6,718	5,379	7,074	4,109	7,168
Ingots, billets, slabs, etc	2,196	60,240	1,371	29,232	2,071	40,993
Other wrought	1,404	40,368	783	22,965	778	20,509
Total	8,096	108,800	7,830	61,370	7,333	70,861
Pigment and oxides:						
Titanium dioxide pigments	72,823	77,657	91,702	86,900	106,124	97,804
Titanium compounds, except pigment-grade	1,299	4,411	1,819	5,232	2,123	5,024
Total	74,122	82,068	93,521	92,132	108,247	102,828

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

Table 13.—U.S. imports for consumption[1] of titanium concentrates, by country

Concentrate and country	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Ilmenite:						
Australia	342,279	$8,671	259,328	$9,262	409,605	$11,063
Germany, Federal Republic of[2]	24	2	--	--	--	--
Sri Lanka	6,063	92	--	--	--	--
Total	348,366	8,765	259,328	9,262	409,605	11,063
Titanium slag:						
Canada	201,168	24,908	127,691	18,533	160,155	25,081
South Africa, Republic of	45,685	7,348	11,016	1,628	49,685	7,702
Other	992	609	--	--	--	--
Total[3]	247,845	32,865	138,708	20,161	209,839	32,783
Rutile, natural:						
Australia	74,501	20,498	80,096	16,450	93,871	25,046
Canada[2]	--	--	--	--	219	55
Sierra Leone	53,308	13,200	--	--	48,436	13,326
South Africa, Republic of	11,320	2,431	10,817	3,365	15,939	2,674
Other	2	2	79	21	--	--
Total[3]	139,131	36,131	90,992	19,836	158,465	41,100
Rutile, synthetic:						
Australia	22,744	2,876	11,118	1,767	22,043	3,810
France	--	--	127	111	--	--
Japan	1,450	603	617	235	--	--
Taiwan	--	--	8,723	1,583	--	--
Total[3]	24,194	3,479	20,586	3,696	22,043	3,810
Titaniferous iron ore:[4]						
Canada	6,996	336	2,124	107	1,966	77

[1]Adjusted by the Bureau of Mines.
[2]Country of transshipment rather than country of production.
[3]Data may not add to totals shown because of independent rounding.
[4]Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel furnace flux.

Table 14.—U.S. imports for consumption of titanium dioxide pigments, by country

Country	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Australia	4,712	$4,850	5,591	$5,824	5,277	$5,398
Belgium-Luxembourg	4,731	4,902	14,456	11,287	10,840	9,824
Canada	21,912	25,135	25,563	27,396	26,212	29,388
Finland	4,026	4,176	4,829	4,678	6,079	5,954
France	20,862	22,726	31,195	30,032	47,801	45,107
Germany, Federal Republic of	37,506	37,432	36,659	35,804	34,980	34,156
Italy	297	318	1,223	1,082	1,078	1,032
Japan	5,266	6,084	4,888	4,870	4,546	4,900
Mexico	--	--	67	61	1,668	1,201
Norway	7,312	7,125	6,428	5,638	6,931	6,304
Spain	19,234	19,614	23,006	18,784	22,129	20,863
United Kingdom	12,014	13,266	19,761	19,135	22,847	20,857
Yugoslavia	506	494	155	115	2,597	1,447
Other[1]	544	446	[r]1,035	[r]788	518	520
Total[2]	138,922	146,569	174,857	165,495	193,501	186,952

[r]Revised.
[1]Includes Algeria, China, Denmark, Hong Kong, India, the Republic of Korea, Macao, the Netherlands, Poland, Sweden, and Switzerland.
[2]Data may not add to totals shown because of independent rounding.

Table 15.—U.S. imports for consumption of titanium metal, by class and country

Class and country	1982 Quantity (short tons)	1982 Value (thousands)	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Unwrought: Sponge						
Canada[1]	3	$32	--	--	--	--
China	24	287	1	$4	--	--
Japan	1,283	16,753	976	6,761	[2]2,662	$15,789
U.S.S.R	44	160	193	913	--	--
United Kingdom	--	--	30	177	[2]5	26
Total[3]	1,354	17,232	1,199	7,856	[2]2,667	15,815
Ingot and billet:						
Austria	20	194	--	--	--	--
Canada	35	634	7	102	6	62
China	([4])	1	--	--	([4])	1
France	--	--	--	--	38	162
Germany, Federal Republic of	6	134	19	405	30	561
Japan	66	1,154	44	546	77	1,327
U.S.S.R	13	182	4	38	--	--
United Kingdom	71	1,260	6	133	26	328
Other	([4])	2	([4])	4	([4])	5
Total[3]	212	3,560	81	1,228	176	2,447
Waste and scrap:						
Austria	--	--	39	55	217	390
Belgium	63	62	66	89	28	11
Canada	195	698	451	2,240	190	320
China	17	88	22	19	68	168
France	31	106	62	95	149	451
Germany, Federal Republic of	72	261	166	365	294	851
Japan	48	191	44	130	117	522
Sweden	69	197	90	168	100	301
Switzerland	--	--	117	184	--	--
U.S.S.R	280	516	--	--	90	270
United Kingdom	475	1,489	463	1,036	544	2,215
Other	26	41	52	80	53	202
Total[3]	1,277	3,648	1,572	4,461	1,850	5,703
Wrought titanium:						
Canada	469	7,549	317	5,219	212	3,701
China	5	279	--	--	--	--
Germany, Federal Republic of	([4])	24	([4])	2	6	140
Japan	367	7,495	605	8,842	529	6,091
United Kingdom	16	695	8	258	68	1,130
Other	12	199	5	33	25	441
Total[3]	870	16,240	935	14,354	840	11,504

[1]Country of transshipment rather than country of origin.
[2]Excludes sponge imported by GSA for the national stockpile.
[3]Data may not add to totals shown because of independent rounding.
[4]Less than 1/2 unit.

WORLD REVIEW

World production of titanium concentrates increased because of rising TiO_2 pigment production and demand. Prices of concentrates and pigment increased, reflecting the high demand.

Titanium sponge metal production in the market economy countries increased about 60% to an estimated 44,000 tons, reflecting improved demand in both aerospace and other industrial applications.

Australia.—Australia continued to be the largest producer of titanium minerals with exports of ilmenite, in order of decreasing volume, to the United States, Japan, the United Kingdom, Spain, the U.S.S.R., and France, and exports of rutile mainly to the United States, the United Kingdom, the Netherlands, and Japan.

Consolidated Rutile Ltd. was expected to complete a $27 million expansion of its mineral sands operations on North Stradbroke Island, Queensland, before the original target date of June 1985. Total annual production capacity was expected to increase about 75% to about 96,000 tons of rutile and 70,000 tons of zircon.

Westralian Sands Ltd. announced plans for a $57 million synthetic rutile plant at Capel, Western Australia, to process 200,000 tons of ilmenite into 110,000 tons of synthetic rutile. The project was to be in partnership with Tioxide Group PLC., United Kingdom, and Ishihara Sangyo Kaisha, Japan.

Brazil.—Cia. Vale do Rio Doce authorized construction of a new facility for production of anatase concentrates. The plant was to have a capacity of 220,000 tons per year (TiO_2 content) and supply a TiO_2 pigment plant in the State of Minas Gerais. These plans followed the successful results obtained from the company's titanium concentrates pilot plant at Tapira, Minas Gerais, which had a capacity of 15,000 tons per year of concentrates containing 90% TiO_2.[6]

Italy.—In September, the Tioxide Group, United Kingdom, agreed to buy for about $31 million Montedison S.p.A.'s Sibit subsidiary, Italy's only TiO_2 producer, at Scarlino. This acquisition will raise Tioxide's annual capacity from 385,000 tons to about 455,000 tons.

Japan.—Showa Titanium Co. Ltd. reportedly increased its sponge output gradually to about 80% of its 2,200 tons per year capacity by midyear. Japan's three other producers, Osaka Titanium, Toho Titanium, and Nippon Soda, operated at somewhat lower proportions of their annual capacities, which were approximately as follows: Osaka Titanium, 20,000 tons; Toho Titanium, 13,200 tons; and Nippon Soda, 2,400 tons. Total Japanese sponge capacity was 37,800 tons, and 1984 sponge production was 16,938 tons, 46% higher than in 1983.

Nippon Steel was to begin production of titanium mill products in late 1984. The company was to obtain 55 tons of titanium ingot per month from Toho Titanium for conversion into billet, sheet, and tube at various Nippon Steel plants.

Sumitomo Metal Industries Ltd. was preparing to produce titanium alloy bars, using feedstock from Osaka Titanium. The company planned to produce about 60 tons per month of small- and large-diameter bars, mainly for the domestic market.

Norway.—Allis Chalmers Corp. announced receipt of a $28 million order from the Engineering Div. of Elkem A/S for a pelletizing-reduction (Grate-Car) system to prereduce 350,000 tons per year of ilmenite concentrate. This system will be part of a plant that Elkem is building for K/S Ilmenittsmelteverket A/S in Tyssedal, to be completed in 1986. The Grate-Car reduction product will be smelted in an Elkem electric furnace to produce about 220,000 tons per year of 75% TiO_2 slag product for TiO_2 pigment manufacture and 120,000 tons per year of byproduct pig iron. The ilmenite concentrate for the process is to be supplied by the Titania A/S Tellnes Mine near Hauge-i Dalane in Rogaland County.

Sierra Leone.—Following resumption of operations in 1983 under 100% Nord Resources Corp. ownership, Sierra Rutile Ltd. (SRL) became the world's single largest producer of natural rutile. In 1984, SRL's production amounted to over 90% of its nominal 110,000 tons per year capacity. Maximum production before 1983 was about 56,000 tons per year.[7]

Sri Lanka.—The Ceylon Mineral Sands Corp. (CMSC) was planning to install a wet gravity and magnetic separation plant at Pulmoddai that would increase ilmenite production by an additional 16,500 tons per year.[8] CMSC was also reportedly planning to establish a joint venture to convert ilmenite stocks into synthetic rutile.[9]

U.S.S.R.—Production of titanium sponge metal was estimated to be 46,000 tons. Annual production capacity was estimated to be about 52,000 tons. Imports of ilmenite from Australia were 114,000 tons, about the same as in 1983, indicating some shortage of domestic titanium concentrates.

United Kingdom.—Production of sponge granules by Deeside Titanium Ltd. was estimated to be about 55% of its 5,500 tons per year capacity. Higher output of titanium was being encouraged by increased use by British Aerospace PLC of superplastic forming and diffusion bonding to fabricate structures that can save as much as 40% in weight and 50% in costs and account for up to 18% of an aircraft's structural weight.[10]

In September, SCM Corp. completed the acquisition of Laporte Industries Ltd.'s TiO_2 plants at Stallingborough, England, and Bunbury, Australia, for about $125 million, increasing SCM's total capacity by about 60% to 300,000 tons per year. SCM planned to increase the annual capacity of the Stallingborough plant from 80,000 to 96,000 tons, within about 18 months.

A proposal by the Commission of the European Communities to establish uniform maximum emissions standards for discharges to water or air of waste from TiO_2

production was rejected by the United Kingdom House of Lords. A report by the House of Lords Select Committee on the European Communities concluded that as far as the United Kingdom is concerned, special provisions for the TiO_2 industry are not necessary or desirable, stating that the two Humberside TiO_2 plants have been discharging wastes into tidal waters continuously for 30 years with no observable effects on fish stocks in the river. The report gives industry estimates that complying with the Commission's draft directive would increase the cost of TiO_2 by 10% to 15%, making European Economic Community producers uncompetitive in the world market.[11]

Table 16.—Titanium: World production of concentrates (ilmenite, leucoxene, rutile, and titaniferous slag), by country[1]

(Short tons)

Concentrate type and country	1980	1981	1982	1983[p]	1984[e]
Ilmenite and leucoxene:[2]					
Australia:					
Ilmenite	[r]1,526,217	1,456,303	1,266,788	983,889	1,210,220
Leucoxene	26,393	21,232	21,758	14,330	21,000
Brazil	18,562	[r]21,924	14,530	53,124	55,000
China[e]	NA	150,000	150,000	154,000	154,000
Finland	175,267	178,023	184,968	180,669	184,000
India[3]	185,078	179,141	168,543	[e]165,000	165,000
Malaysia[4]	208,470	190,432	111,556	245,509	215,000
Norway	912,508	724,907	608,215	599,919	606,000
Portugal	258	368	322	272	275
Sri Lanka	37,430	88,197	75,268	90,145	88,000
U.S.S.R.[e]	460,000	470,000	475,000	480,000	485,000
United States[5]	556,646	542,357	263,391	W	W
Total	[r]4,106,829	[r]4,022,884	3,340,339	2,966,857	3,183,495
Rutile:					
Australia	343,639	254,432	243,277	180,089	200,183
Brazil	472	[r]226	248	1,166	1,200
India[3]	5,908	7,397	7,385	[e]7,700	7,700
Sierra Leone[6]	52,356	55,992	52,590	79,146	100,600
South Africa, Republic of[e]	53,000	55,000	52,000	62,000	62,000
Sri Lanka	14,097	14,662	7,950	9,814	8,800
U.S.S.R.[e]	11,000	11,000	11,000	11,000	11,000
United States	W	W	W	W	W
Total	480,472	[r]398,709	374,450	350,915	391,483
Titaniferous slag:					
Canada[7]	[r]934,439	836,864	737,445	700,000	800,000
South Africa, Republic of[e] [8]	379,000	408,000	420,000	[r]460,000	460,000
Total	[r]1,313,439	1,244,864	1,157,445	1,160,000	1,260,000

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1]Table excludes production of unbeneficiated anatase ore in Brazil, in short tons, as follows: 1980—not available; 1981—3,208,185; 1982—3,136,054; 1983—2,610,028; and 1984—3,030,000 (estimated). This material reportedly contains 20% TiO_2. Table includes data available through June 18, 1985.

[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 1980-82, 74% TiO_2 in 1983, and 80% TiO_2 in 1984.

[8]Contains 85% TiO_2.

TECHNOLOGY

The Bureau of Mines evaluated the international availability of titanium from market economy countries.[12] The study concluded that rutile shortages could be alleviated by production from other high-grade titanium resources such as higher cost rutile deposits and anatase deposits, or through an increase in world synthetic rutile capacity. The Bureau also investigated the occurrence and recovery of byproduct gold and heavy minerals such as ilmenite and rutile from west coast sand and gravel operations. Heavy mineral concentrates were prepared from sand samples from 150 locations, and individual titanium minerals and other products were prepared from selected concentrates.[13] Other Bureau of Mines research was reported on the smelting of a domestic rock ilmenite in an electric furnace with coke, woodchips, and sodium carbonate to separate most of the iron as pig iron and produce a low-iron, titanium-enriched slag. The slag was upgraded by sulfation with SO_2 and air at 750° to 950° C, followed by leaching in water to decrease to tolerable levels the calcium, magnesium, and manganese impurities that cause trouble in fluid bed chlorination of titanium concentrates.[14] The Bureau also conducted studies to provide data on the mechanical properties of Ti-6Al-4V alloy cast in waterglass-bonded zircon sand and to determine the effect of hot isostatic pressing (HIP) on these properties. The room temperature data on the cast and annealed alloy compared favorably with published values for investment-cast Ti-6Al-4V alloy. The HIP process healed the internal casting porosity in the test specimens, but the fatigue strength was not significantly improved.[15]

A study was made of the Yulee heavy minerals sand deposits of northeastern Florida, which contain about 800,000 tons of TiO_2 in ilmenite, leucoxene, and rutile. A comparison with the Trail Ridge, FL, ore body led to the conclusion that concentration of the Yulee heavy minerals was the result of normal reworking and sorting of sediments, but for the Trail Ridge deposits, a high energy environment, perhaps dominated by waves, wind, and storms, seemed logical.[16]

The Fifth International Conference on Titanium was held at Munich, Federal Republic of Germany, September 10 through 14, 1984, and was attended by about 600 representatives from over 20 countries. The conference program covered a wide range of topics including metal production and melting, scrap handling, physical properties, forming and joining, heat treatment, powder metallurgy, and applications. Producers were optimistic that demand would continue to improve, particularly in view of reports of increased rates of ordering for commercial aircraft, but this optimism was tempered by the observation that demand for other industrial applications was growing rather slowly. New technological developments reported on included new alloys with higher strength and/or easier formability, optimizing alloy properties by improved heat treatment routines, and new melting and forming techniques.[17]

Discussion on titanium extraction metallurgy centered around the possibility of reducing the cost of titanium production by replacing the currently used Hunter or Kroll processes, perhaps by going directly from the ore, or beneficiated ore, to a prealloyed powder suitable for use in demanding applications. It was concluded that a number of possibilities exist for production of low-cost prealloyed titanium powder directly from titanium compounds such as TiO_2, $TiCl_4$, and sodium fluotitanate (Na_2TiF_6). However, technical problems remain to be solved before a homogeneous alloy powder can be produced in quantity.[18]

A symposium on titanium net-shape technologies was held at the annual meeting of the American Institute of Mining, Metallurgical, and Petroleum Engineers in February. Subjects discussed included precision casting, isothermal forging, and powder metallurgy (PM).[19] A review article on titanium PM discussed PM parts and processes currently in production and possible future applications.[20]

Rapid solidification of titanium alloys by an arc plasma melt spinning technique was reviewed, and the advantages of a devitrified titanium alloy (one that has been quenched to an amorphous state and is subsequently crystallized by heat treatment) were discussed. Preliminary results on some mechanical and microstructural properties of rapidly solidified (RS) titanium alloys appear promising. Among the areas critical to the development of RS titanium alloys is the ability to consolidate such alloys into bulk form and to retain the enhanced mechanical properties.[21]

Other technological areas of titanium metallurgy that were reported included development of high-temperature titanium alloys for use in gas turbine engines, airframes, and other applications;[22] melting of titanium by various methods;[23] advances in welding technology;[24] corrosion behavior in a wide range of applications;[25] developments in titanium metal matrix applications;[26] nonrutile feed materials for producing titanium;[27] and the history of titanium tubing development.[28] The threat of substitution of competing materials, especially nonmetallic composites, was examined, and it was concluded that direct competition with titanium in primary load bearing aircraft components is unlikely. These nonmetallic composites have been replacing aluminum, which in turn creates a demand for titanium fasteners.[29]

General Electric Co.'s Aircraft Engine Business Group, Lynn, MA, reportedly planned to use a new graphite polyimide composite for an outer compressor duct, currently made of titanium, in its F404 engine. The composite duct was said to provide the same strength as titanium, withstanding temperatures up to 550° F, and would weigh 15% less and offer considerable cost savings.[30] At another location, General Electric's Evandale, OH, jet engine plant was conducting Air Force-sponsored research to develop high-temperature RS titanium alloys intended to replace superalloys in jet engine parts. The target temperature of these alloys would be 1,300° F, compared with a 950° to 1,000° F upper limit for currently used titanium alloys.[31]

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[1]Physical scientist, Division of Nonferrous Metals.

[2]Mineral data assistant, Division of Nonferrous Metals.

[3]Weight units used in this chapter are short tons unless otherwise specified.

[4]U.S. International Trade Commission. Titanium Sponge From Japan and the United Kingdom. USITC Pub. 1600, Nov. 1984, 80 pp.

[5]Titanium Development Association (Dayton, OH). Titanium in Aerospace. 1984, 8 pp.

[6]Industrial Minerals (London). A New Anatase Facility. No. 203, Aug. 1984, pp. 9-10.

[7]Steinberger, R. L., and S. Y. Katz. The Emergence of Sierra Rutile—Perspective From Producer and Trader. Paper in Proceedings of 6th Industrial Minerals International Congress (Toronto, Canada, May 21-25, 1984). Met. Bull. Conf. Ltd. (London), pp. RLS1-RLS8.

[8]Wijesekera, N. Mineral Exploration in Sri Lanka. Min. Mag., v. 150, No. 5, May 1984, pp. 464-467.

[9]Luther, C. J. Mineral Development in Sri. Lanka. State Dep. Airgram A-38, Aug. 22, 1984, 4 pp.

[10]Salak, J. British Aerospace Ups Its Commercial Output for New Titanium Alloy. Am. Met. Mark., v. 92, No. 224, Nov. 16, 1984, pp. 1, 8.

[11]European Chemical News. U.K. House of Lords Criticizes EEC Titanium Dioxide Plans. V. 42, No. 1122, Mar. 12, 1984.

[12]Fantel, R. J., D. A. Buckingham, and D. E. Sullivan. The Impact of Diminishing Rutile Resources on Titanium Production and Costs (Soc. Min. Eng. AIME 113th Annu. Meeting, Los Angeles, CA, Feb. 26-Mar. 2, 1984). Soc. Min. Eng. AIME preprint 84-109, 1984, 11 pp.

[13]Gomes, J. Black Sand Survey Along the Pacific Coast. Paper in 5th Annual Conference on Alaskan Placer Mining (sponsored by the Univ. of AK, Fairbanks, AK, Mar. 30-31, 1983), comp. and ed. by B. W. Campbell, J. Madonna, and M. S. Husted. Miner. Ind. Res. Lab. Rep. No. 68, 1983, pp. 49-52.

[14]Wright, J. B., G. W. Elger, J. E. Tress, and H. E. Bell. Chlorination-Grade Feedstock From Domestic Ilmenite (Soc. Min. Eng. AIME Fall Meeting, Denver, CO, Oct. 24-26, 1984). Soc. Min. Eng. preprint 84-379, 1984, 13 pp.

[15]Paige, J. T., P. G. Clites, and J. L. Henry. Ti-6Al-4V Alloy Castings Prepared in Zircon Sand Molds and the Effect of Hot Isostatic Pressing. BuMines RI 8897, 1984, 16 pp.

[16]Pirkle, E. C., F. L. Pirkle, W. A. Pirkle, and P. R. Stayert. The Yulee Heavy Mineral Sand Deposits of Northeastern Florida. Econ. Geol., v. 79, No. 4, 1984, pp. 725-737.

[17]Lutjering, G., U. Zwicker, and W. Bunk (eds.) Titanium '84. Proc. of DGM Informationsgesellschaft mbH, Adenauerallee 21, D-6370 Oberursel, Federal Republic of Germany, 4 v., 3,500 pp.

[18]Hayes, F. H., H. B. Bomberger, F. H. Froes, L. Kaufman, and H. M. Burte. Advances in Titanium Extractive Metallurgy. J. Met., v. 36, No. 6, June 1984, pp. 70-76.

[19]Eylon, D., and F. H. Froes. Titanium Net-Shape Technologies. Conference Review. J. Met., v. 36, No. 6, June 1984, pp. 36-41.

[20]Parsons, L., J. Bruce, J. Lane, and F. H. Froes. Titanium P/M Comes of Age. Met. Prog., v. 126, No. 4, Sept. 1984, pp. 83-94.

[21]Whang, S. H. Rapidly Solidified Ti Alloys Containing Novel Additives. J. Met., v. 36, No. 4, Apr. 1984, pp. 34-40.

[22]Eylon, D., S. Fujishiro, P. J. Postans, and F. H. Froes. High Temperature Titanium Alloys—A Review. J. Met., v. 36, No. 11, Nov. 1984, pp. 55-61.

[23]Bomberger, H. B., and F. H. Froes. The Melting of Titanium. J. Met., v. 36, No. 12, Dec. 1984, pp. 39-47.

[24]Baeslack, W. A., III, D. W. Becker, and F. H. Froes. Advances in Titanium Alloy Welding Technology. J. Met., v. 36, No. 5, May 1984, pp. 46-58.

[25]Myers, J. R., H. B. Bomberger, and F. H. Froes. Corrosion Behavior and Use of Titanium and Its Alloys. J. Met., v. 36, No. 10, Oct. 1984, pp. 50-60.

[26]Smith, P. R., and F. H. Froes. Developments in Titanium Metal Matrix Composites. J. Met., v. 36, No. 3, Mar. 1984, pp. 19-26.

[27]Kahn, J. A. Non-Rutile Feedstocks for the Production of Titanium. J. Met., v. 36, No. 7, July 1984, pp. 33-38.

[28]McCue, D. Titanium Tubing: 1964-84. Met. Bull. Monthly Supplement, No. 163, July 1984, pp. 5-7.

[29]Goodwill, J. The Threat of Substitution. Am. Met. Mark., Titanium Supplement, v. 92, No. 100, June 15, 1984, pp. 17A, 27A.

[30]Kingman, N. GE Planning Composite Engine Compressor Duct. Am. Met. Mark., v. 92, No. 186, Sept. 24, 1984, p. 19.

[31]———. RS Titanium Alloys for Jet Engines Researched by GE. Am. Met. Mark., v. 92, No. 132, July 9, 1984, p. 8.

Tungsten

By Philip T. Stafford[1]

Consumption of tungsten increased to a record-high level, 66% more than that of 1983, and imports were at their highest level since 1956. Mine shipments increased 15% from those of 1983, but still remained lower than those of any year since 1934. Tungsten concentrate prices remained at a relatively low level increasing only slightly from those of 1983.

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.

A 21-year deadlock between tungsten producing and consuming countries continued, as no agreement was reached at the 1984 Geneva conference on stabilization of the world tungsten market.

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 the "Tungsten Ore and Concentrate," "Tungsten Concentrate and Tungsten Products," and "Tungsten Concentrate." Of the 44 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)

	1980	1981	1982	1983	1984
United States:					
Concentrate:					
Mine production	2,754	3,605	1,521	980	1,203
Mine shipments	2,738	3,545	1,575	1,016	1,173
Value thousands	$50,575	$62,231	$22,062	$10,528	$13,409
Consumption	9,268	9,839	4,506	5,181	8,577
Shipments from Government stocks	1,703	958	344	259	1,368
Exports	920	79	305	1	129
Imports for consumption	5,158	5,331	3,528	2,861	5,807
Stocks, Dec. 31:					
Producer	48	108	54	47	46
Consumer	601	671	1,765	1,085	959
Ammonium paratungstate:					
Production	7,664	8,855	4,914	5,021	7,339
Consumption	8,430	9,165	5,873	5,655	8,808
Stocks, Dec. 31: Producer and consumer	438	699	748	970	1,191
Primary products:					
Production	9,134	9,960	6,441	6,020	9,799
Consumption	9,163	9,613	6,349	6,523	10,216
Stocks, Dec. 31:					
Producer	1,598	1,472	1,477	1,433	1,850
Consumer	1,075	936	933	1,446	1,585
World: Concentrate:					
Production	[r]51,985	[r]49,088	45,686	[p]39,430	[e]44,939
Consumption	[r]47,070	[r]47,104	40,135	[p]40,275	[e]47,180

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

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 1,486,006 kilograms of tungsten, of which 1,233,951 kilograms was for domestic use and 252,055 kilograms was for export.

Actual shipment of excess concentrate from the stockpile totaled 1,367,770 kilograms of tungsten content in concentrate.

Stockpile goals in effect remained as established in May 1980 by the Federal Emergency Management Agency.

Table 2.—U.S. Government tungsten stockpile material inventories and goals

(Metric tons of tungsten content)

Material	Goals	Inventory by program, Dec. 31, 1984: National stockpile	DPA[1] inventory	Total
Tungsten concentrate:				
Stockpile grade	25,152	25,012	72	25,084
Nonstockpile grade	--	12,369	83	12,452
Total	25,152	37,381	155	37,536
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 increased 23% and 15%, respectively, compared with those of 1983. Production totaled 1,203 metric tons of tungsten content in 1984, and shipments totaled 1,173 tons, the smallest amounts since 1934, except for 1983. Although eight mines in four 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 Teledyne Inc., near North Fork, CA, in Madera County, produced tungsten concentrate except during the winter, when it was closed owing to weather conditions.

Normally the largest producer, the Pine Creek Mine and APT plant of Umetco Minerals Corp., a subsidiary of Union Carbide Corp. (UCC), situated near Bishop, CA, was closed or operated at a reduced capacity at various times during the year.

The Climax Mine and mill of Climax Molybdenum Co., a division of AMAX Inc., at Climax, CO, was closed until mid-April, after which it was operated at one-half capacity through yearend. The Climax Mine, in Lake County, principally produces molybdenum.

Two major operations were closed throughout the year: Emerson Mine and mill of UCC, at Tempiute, NV, in Lincoln County and the Springer Mine, mill, and APT plant of General Electric Co., near Imlay, NV, in Pershing County.

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
1980	345,239	2,738	$50,575	$146.49	$18.47
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

[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 1984

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.
Li Tungsten Corp	Glen Cove, NY.
North American Phillips Lighting Corp	Bloomfield, NJ.
Teledyne Firth Stirling	Pittsburgh, PA.
Teledyne Wah Chang Huntsville	Huntsville, AL.

CONSUMPTION

Domestic consumption of tungsten in primary products increased 57% to a record-high level. The major end use, 63% of the total, continued to be in cutting and wear-resistant materials, primarily as tungsten carbide. Other end uses were mill products, 20%; specialty steels, 6%; and miscellaneous, including superalloys, hard-facing rods, chemicals, catalysts, and other tungsten materials, 11%.

Consumption of tungsten products used directly to make end-use items was distributed as follows: tungsten carbide, 64%; tungsten metal powder, 24%; scheelite, 4%; tungsten scrap, 3%; ferrotungsten, 3%; and other, 3%.

Table 5.—Production, disposition, and stocks of tungsten products in the United States in 1984

(Metric tons of tungsten content)

	Hydrogen-reduced metal powder	Tungsten carbide powder: Made from metal powder	Tungsten carbide powder: Crushed and crystalline	Chemicals	Other[1]	Total
Gross production during year	8,643	5,452	973	2,888	70	18,026
Used to make other products listed here	5,452	9	131	2,635	--	8,227
Net production	3,191	5,443	842	253	70	9,799
Producer stocks, Dec. 31	835	531	355	122	7	1,850

[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 1984, 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	48	--	--	33	W	--	81
Alloy	38	--	--	W	--	--	38
Tool	177	--	--	324	W	15	516
Superalloys	W	W	--	W	W	5	5
Alloys (excludes steels and superalloys):							
Cutting and wear-resistant materials	--	W	6,385	--	W	1	6,386
Other alloys[3]	W	24	W	--	8	--	32
Mill products made from metal powder	--	2,036	W	--	--	--	2,036
Chemical and ceramic uses	--	--	--	--	--	139	139
Miscellaneous and unspecified	17	341	121	96	305	103	983
Total	280	2,401	6,506	453	313	263	10,216
Consumer stocks, Dec. 31, 1984	37	137	1,227	51	51	82	1,585

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, increased 10% to $90.63 per metric ton unit of WO_3, compared with the 1983 value. Excess tungsten concentrate was purchased from GSA during the year at prices ranging from $67.02 to $90.78 per metric ton unit for domestic use and from $63.93 to $97.80 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 1984, prices increased 1%, compared with those for 1983.

Prices for intermediate products were not announced because of their competitiveness.

Table 7.—Monthly price quotations of tungsten concentrate in 1984

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	(1)	(1)	(1)	(1)	72.38	76.88	74.63	67.70	69.38	74.75	72.06	79.44	75.69	68.66
February	(1)	(1)	(1)	(1)	74.38	78.38	76.38	69.29	69.63	76.00	72.81	80.26	75.28	68.29
March	(1)	(1)	(1)	(1)	79.89	83.11	81.50	73.94	74.20	79.20	76.70	84.55	77.09	69.93
April	(1)	(1)	(1)	(1)	83.57	86.57	85.07	77.18	78.00	80.50	79.25	87.36	82.85	75.16
May	90.88	94.63	92.75	84.14	85.00	88.50	86.75	78.70	79.00	85.00	82.00	90.39	83.74	75.97
June	93.89	97.56	95.72	86.84	84.67	88.78	86.72	78.67	78.00	87.20	82.60	91.05	85.23	77.32
July	97.78	100.89	99.33	90.11	79.56	83.00	81.28	73.73	73.50	89.50	81.50	89.84	87.75	79.61
August	95.88	99.25	97.56	88.51	77.88	80.88	79.38	72.01	71.00	88.40	79.70	87.85	86.07	78.08
September	92.13	96.38	94.25	85.50	82.75	85.50	84.13	76.32	76.00	88.00	82.00	90.39	85.38	77.46
October	86.44	89.78	88.11	79.93	83.11	85.89	84.50	76.66	77.25	87.25	82.25	90.67	86.36	78.34
November	85.00	87.00	86.00	78.02	78.00	81.22	79.61	72.22	72.00	79.20	75.60	83.33	84.59	76.74
December	82.00	84.57	83.29	75.55	71.43	76.71	74.07	67.20	65.50	73.00	69.25	76.34	82.84	75.15

[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 $92.27 for May-December 1984. The average equivalent price per short ton unit of WO_3 was $83.70 for May-December. Scheelite prices were not reported prior to May 1984.

[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 $81.28 for 1984. The average equivalent price per short ton unit of WO_3 was $73.73 for 1984.

[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 $77.18 for 1984. The average equivalent price per metric ton unit of WO_3 was $85.08 for 1984.

[4]Weighted average price per metric ton unit of WO_3 was $82.75 for 1984. The equivalent weighted average price per short ton unit of WO_3 was $75.07 for 1984.

FOREIGN TRADE

Exports of tungsten in concentrate and primary products increased 78% from 953 tons in 1983 to 1,700 tons in 1984. Imports increased 98% from 4,091 tons in 1983 to 8,092 tons in 1984. This quantity was the largest since 1956, when purchases of concentrate for the Government stockpile were made under contracts still in effect from the Korean war.

Table 8.—U.S. exports of tungsten ore and concentrate, by country

	1983		1984	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Austria	--	--	29	$279
Brazil	--	--	25	161
Canada	(1)	$3	--	--
France	--	--	6	93
Germany, Federal Republic of	1	7	48	571
Ireland	--	--	(1)	3
Mexico	--	--	21	133
Saudi Arabia	(1)	1	--	--
Total	1	11	129	1,240

[1]Less than 1/2 unit.

Table 9.—U.S. exports of ammonium paratungstate, by country

Country	1983			1984		
	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)	(2)	(2)	(2)	$1
Belgium-Luxembourg	(2)	(2)	$2	--	--	--
Canada	--	--	--	3	2	39
France	2	2	12	2	1	9
Germany, Federal Republic of	6	4	44	1	1	9
Japan	--	--	--	(2)	(2)	5
Korea, Republic of	(2)	(2)	3	--	--	--
South Africa, Republic of	--	--	--	5	4	56
Total	8	6	61	11	8	119

[1]Tungsten content estimated by multiplying gross weight by 0.7066.
[2]Less than 1/2 unit.

Table 10.—U.S. exports of tungsten carbide powder, by country

Country	1983		1984	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Argentina	5	$143	8	$285
Australia	(1)	2	2	161
Austria	19	505	48	973
Belgium-Luxembourg	4	146	15	396
Brazil	10	258	7	198
Canada	113	2,771	121	2,671
Denmark	--	--	8	205
Finland	5	63	1	27
France	5	126	(1)	3

See footnotes at end of table.

Table 10.—U.S. exports of tungsten carbide powder, by country —Continued

Country	1983		1984	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Germany, Federal Republic of	33	$798	38	$902
India	3	167	1	48
Ireland	2	491	11	1,185
Italy	19	796	48	1,715
Japan	16	504	61	1,193
Mexico	9	378	14	439
Netherlands	7	402	6	367
Peru	2	30	--	--
Philippines	1	21	6	18
Singapore	3	47	2	47
South Africa, Republic of	2	37	--	--
Sweden	2	41	(1)	1
United Kingdom	67	1,432	49	1,496
Venezuela	2	56	2	54
Other	r1	r63	(1)	31
Total	330	9,277	448	12,415

rRevised.
1Less than 1/2 unit.

Table 11.—U.S. exports of tungsten and tungsten alloy powder, by country

Country	1983			1984		
	Gross weight (metric tons)	Tungsten content[1] (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content[1] (metric tons)	Value (thousands)
Argentina	(2)	(2)	$4	2	1	$43
Australia	(2)	(2)	10	7	6	121
Austria	(2)	(2)	2	23	19	400
Belgium-Luxembourg	1	1	11	5	4	109
Brazil	1	1	29	3	2	67
Canada	20	16	417	20	16	497
China	--	--	--	1	1	21
Finland	11	8	194	4	3	69
France	2	1	49	(2)	(2)	8
Germany, Federal Republic of	53	42	1,526	98	78	2,471
Ireland	--	--	--	4	3	104
Israel	94	75	2,010	520	416	8,880
Italy	2	2	41	(2)	(2)	1
Japan	12	10	414	61	49	1,834
Korea, Republic of	(2)	(2)	6	1	1	23
Mexico	2	2	57	2	2	56
Netherlands	229	183	2,426	242	193	2,218
Singapore	(2)	(2)	17	3	3	64
Sweden	5	4	120	--	--	--
Switzerland	7	6	179	1	1	62
Turkey	3	2	87	--	--	--
United Kingdom	2	2	65	23	18	279
Other	r1	r1	r28	(2)	(2)	2
Total	445	356	7,692	1,020	816	17,329

rRevised.
1Tungsten content estimated by multiplying gross weight by 0.80.
2Less than 1/2 unit.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials

Product and country	1983 Tungsten content (metric tons)	1983 Value (thousands)	1984 Tungsten content (metric tons)	1984 Value (thousands)
Tungsten and tungsten alloy wire:				
Argentina	1	$412	1	$369
Brazil	6	1,083	7	1,161
Canada	19	3,510	19	3,179
France	2	375	2	356
Germany, Federal Republic of	4	1,302	7	1,462
Hong Kong	1	100	1	108
India	1	101	3	261
Italy	3	496	2	431
Japan	6	1,071	9	1,229
Korea, Republic of	1	223	2	297
Mexico	4	497	10	1,258
Poland	2	172	3	201
Taiwan	(1)	60	1	155
U.S.S.R.	4	279	6	446
United Kingdom	3	661	2	505
Venezuela	1	582	(1)	243
Other	r2	r937	2	776
Total	60	11,861	77	12,437
Unwrought tungsten and alloy in crude form, waste, and scrap:				
Australia	(1)	5	7	55
Austria	9	46	77	347
Belgium-Luxembourg	--	--	128	1,106
Brazil	1	51	(1)	15
Canada	22	368	28	422
Finland	--	--	1	19
Germany, Federal Republic of	206	1,640	219	1,611
Ireland	--	--	1	30
Israel	--	--	50	987
Italy	1	19	7	130
Japan	14	140	--	--
Mexico	--	--	1	11
Netherlands	--	--	28	227
Saudi Arabia	--	--	1	14
South Africa, Republic of	13	147	26	602
Sweden	5	58	2	20
United Kingdom	7	72	29	296
Other	1	r24	1	7
Total	279	2,570	606	5,899
Other tungsten metal:				
Australia	1	90	2	202
Austria	--	--	1	17
Canada	24	1,236	28	1,692
France	3	403	5	626
Germany, Federal Republic of	18	749	30	1,178
Italy	4	298	2	227
Japan	11	1,447	10	1,679
Mexico	5	326	3	260
Singapore	(1)	4	3	106
Sweden	--	--	1	49
Switzerland	5	238	6	305
Taiwan	1	234	2	150
United Kingdom	9	848	16	1,277
Venezuela	(1)	1	1	31
Other	r7	r486	2	309
Total	88	6,360	112	8,108

See footnotes at end of table.

Table 12.—U.S. exports of miscellaneous tungsten-bearing materials —Continued

Product and country	1983 Tungsten content (metric tons)	1983 Value (thousands)	1984 Tungsten content (metric tons)	1984 Value (thousands)
Other tungsten compounds:				
Australia	1	$11	(1)	$8
Austria	--	--	2	77
Belgium-Luxembourg	21	196	(1)	(1)
Brazil	12	141	2	34
Canada	7	264	8	280
France	3	101	6	152
Germany, Federal Republic of	7	175	4	78
Haiti	--	--	19	60
Hong Kong	1	15	(1)	16
Ireland	1	26	6	148
Israel	11	492	75	1,340
Italy	1	50	2	91
Japan	11	188	10	201
Korea, Republic of	6	27	(1)	2
Mexico	6	182	13	243
Netherlands	1	49	58	790
Singapore	10	360	11	323
Sweden	(1)	18	1	21
United Kingdom	104	319	1	25
Venezuela	(1)	11	1	24
Other	2	r73	1	64
Total	205	2,698	220	3,977

rRevised.
1Less than 1/2 unit.

Table 13.—U.S. imports for consumption of tungsten ore and concentrate, by country

Country	1983 Tungsten content (metric tons)	1983 Value (thousands)	1984 Tungsten content (metric tons)	1984 Value (thousands)
Argentina	5	$39	--	--
Australia	28	198	133	$1,166
Bolivia	662	6,299	1,302	12,694
Brazil	78	658	149	1,309
Burma	201	1,401	341	2,545
Canada	649	6,286	1,464	12,645
Chile	12	89	9	161
China	62	654	31	221
France	40	353	16	140
India	--	--	7	56
Japan	--	--	10	92
Korea, Republic of	117	846	16	98
Malaysia	6	50	25	214
Mexico	215	1,698	196	1,610
Peru	199	1,610	605	5,258
Portugal	339	3,524	606	5,504
Rwanda	--	--	6	55
Singapore	--	--	13	90
Spain	--	--	22	220
Sweden	26	179	--	--
Thailand	142	1,197	774	7,038
Turkey	53	426	51	422
United Kingdom	27	210	25	114
Zimbabwe	--	--	6	63
Total	2,861	25,717	5,807	51,715

Table 14.—U.S. imports for consumption of ammonium tungstate, by country

Country	1983		1984	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Australia	73	$942	44	$466
Austria	12	136	--	--
China	174	2,524	720	8,275
Germany, Federal Republic of	52	921	26	397
Hong Kong	--	--	24	235
Korea, Republic of	431	5,011	356	3,999
Netherlands	--	--	2	42
South Africa, Republic of	17	252	--	--
United Kingdom	3	18	(1)	(1)
Total	762	9,804	1,172	13,414

[1]Less than 1/2 unit.

Table 15.—U.S. imports for consumption of ferrotungsten, by country

Country	1983		1984	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Austria	25	$295	93	$1,135
Brazil	--	--	26	319
China	--	--	8	90
France	--	--	10	115
Germany, Federal Republic of	--	--	38	425
Netherlands	--	--	8	92
Portugal	19	257	65	803
Sweden	4	52	32	369
United Kingdom	--	--	5	72
Total	48	604	285	3,420

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials

Product and country	1983		1984	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Other metal-bearing materials in chief value of tungsten:				
Canada	(1)	$3	--	--
United Kingdom	6	23	--	--
Total	6	26	--	--
Waste and scrap containing not over 50% tungsten:				
Canada	(1)	4	1	$5
France	--	--	3	30
Portugal	--	--	9	44
United Kingdom	1	26	13	135
Other	(1)	r1	(1)	3
Total	1	r31	26	217

See footnotes at end of table.

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials —Continued

Product and country	1983 Tungsten content (metric tons)	1983 Value (thousands)	1984 Tungsten content (metric tons)	1984 Value (thousands)
Waste and scrap containing over 50% tungsten:				
Australia	--	--	2	$23
Belgium-Luxembourg	--	--	4	35
Canada	19	$167	35	359
China	--	--	18	206
Finland	1	32	--	--
France	7	49	14	148
Germany, Federal Republic of	26	284	240	2,526
Israel	218	2,791	496	5,716
Japan	18	254	6	102
Mexico	5	44	1	9
Netherlands	157	994	131	782
Singapore	31	696	29	636
South Africa, Republic of	--	--	12	122
Sweden	22	168	48	518
Switzerland	--	--	2	31
Thailand	--	--	18	101
United Arab Emirates	--	--	2	17
United Kingdom	89	766	104	898
Total	593	6,245	1,162	12,229
Unwrought tungsten, except alloys, in lumps, grains, and powders:				
Belgium-Luxembourg	1	35	4	50
China	3	70	--	--
Germany, Federal Republic of	9	240	14	431
Japan	1	23	3	79
Korea, Republic of	25	485	3	47
United Kingdom	1	13	2	40
Other	r(1)	r21	(1)	21
Total	40	887	26	668
Unwrought tungsten, ingots, and shot	(1)	1	(1)	5
Unwrought tungsten, other:[2]	(1)	3	(1)	25
Unwrought tungsten, alloys:				
Austria	(1)	22	14	190
Canada	4	134	6	368
China	30	679	38	760
Germany, Federal Republic of	11	246	19	425
Korea, Republic of	--	--	1	25
Other	3	r99	(1)	31
Total	48	1,180	78	1,799
Wrought tungsten:[2]				
Australia	6	424	7	542
Belgium-Luxembourg	2	58	12	932
France	(1)	(1)	4	28
Germany, Federal Republic of	2	146	1	80
Japan	9	1,174	9	1,788
Netherlands	(1)	95	1	103
Switzerland	1	29	1	96
United Kingdom	1	62	1	61
Other	r1	r85	2	123
Total	22	2,073	38	3,753
Tungstic acid:				
China	--	--	192	1,742
Other	(1)	7	1	10
	(1)	7	193	1,752
Calcium tungstate:				
Germany, Federal Republic of	6	269	6	236
Japan	--	--	1	31
Total	6	269	7	267
Sodium tungstate	1	10	(1)	4

See footnotes at end of table.

Table 16.—U.S. imports for consumption of miscellaneous tungsten-bearing materials —Continued

Product and country	1983 Tungsten content (metric tons)	1983 Value (thousands)	1984 Tungsten content (metric tons)	1984 Value (thousands)
Tungsten carbide:				
Australia	--	--	2	$24
Austria	2	$45	1	31
Belgium-Luxembourg	23	715	33	921
Canada	2	62	2	74
China	3	76	4	98
Germany, Federal Republic of	177	3,356	317	6,551
Japan	(1)	3	2	53
Korea, Republic of	15	274	47	779
Mexico	7	111	--	--
South Africa, Republic of	1	6	1	1
United Kingdom	1	23	42	695
Other	r(1)	r13	(1)	6
Total	231	4,684	451	9,233
Other tungsten compounds:				
Canada	(1)	12	1	33
China	64	544	--	--
Other	2	r32	(1)	18
Total	66	588	1	51
Mixtures, organic compounds, chief value in tungsten:				
Canada	--	--	2	53
Germany, Federal Republic of	1	17	2	60
Italy	--	--	28	51
Other	(3)	(3)	(1)	5
Total	1	17	32	169

rRevised.
1Less than 1/2 unit.
2Estimated from reported gross weight.
3Revised to zero.

Table 17.—U.S. import duties on tungsten

TSUS No.	Item	Rate of duty effective Jan. 1, 1984: 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	7.5% ad valorem	35% ad valorem.
629.25	Waste and scrap containing by weight not over 50% tungsten.	5.9% 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.	3 cents per pound on tungsten content and 12.5% ad valorem.	58% ad valorem.
629.29	Unwrought tungsten, ingots, and shot	8.3% ad valorem	50% ad valorem.
629.30	Unwrought tungsten, other	9.6% ad valorem	60% ad valorem.
629.32	Unwrought tungsten, alloys, containing by weight not over 50% tungsten.	5.6% ad valorem	35.5% ad valorem.
629.33	Unwrought tungsten, alloys, containing by weight over 50% tungsten.	9.6% ad valorem	60% ad valorem.
629.35	Wrought tungsten	8.8% ad valorem	Do.
416.40	Tungstic acid	12.2% ad valorem	55% ad valorem.
417.40	Ammonium tungstate	11.2% ad valorem	49.5% ad valorem.
418.30	Calcium tungstate	10.5% ad valorem	43.5% ad valorem.
420.32	Potassium tungstate	15.6% ad valorem	50.5% ad valorem.
421.56	Sodium tungstate	11% ad valorem	46.5% ad valorem.
422.40	Tungsten carbide	12% ad valorem	55.5% ad valorem.
422.42	Other tungsten compounds	10.7% 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 December in an effort to resolve a 21-year deadlock between producing and consuming countries concerning the stabilization of the world tungsten market. No agreement was reached by COT, but it established a sessional working group to review and assess the current market situation and short-term outlook. Recommendations were made to expand and improve the COT quarterly "Tungsten Statistics" bulletin and it was recommended that another meeting be convened in 1985.

Canada.—The mine and mill operated by Canada Tungsten Mining Corp. Ltd. at Tungsten, Northwest Territories, produced 2,777 tons in 1984 compared with 280 tons in 1983, when the mine was shut down for 10-1/2 months. The mine began 1984 operations at one-half capacity, but reached full capacity production in August. Production capacity is 3,500 tons per year. Mill recovery was 79.6% from ore grading 1.43% WO_3. At yearend, ore reserves were reported by the company to contain 28,000 tons of tungsten.[2]

The Mount Pleasant tungsten-molybdenum mine and mill, in Charlotte County, New Brunswick, operated at one-half to full production capacity rates during various times in 1984. The joint venture between Billiton Canada Ltd. and Brunswick Tin Mines Ltd. has the capacity to produce concentrate containing 1,500 tons of tungsten 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.

Peru.—The International Finance Corp. loaned $5 million to the Peruvian mining company S.A. Minera Regina (SAMR) for part of the financing of a $21.4 million expansion and improvement of its tungsten mining operations. SAMR expects to increase its production from 155 tons of tungsten content in 1983 to 1,450 tons in 1988 upon completion of the project. Its operations are in the southeastern altiplano region, about 70 kilometers north of Lake Titicaca, in the district of Inchupalla, Department of Puno, in an area with an average elevation of 4,600 meters.

United Kingdom.—The United Kingdom's Secretary of State for Environment rejected the planning application for a tungsten-tin mine and mill to be constructed by AMAX Exploration of U.K. Inc. and Hemerdon Mining and Smelting (U.K.) Ltd. near Plymouth. The proposed plant would have a capacity of 2,000 tons per year of tungsten and 400 tons per year of tin. Minable ore reserves were placed at 60,000 tons of tungsten.

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[1]Physical scientist, Division of Ferrous Metals.
[2]Canada Tungsten Mining Corp. Ltd. 1984 Annual Report. 16 pp.

Table 18.—Tungsten: World concentrate production, by country[1]

(Metric tons of tungsten content)

Country	1980	1981	1982	1983[p]	1984[p]
Argentina	44	[r]11	17	41	[e]40
Australia	3,575	3,517	2,618	2,015	1,843
Austria	2,150	1,435	1,714	1,405	1,294
Bolivia	2,732	2,779	2,534	2,449	[e]2,100
Brazil	[r]1,116	[r]1,576	1,574	1,056	998
Burma	823	825	844	930	1,096
Canada	3,179	1,993	2,842	328	3,690
China[e]	15,000	13,500	12,500	12,500	13,500
Czechoslovakia[e]	80	50	50	50	50
France	577	591	727	832	796
India	22	18	25	15	21
Japan	668	[r]631	604	475	477
Korea, North[e]	2,200	2,200	2,200	500	1,000
Korea, Republic of	2,737	2,739	2,420	2,480	2,703
Malaysia	14	35	43	25	3
Mexico	266	263	194	186	274

See footnotes at end of table.

Table 18.—Tungsten: World concentrate production, by country[1] —Continued

(Metric tons of tungsten content)

Country	1980	1981	1982	1983[p]	1984[p]
Namibia[e]	150	--	--	--	--
New Zealand	4	10	7	6	7
Peru	[r]581	521	658	802	878
Portugal	1,568	1,395	1,358	1,183	1,493
Rwanda	[r]367	[r]281	324	231	291
Spain	446	437	545	517	[e]500
Sweden	[r]289	[r]312	268	365	385
Thailand	1,615	1,209	855	562	741
Turkey	96	153	[e]150	[e]325	[e]350
Uganda	5	1	4	4	4
U.S.S.R.[e]	8,700	8,850	9,000	9,100	9,100
United Kingdom	68	50	--	--	--
United States	2,754	3,605	1,521	980	1,203
Zaire	[r]69	[r]46	38	44	30
Zimbabwe	[e]90	[e]55	52	24	72
Total	[r]51,985	[r]49,088	45,686	39,430	[e]44,939

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through Aug. 22, 1985.

Table 19.—Tungsten: World concentrate consumption, by country[1]

(Metric tons of tungsten content)

Country[2]	1980	1981	1982	1983[p]	1984[e 3]
Reported consumption:					
Australia	76	100	145	160	140
Austria	[r]2,321	[r]1,850	1,304	[r e]1,629	2,000
Canada[e 3]	[r]21	[r]21	[r]18	[r]15	15
France	841	684	647	504	[4]627
Japan	2,931	2,238	1,826	1,977	[4]2,350
Korea, Republic of	1,434	1,793	1,560	[e]1,555	1,970
Mexico	[e]40	[e]40	[r e]19	22	[4]61
Portugal	206	227	183	174	200
Sweden	2,155	1,432	994	[r e]774	600
United Kingdom	1,462	879	367	[e]300	400
United States	9,268	9,839	4,506	5,181	[4]8,577
Apparent consumption:[5]					
Argentina	19	20	29	41	50
Belgium-Luxembourg	[e]100	9	9	10	20
Brazil	556	480	454	450	369
China[e 3]	4,500	4,800	4,500	[r]5,000	5,500
Czechoslovakia[e 3]	1,300	1,300	1,300	1,300	1,300
German Democratic Republic[e]	270	270	270	[r]250	270
Germany, Federal Republic of	1,499	1,348	1,541	2,030	3,600
Hungary[e]	600	600	600	[r]400	500
India[e]	299	459	[r]300	[r]300	400
Italy[e]	90	40	40	40	40
Korea, North[e 3]	1,600	1,600	1,600	500	1,000
Netherlands[e]	400	400	300	300	300
Poland	895	427	1,312	1,073	594
South Africa, Republic of[e]	250	250	250	250	250
Spain	137	98	161	140	47
U.S.S.R.[e 3]	13,800	15,900	15,900	15,900	16,000
Total	[r]47,070	[r]47,104	40,135	40,275	47,180

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Source, unless otherwise specified, is the Quarterly Bulletin of the UNCTAD Committee on Tungsten: Tungsten Statistics. V. 19, Nos. 1-2, Jan.-Apr. 1985.
[2]In addition to the countries listed, Bulgaria, Denmark, Finland, Israel, Norway, Romania, Switzerland, and Yugoslavia may consume 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]

The world vanadium industry recovered partially in 1984 from the worst market situation in more than 15 years. This recovery was primarily the result of increased raw steel production in the United States, Japan, and the European Community. More than 85% of the vanadium sold on the world market was consumed in steelmaking as ferrovanadium or related vanadium-carbon ferroalloys. Producers of vanadium oxides and slag in the Republic of South Africa began restarting idled extraction equipment in February and were operating at about 80% of capacity by midyear.

On April 2, Union Carbide Corp. regrouped its worldwide mining, processing, and metals exploration activities into a new, wholly owned subsidiary. The new subsidiary, Umetco Minerals Corp., was responsible for the company's chromium, tungsten, uranium, and vanadium businesses in the United States, the Republic of South Africa, and Brazil. The creation of Umetco put Union Carbide's vanadium operations in the United States and the Republic of South Africa under a unified financial and management structure.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium[1]	4,806	5,126	4,098	2,171	1,617
Value thousands	$64,370	$71,496	$52,577	$30,675	$24,551
Vanadium oxides recovered from ore[2]	5,506	6,368	4,867	2,433	2,620
Vanadium oxides recovered from petroleum residue[3]	1,520	1,900	1,513	893	1,663
Consumption	6,139	6,863	3,496	3,277	4,761
Exports:					
Ferrovanadium (gross weight)	803	435	326	775	469
Ore and concentrate	46	56	57	59	12
Vanadium pentoxide, anhydride (gross weight)	724	346	1,582	2,648	3,712
Other compounds (gross weight)	190	61	361	95	305
Imports (general):					
Ferrovanadium (gross weight)	328	1,236	855	846	1,461
Ores, slags, residues	1,786	2,435	1,112	58	633
Vanadium pentoxide, anhydride	856	354	129	408	149
World: Production from ores, concentrates, slags	r40,709	r38,562	36,125	p30,924	e34,292

eEstimated. pPreliminary. rRevised.

[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.

In the United States, the beleaguered vanadium industry was in the midst of a major restructuring in order to better compete in international markets against products derived from Chinese and South African magnetite 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 operations at its vanadiferous clay mine in Arkansas to compensate for the shutdown of its uranium-vanadium operations on the Colorado Plateau. Atlas Corp. also put its uranium-vanadium mill on standby and switched resources to the company's gold operations. By yearend 1984, the uranium-vanadium industry was at a complete standstill.

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 sharp rise in ferrovanadium consumption represented a modest recovery from a 20-year low, rather than a sanguine outlook for the vanadium industry. For the first time in 23 years, the U.S. Government purchased vanadium materials for the National Defense Stockpile (NDS).

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. All 18 of the plants or mills canvassed in 1984 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 35 mines in the United States reported production or shipments of vanadium-bearing ores in 1983, compared with more than 55 in 1982. In 1983, 18 uranium-vanadium mines on the Colorado Plateau permanently closed or were on standby because of the depressed market for yellowcake (natural U_3O_8 concentrate).

Legislation and Government Programs.—After 10 years of inactivity, the General Services Administration (GSA) took action to upgrade and increase the stocks of vanadium materials held in the NDS. The NDS goals of 1,000 short tons of vanadium contained in ferrovanadium and 7,700 tons of vanadium contained in vanadium pentoxide (V_2O_5) remained in effect throughout the year. These goals were established by GSA on May 1, 1980. On September 21, 1983, Gulf Chemical & Metallurgical Co. was awarded a contract to supply the stockpile with 101 tons of vanadium contained in pentoxide meeting Grade A purchase specifications. 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%. On June 4, 1984, a second pentoxide contract for 80 tons of contained vanadium was awarded to Umetco. Umetco, the newly formed subsidiary of Union Carbide, won the award with a bid of \$2.95 per pound of V_2O_5. Five lots from Gulf Chemical containing a total of 69 tons of vanadium were accepted by GSA during the fourth quarter of 1984 after extensive sampling and testing. This was 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, 1984, the U.S. Government inventory consisted of 609 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 were advising the group. All of the stockpile purchase specifications and special instructions pertaining to vanadium were being reviewed in 1984 by the Interagency Working Group and were expected to be substantially changed.

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.

In January, Oak Ridge National Laboratory began a 3-year effort to survey 8,000 properties in nine Western States for possible low-level radioactive contamination from the use of uranium mill tailings in construction materials. The effort was part of the DOE remedial action program mandated by the Uranium Mill Tailings Radiation Control Act of 1978. About 6,800 of the properties being surveyed are near Grand Junction, CO. Some of the other inactive uranium-vanadium millsites on the list were Monument Valley and Tuba City, AZ; Durango, Naturita, and Old Rifle, CO; Edgemont, SD; and Green River, UT. Also in January, DOE signed an agreement with the Navajo and Hopi Indian Tribes permitting cleanup of the now-dismantled Tuba City mill, starting in late 1986. The Tuba City mill, about 20 miles northeast of Cameron, was operated by the Rare Metals Corp. of America from 1955 to 1962 and by El Paso Natural Gas Co. from 1962 to 1966. DOE also agreed in 1984 to clean up tailings at Shiprock, NM, and two other sites in the Four Corners area of the Navajo Reservation. Total cleanup of the four tribal properties was expected to take about 5 years and cost at least $50 million. In February, DOE and the State of Utah awarded a $38 million contract to the Argee Corp. of Denver to remove 2.9 million tons of tailings from the Vitro millsite in South Salt Lake. Argee will transport the material by rail 85 miles to a specially designed burial pit near Clive in Tooele County, UT.

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. In November 1984, the Nuclear Regulatory Commission (NRC) announced that it would begin revising its own tailings disposal regulations so that they would conform with the 1983 EPA standards and be compatible with various EPA ground water protection requirements. The proposed NRC rules would require the permanent tailings disposal site to be designed so that there was reasonable assurance of control of radiological hazards for at least 200 years. The NRC rules would also incorporate the EPA standard restricting radon emission from the tailings into the atmosphere to less than 20 picocuries per square meter per second.

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. The proposed disposal site would be on Spring Creek Mesa along the eastern side of the San Miguel River opposite Uravan. Under an agreement signed with the Colorado Water Control Division in 1981, Umetco must 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. The Uravan mill was placed on standby in November because of the depressed uranium market.

DOMESTIC PRODUCTION

Domestic production, expressed in terms of recovered vanadium, made a modest recovery from the depressed level of 1983, the worst year for vanadium mining and milling operations since 1951. However, recoverable production, which represents shipments of ore and vanadium-bearing ferrophosphorus, continued to decline. Colorado was the leading producing State followed by Idaho. In both Colorado and Utah, vanadium was obtained as a coproduct from the mining of uraniferous sandstones on the Colorado Plateau. In Idaho, V_2O_5 was produced from vanadium-bearing ferrophosphorus by Kerr-McGee Chemical Corp. at Soda Springs. The ferrophosphorus was a byproduct of nearby elemental phosphorus plants. Umetco resumed operations at its mine and mill complex in Garland County, AR, to compensate for the closure of many 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, uses vanadiferous micaceous clays as its major feed material. The clays are mined from four open pits in the Wilson Springs carbonatite-alkalic igneous complex.

More than one-third of the Colorado Plateau coproduct operations that survived the 1981-82 ore market collapse closed in 1984 because of the steadily declining price for U_3O_8. Continued world overproduction of U_3O_8, the downturn in nuclear powerplant construction, and the discovery of high-grade uraninite deposits in Saskatchewan and South Australia all helped drag the price of natural uranium to an 11-year low in terms of constant dollars. At yearend 1984, the spot price of uranium concentrate (represented by Nuclear Exchange Corp.'s Exchange Value) was at $15.25 per pound U_3O_8, a drop of $25.50 from the early 1980 price of $40.75.

At the beginning of January, the poor market for U_3O_8 forced the Metals Div. of Union Carbide to lay off 100 employees at its uranium-vanadium mines near Uravan and Egnar, CO, and in the LaSal area of Utah. Approximately 20 employees were retained to operate the Deremo-Snyder Mine west of Egnar. On January 11, Union Carbide acquired a 70% interest in the White Mesa uranium-vanadium mill from Energy Fuels Nuclear Inc. The $40 million mill, south of Blanding, UT, was placed in operation in May 1980 and is one of the newer and more efficient uranium and vanadium processing facilities in the United States. The 2,000-ton-per-day facility had been on standby since January 1983 and was left idle by Union Carbide because of continuing weak demand for uranium. On May 1, Umetco temporarily reopened its uranium-vanadium mill at Uravan in Montrose County, CO. The 1,200-ton-per-day mill had been on standby since November 1983. The company quickly resumed shipments of vanadium liquor from Uravan to its Rifle upgrading facility in nearby Garfield County. However, production operations were halted indefinitely at both facilities in December. About 25 of the 135 employees at Uravan were retained to maintain the mill in standby condition and continue tailings reclamation projects. Five of the thirty employees at Rifle were also retained to fill orders for vanadium oxide and ammonium metavanadate. The resumption of modified vanadium oxide production in October at Hot Springs enabled Umetco to meet all of its orders despite the Rifle shutdown.

On February 15, Atlas announced that it was suspending operations at its uranium-vanadium mill near Moab, UT, until uranium oxide sales and prices improved. It took about 30 days for the company to finish processing its ore stockpile and draw down its supply of chemical milling agents. The company's last three operating mines in San Juan County—the Pandora, the Velvet, and the Rim Columbus—were all placed on standby. About 180 workers were affected by the closures. Atlas reportedly had enough U_3O_8 and V_2O_5 stockpiled to fill orders for at least 12 months. The company also delayed development of its new uranium-vanadium mine near Ticaboo in Garfield County, and instead focused its attention on its newly discovered Gold Bar deposit in Eureka County, NV. The expected profits from the Gold Bar property, which has an estimated 250,000 ounces of economically recoverable gold, could enable Atlas to keep its uranium-vanadium operations on standby for several years.[2]

Increased demand for elemental phosphorus led to a buildup of stocks of vanadium-rich, byproduct ferrophosphorus in Idaho and Montana. Stauffer Chemical Co. reactivated its Wooley Valley phosphate mine in Caribou County, ID, and resumed shipments of vanadium-bearing phosphatic shale to its elemental phosphorus plant at Silver Bow, MT. In September, J. R. Simplot Co. began operations at its new Smoky Canyon Mine in Caribou County near the Idaho-Wyoming border. The $40 million project consists of an open pit mine, a milling-pumping complex, and a 27-mile slurry pipeline to a filtering and drying plant at Conda, ID. The Smoky Canyon output will replace that of the nearly depleted Conda Mine and will be used entirely to make phosphoric acid at Simplot's fertilizer complex in Pocatello. Smoky Canyon is important to the U.S. vanadium industry because it will indirectly free reserves at the Gay and other mines in Idaho over the next 30 years for ferrophosphorus production and downstream vanadium oxide recovery operations.

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 1984 totaled 1,663 tons of contained vanadium, 86% more than the 893 tons for 1983.

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 798 tons of V_2O_5, compared with 794 tons in 1983. 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 a sludge recovered from its wastewater treatment plants that averages 16% V_2O_5 when dried.

The near-depression conditions in the steel industry since 1981 have had a particularly adverse effect on U.S. producers of ferrovanadium and proprietary vanadium-iron-carbon alloys. Ashland Chemical Co. of Columbus, OH, acquired part of the production equipment of the defunct Pesses Co. Pesses, a specialty ferroalloys and scrap broker with ferrovanadium operations at Pulaski, PA, was declared bankrupt in late 1983. Chemstone Corp., a subsidiary of Engelhard Corp., sold its idle ferrovanadium plant at Strasburg, VA, to an undisclosed buyer at the beginning of 1984. The Strasburg plant, built in 1979, had been producing both 50% and 80% grades of ferrovanadium by aluminothermic reduction. The new owner had no immediate plans to reactivate the plant because of the limited outlook projected for ferrovanadium in 1985. Affiliated Metals and Minerals Inc., in contrast, went ahead with the commissioning of its specialty ferroalloys plant at Newcastle, PA. The first products of Affiliated Metals were ferrovanadium, ferromolybdenum, molybdenum briquets, and ferroboron.

The market for vanadium chemicals improved slightly during the year, as the recovery began to spread to the more traditional sectors of the U.S. chemical industry. Producers of primary vanadium chemicals included Foote Mineral Co., Cambridge, OH; Stauffer, Weston, MI; and Umetco, Niagara Falls, NY. Vanadium oxytrichloride and vanadium tetrachloride were the two ranking chemicals after pentoxide.

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]
1980	5,832	4,806
1981	5,852	5,126
1982	4,093	4,098
1983	W	2,171
1984	W	1,617

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]
1980	10,048	9,829
1981	11,366	11,367
1982	8,850	8,689
1983	4,590	4,344
1984	4,688	4,678

[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 increased 45% in 1984 compared with that of 1983. This sharp rise in consumption represented a modest recovery from the 20-year low of 1983, rather than a sanguine outlook for the U.S. vanadium industry. The primary cause of the recovery was 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 gain of 9% in raw steel output from the depressed level of 1983, but remained in an uphill battle against record-high imports of major iron and steel products, a strong dollar, and low profitability.

Approximately 80% 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 marketed by Umetco, is designed primarily for addition to tool steel and can be added directly to the argon-oxygen-decarburization vessel. Vanadium pentoxide 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.

The dependence of the vanadium industry on the struggling iron and steel industry continued to create marketing problems for the five remaining domestic producers of ferrovanadium. Increased consumption of ferrovanadium occurred in all five of the specified steel categories. However, European and Canadian converters were able to increase their share of the U.S. ferrovanadium market because of the strong dollar. Total shipments of sheet steel and strip to the automotive industry and other consumer goods sectors were up 5.8% with the alloy grades showing an even greater percent increase. Shipments of steel plate, structural shapes, rails, and tool steel all improved significantly. Even shipments of oil country tubular goods and line pipe, which plummeted dramatically in 1983, showed a modest comeback. Continued drilling activity in the Gulf of Mexico and offshore California helped shrink inventories of high-strength and full alloy pipe. Construction of two crude oil pipelines between southern California and Texas sparked competition between European and U.S. producers of large-diameter line pipe.

The restructuring of the U.S. steel industry continued in 1984. The loss of over $6 billion between 1982 and 1983 triggered a string of steel company mergers, modernization programs, and permanent closures of obsolete plants. The largest merger, between Republic Steel Corp. and the Jones & Laughlin Div. of LTV Corp., was finalized in June. This radical restructuring, coupled with recent investments in continuous casters, continuous annealing lines, and other new equipment, should lead to a smaller, but more productive industry. The technological changes accompanying the modernization programs were expected to accelerate the marked trend away from traditional carbon steels to high-performance and secondary refined specialty steels. All of these post-recession changes should have a positive effect on the long-term outlook for vanadium.

Demand for vanadium in titanium alloys was almost double that of 1983 because of the B-1B bomber program and increased production of other military aerospace products. However, shipments of titanium mill products to commercial aircraft manufacturing plants remained weak. According to the Aerospace Industries Association, the Boeing Co., Lockheed Corp., and McDonnell Douglas Corp. together shipped a total of only 182 civil jet transport aircraft in 1984, compared with 257 in 1983 and 236 in 1982. 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 1984. 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 new 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 Titanium Development Association was formed at the beginning of 1984 to increase usage of titanium and promote new applications for both the metal and its alloys. The association agreed to focus 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.

In August, Martin Marietta Corp. and Nippon Kokan K.K., a Japanese steel producer, established a joint venture to produce advanced titanium and aluminum fabricated products. The joint venture, known as the International Light Metals Corp., acquired control of Martin Marietta's extrusion and forging plant at Torrance, CA. The Torrance plant employed 1,570 workers and was producing titanium alloy extrusions and bars for the aerospace industry. The plant had been using significant amounts of vanadium-aluminum master alloys to strengthen its titanium products. International Light Metals was examining ways of expanding the plant's titanium forgings capabilities.

Consumption of ammonium metavanadate, granular pentoxide, and other vanadium chemicals for catalysts recovered slightly from the depressed levels of 1983, but was still far below the average of the last decade. Sulfuric acid production, a major end use for vanadium oxidation catalysts, was up only 8.5% over that of 1983.

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 maleic anhydride, adipic acid, and phthalic anhydride. These three key organic intermediates had production gains for 1984 that ranged from 4% to 21%. Monsanto Industrial Chemicals Co. was in the process of expanding the capacity of its maleic anhydride unit at Pensacola, FL, from 130 to 170 million pounds.[3] The Pensacola unit uses butane rather than the traditional benzene as feedstock.

In addition to the consumers' stocks, producers' stocks of vanadium as fused oxide, precipitated oxide, vanadates, metal, alloys, and chemicals totaled 3,321 tons of contained vanadium at yearend 1984, compared with 4,463 tons at yearend 1983.

Table 4.—Producers of vanadium alloys or metal in the United States in 1984

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	1983		1984	
	Consumption	Ending stocks	Consumption	Ending stocks
Ferrovanadium[1]	2,741	313	3,826	334
Oxide	24	10	26	W
Ammonium metavanadate	3	1	W	W
Other[2]	509	50	909	115
Total	3,277	374	4,761	449

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 1984, by end use

(Short tons of contained vanadium)

End use	Quantity
Steel:	
Carbon	683
Stainless and heat-resisting	20
Full alloy	816
High-strength, low-alloy	1,636
Tool	610
Unspecified	10
Total	3,775
Cast irons	18
Superalloys	10
Alloys (excluding steels and superalloys):	
Cutting and wear-resistant materials	W
Welding and alloy hard-facing rods and materials	6
Nonferrous alloys	905
Other alloys[1]	W
Chemicals and ceramics:	
Catalysts	22
Other[2]	W
Miscellaneous and unspecified	25
Grand total	4,761

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 vanadium pentoxide (metallurgical-grade) at the beginning of 1984 was \$3.35 to \$3.65 per pound V_2O_5, f.o.b. mill. This price spread was established on May 15, 1981, and remained in effect throughout all of 1984. The modest recovery in U.S. demand for ferrovanadium from the depressed levels of 1983 gave little encouragement to domestic pentoxide producers. Considerable discounting of metallurgical-grade material continued throughout 1984 because of the strong dollar and downstream pressure from record-high imports of ferrovanadium.

Prices for metallurgical-grade pentoxide in Japan and Western Europe firmed during the first half of 1984 owing to increased production of ferrovanadium by major converters and reduced exports of pentoxide from China. On July 1, Highveld Steel and Vanadium Corp. Ltd. raised its list price from \$2.30 to \$2.41 per pound 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 gradually increased from \$2.05 to \$2.15 per pound in early January to a high in May of \$2.45 to \$2.50, a price level that approximated the cost of production for several companies. When sales of Chinese pentoxide were resumed in the fall, the spot price dropped to a low of \$2.00 to \$2.10 and eventually closed at \$2.25 to \$2.30.

The Metals Week price spread for technical air-dried vanadium pentoxide (chemical-grade) of \$4.10 to \$4.94 per pound V_2O_5 was set on April 1, 1982, and remained unchanged throughout 1984.

Increased production of HSLA and tool steels in the United States and Canada during the last quarter of 1983 triggered a series of price adjustments between January 6 and May 17, 1984, for ferrovanadium and other vanadium-iron-carbon additives. The end results of the price adjustments are presented in the following:

Company and product	Price per pound of contained vanadium	
	Jan. 1, 1984	Dec. 31, 1984
Foote Mineral Co.:		
Ferovan	\$5.50	\$6.25
70% to 80% FeV	6.00	6.50
Shieldalloy Corp.:		
Standard 60% to 70% FeV	5.50	6.25
Umetco Minerals Corp.:		
Carvan	5.50	6.00
UCAR 80% FeV	6.00	6.50

On May 23, Umetco took action to protect its market share against the surge of 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 more expensive, imported ferrovanadium.

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 Community 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 hurt U.S. export sales of vanadium-iron-carbon alloys in 1984. Exports of ferrovanadium totaled only 469 tons gross weight, compared with 775 tons for 1983. The average declared value of the ferrovanadium was $5.55 per pound of alloy, a 40% increase over the $3.96 value for 1983. 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 kept the pressure on U.S. producers to compete aggressively against South African material in Western Europe, Canada, and Japan. Exports of vanadium pentoxide (anhydride) and catalysts containing pentoxide totaled 3,712 tons gross weight, a 40% increase over the 2,648 tons for 1983.

U.S. imports of ferrovanadium reached an historical high of 1,171 tons of contained vanadium in 1984. The record-high tonnage averaged 80.8% vanadium and was almost double the 681 tons imported in 1983. This surge in imports is part of a long-term trend in which European converters have been gradually capturing a larger share of the U.S. ferrovanadium market. Imports accounted for almost 31% of reported U.S. consumption of vanadium-iron-carbon alloys, compared with less than 4% in 1973. Canada continued to be the principal source of imported ferrovanadium, but during the year lost more than one-half of its share of the U.S. ferrovanadium market to the European Community and Austria.

More than 93% of the V_2O_5 imported in 1984 came from Rautaruukki Oy's operations in Finland. For the first time in 11 years, there were no imports of pentoxide from the Republic of South Africa. However, according to the Bureau of the Census, 709 tons gross weight of South African trioxide entered the United States through the Port of Baltimore in the first half of 1984.

Imports of vanadium contained in ores, slags, and residues totaled 633 tons, compared with only 58 tons in 1983. About 80% of this vanadium came from Highveld's Witbank steelworks in the Transvaal and was in the form of a 14%-vanadium iron slag. The remaining 20% was contained in assorted petroleum refinery residues and utility ashes from, in order of decreasing tonnage, the Netherlands Antilles, Venezuela, Italy, and Jamaica.

Potassium vanadate imports amounted to 115 tons gross weight, of which 75 tons came from the Republic of South Africa and 39 tons came from the Federal Republic of Germany. In addition, 6 tons of ammonium vanadate was received from the United Kingdom. Slightly more than 1 ton of vanadium carbide was imported from Western Europe. Imports classified as "Other vanadium compounds" totaled 831 tons gross weight, compared with only 54 tons in 1983. As mentioned earlier, 85% of this material was vanadium trioxide from the Republic of South Africa. Approximately 118 of the remaining 122 tons was unspecified chemicals from the United Kingdom.

Table 7.—U.S. exports of vanadium in 1984, 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	--	--	--	--	224	575	--	--
Australia	--	--	--	--	84	125	([3])	3
Austria	--	--	--	--	104	240	--	--
Belgium-Luxembourg	--	--	24	109	2,045	3,964	1	4
Bolivia	--	--	--	--	10	15	--	--

See footnotes at end of table.

Table 7.—U.S. exports of vanadium in 1984, 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
Brazil	--	--	--	--	593	855	(3)	2
Canada	383	2,121	--	--	405	859	175	409
Chile	--	--	--	--	92	159	107	169
Colombia	--	--	--	--	8	15	--	--
Denmark	--	--	--	--	81	92	--	--
Germany, Federal Republic of	--	--	--	--	2	13	1	19
Honduras	--	--	--	--	6	23	--	--
Indonesia	--	--	--	--	422	493	(3)	4
Israel	--	--	--	--	--	--	(3)	1
Italy	--	--	--	--	168	161	--	--
Japan	--	--	--	--	539	1,075	(3)	3
Korea, Republic of	21	80	--	--	475	964	--	--
Kuwait	--	--	--	--	2	12	--	--
Malaysia	3	12	--	--	16	35	--	--
Mexico	75	384	--	--	658	2,327	3	15
Netherlands	--	--	--	--	538	1,051	13	38
New Zealand	--	--	--	--	16	35	--	--
Panama	--	--	--	--	--	--	(3)	2
Peru	--	--	--	--	9	16	--	--
Philippines	4	17	--	--	22	53	(3)	1
Qatar	--	--	--	--	--	--	18	24
South Africa, Republic of	--	--	--	--	594	776	1	9
Spain	--	--	--	--	--	--	1	3
Sweden	343	2,028	--	--	--	--	(3)	1
Switzerland	--	--	--	--	29	64	--	--
Syria	--	--	--	--	146	200	--	--
Thailand	--	--	--	--	2	6	--	--
United Kingdom	29	169	--	--	118	290	--	--
Venezuela	80	393	--	--	16	21	290	990
Yemen (Sanaa)	--	--	--	--	--	--	(3)	2
Total[4]	938	5,205	24	109	7,423	14,514	611	1,699

[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.

Table 8.—U.S. imports of ferrovanadium, by country

(Thousand pounds and thousand dollars)

Country	1983			1984		
	Gross weight	Vanadium content	Value	Gross weight	Vanadium content	Value
General imports:						
Austria	282	230	947	445	363	2,022
Belgium-Luxembourg	223	178	823	412	331	1,598
Brazil	r2	r2	r13	1	1	16
Canada	1,042	838	3,970	1,138	923	4,745
France	--	--	--	99	80	416
Germany, Federal Republic of	116	91	424	558	444	2,077
Japan	--	--	--	114	91	493
United Kingdom	26	21	77	156	126	565
Total[1]	r1,691	r1,361	r6,254	2,921	2,359	11,934
Imports for consumption:						
Austria	282	230	947	445	363	2,022
Belgium-Luxembourg	223	178	823	390	313	1,504
Brazil	r2	r2	r13	1	1	16
Canada	1,042	838	3,970	1,138	923	4,745
France	--	--	--	99	80	416
Germany, Federal Republic of	116	91	424	558	444	2,077
Japan	--	--	--	114	91	493
United Kingdom	26	21	77	156	126	565
Total[1]	r1,691	r1,361	r6,254	2,899	2,341	11,839

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

Table 9.—U.S. imports of vanadium pentoxide (anhydride), by country

Country	1983 Gross weight (pounds)	1983 Vanadium content (pounds)	1983 Value	1984 Gross weight (pounds)	1984 Vanadium content (pounds)	1984 Value
General imports:						
Belgium-Luxembourg[1]	--	--	--	33,660	18,855	$40,598
Finland	1,232,651	690,489	$2,070,043	494,953	277,256	1,218,749
Germany, Federal Republic of	400	224	1,833	2,000	1,120	8,643
South Africa, Republic of	224,868	125,963	523,956	--	--	--
United Kingdom	3	2	1,583	14	8	1,134
Total	1,457,922	816,678	2,597,415	530,627	297,239	1,269,124
Imports for consumption:						
Belgium-Luxembourg[1]	--	--	--	33,660	18,855	40,598
Finland	1,232,651	690,489	2,070,043	494,953	277,256	1,218,749
Germany, Federal Republic of	400	224	1,833	2,000	1,120	8,643
South Africa, Republic of	112,434	62,982	289,147	--	--	--
United Kingdom	3	2	1,583	14	8	1,134
Total	1,345,488	753,697	2,362,606	530,627	297,239	1,269,124

[1]Queried by the Bureau of Mines.

WORLD REVIEW

Ferrovanadium consumption in the Western World partially recovered from the depressed level of 1983, but was still significantly below the record high of 1981. This recovery was primarily the result of increased raw steel production in the United States, Japan, and the European Community. Mine production cutbacks in the Republic of South Africa and the United States during the 1982-83 recession led to a drawdown of the excess pentoxide stocks that plagued the world market in 1982. These cutbacks, increased production of ferrovanadium, and a temporary halt in exports of pentoxide and slag from China during the first quarter all contributed to a firming of the spot price of pentoxide. South African pentoxide producers began restarting idled units to meet increased orders and were operating at more than 80% of capacity by midyear. However, continuing depressed prices for U_3O_8 forced the last two U.S. uranium-vanadium mills to halt production.

In the Republic of South Africa, Highveld completed construction of its second vanadium-bearing pig iron plant, but deferred commissioning because of continuing weak demand for steel in international markets. Vanadiferous slag production facilities were also under construction at the Glenbrook steel plant on the North Island of New Zealand. At the same time, Rautaruukki was making preparations to permanently close its two vanadiferous magnetite mines in Finland because of continuing financial losses. In Canada, large-scale equipment was under development for extracting vanadium from fly ash generated by commercial oil sands plants.

A supply and demand study of vanadium, columbium, and molybdenum was published in Brussels by the International Iron and Steel Institute (IISI).[4] The study analyzed the supply vulnerability of each of the three alloying elements and examined the impact of improved technology and controls in the steel industry on their consumption. Since 1974, consumption of specialty steels has been increasing relative to total steel consumption in most of the established steel-producing countries. As a result, consumption of the three alloying elements has increased despite the general decline in steel production in those countries. The IISI authors also delved into the complex subject of substituting the three elements for one another in different types of steel. Some substitution between columbium and vanadium is possible in microalloyed steels. However, molybdenum is more often used in the higher alloy steels and generally cannot be replaced by vanadium or columbium in these instances.

Brazil.—Production of ferrovanadium totaled 515 tons gross weight in 1984, a more than threefold increase over the 112 tons reported for 1983. Installed capacity in December 1983 totaled 2,379 tons per year and was divided between four producers: Cía. Paulista de Ferro-ligas, Eletrometalur S.A. Indústria e Comércio, Prometal-

Produtos Metalúrgicos S.A., and Termoligas Metalúrgicas S.A.[5]

Canada.—Vadnore Enterprises Ltd. of Fort Saskatchewan, Alberta, received a CAN$200,000[6] grant in May from the Federal Department of Regional Industrial Expansion. The money was being used to design and construct large-scale equipment for extracting vanadium from bitumen fly ash. Vadnore recently completed laboratory-scale development work on a new process to recover vanadium from fly ash generated by commercial oil sands plants in northeastern Alberta. The company was planning to build an ash agglomerating facility at Fort McMurray and a salt roasting kiln at Lac La Biche. Fly ash for the CAN$16 million project would come from the oil sands plant operated by Syncrude Canada Ltd. at Mildred Lake. Syncrude Canada has been generating about 60,000 tons of fly ash per year averaging 1.2% V_2O_5. The Syncrude operation also produces 4 tons per day of a spent molybdenum-based hydrocracking catalyst that contains 22% V_2O_5. The spent catalyst would be blended with the fly ash during the agglomeration step. The proposed extraction plant would produce about 900 tons of V_2O_5 and 100 tons of molybdenum trioxide (MoO_3) per year.[7]

China.—The Government of China apparently has revived its multichannel export system for V_2O_5 in an effort to boost sales. In April, China National Chemicals Import and Export Corp. was reportedly made the sole agent for vanadium and given an export goal of 1,100 tons of pentoxide for 1984. In the fall, however, foreign buyers were still able to negotiate purchases with either China National Metals & Minerals Import and Export Corp. (Minmetals) or China Metallurgical Import and Export Corp. (CMIEC). Minmetals, a trading unit of the Ministry of Economic Relations and Foreign Trade, was selling both pentoxide and ferrovanadium, while CMIEC, a unit of the Ministry of Metallurgical Industry, concentrated mainly on vanadiferous slag and ferrovanadium. The situation was further complicated by the establishment of a fourth entity, China National Nonferrous Metals Import and Export Corp., in January.[8] In 1983, China exported more than 2,200 tons of pentoxide to market economy countries.

Finland.—Rautaruukki continued preparations to close both of its vanadiferous magnetite mines. Shutdown of the Otanmäki underground mine near Vuolijoki was scheduled to begin in June 1985, while the surface mine at Mustavaara was to remain open until the following autumn. Mining personnel were in the process of being retrained and were to be transferred to railcar manufacturing facilities being built near the two minesites. The Rautaruukki-Outokumpu Oy exploration joint venture began concentrating its efforts on a belt of platinum mineralization between Kemi and Ranua, but continued to search elsewhere for columbium, rare earths, and tungsten. The two mines produced a total of 6,029 tons of V_2O_5 in 1984, only 4% below the record high of 1983. At Otanmäki, the company recovered 3,163 tons of V_2O_5, 184,000 tons of ilmenite concentrate, and 357,000 tons of magnetite concentrate from 1,371,000 tons of ore. Production at Mustavaara, which produces only pentoxide, declined from 3,024 tons in 1983 to 2,865 tons in 1984.[9]

India.—Visvesvaraya Iron & Steel Ltd. was in the first stage of constructing a 110-ton-per-year ferrovanadium plant at its Bhadravati iron and steel works in the Shimoga District of Karnataka.[10] Visvesvaraya, in collaboration with the National Metallurgical Laboratory, has been working since 1975 on a process to produce vanadium-rich slag from local titaniferous magnetite ores. Limited amounts of ore containing 1.04% V_2O_5 and 53.1% Fe have been shipped to Bhadravati from the Masanikere deposit, about 40 kilometers away. The company has succeeded in producing a vanadium-rich slag containing 20% to 25% V_2O_5 on a commercial scale with a 16-ton basic oxygen furnace. Visvesvaraya is a public sector company owned 60% by the Karnataka State government and 40% by the Government of India. Catalyst India Pvt. Ltd. recovered pentoxide from red muds at Thane in Maharashtra. The pentoxide was used to make a catalyst containing 6.5% V_2O_5. The red muds, which contain 0.3% to 0.4% V_2O_5, are a waste product of the alumina industry. At least seven companies had pilot projects underway for extracting vanadium from muds and sludges generated by Bharat Aluminium Co. Ltd., Hindustan Aluminium Co. Ltd., or Indian Aluminium Co. Ltd.[11]

Japan.—On March 5, the Japan Rare Metals Association purchased 145 tons of vanadium contained in ferrovanadium as part of the 10-day national stockpile program approved for fiscal year 1983. One-half of the ferrovanadium was being stored in the national stockpile, and one-half in joint Government-private industry stockpiles. The contract was divided between Nippon Denko Co. Ltd., Taiyo Mining and Industrial Co. Ltd., Awamura Metal Industry Co. Ltd., and Japan Metals and Chemicals Co. Ltd.

Market conditions improved in 1984 for the four Japanese producers of ferrovanadium. Ferrovanadium consumption by the steel industry was 4,814 tons compared with only 4,421 tons in 1983. Japan produced 4,115 tons of the ferroalloy in 1984, a 32% increase over the 3,110 tons of 1983.[12] Because the country has no vanadium mines and only a limited processing capability for vanadium-bearing ash and spent catalysts, the gain in ferrovanadium output was attained by increasing imports of V_2O_5. Pentoxide imports rose 56% from 3,260 tons gross weight in 1983 to 5,072 tons in 1984. The Republic of South Africa was the principal supplier of pentoxide to Japan and accounted for 84% of the total gross weight. In contrast, ferrovanadium imports declined from 817 to 624 tons gross weight. All of the imported ferrovanadium came from either Austria or the European Community. Japan exported 134 tons of ferrovanadium, with 77 tons going to North Korea and 56 tons to the United States.[13]

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. In October 1984, Exxon Corp. announced that its affiliate, Lago Oil & Transport Co. Ltd., would close its oil refinery and transshipment storage facilities on the island of Aruba by March 31, 1985. 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 Petróleos de Venezuela S.A. The refinery had been operating at two-thirds capacity because of weak international oil prices and showed a $50 million loss for 1984. Shell Petroleum NV also threatened to close its more modern 320,000-barrel-per-day refinery on Curacao unless the Netherlands and Venezuelan Governments made several economic concessions. Closure of both refineries would have a disasterous effect on the Antillean economy.[14]

Somalia.—Construtora Andrade Gutierrez S.A. of Brazil announced plans to build a $300 million uranium mine and mill complex in the Galgudud region of Somalia.[15] Somalia has a reserve base of at least 7,100 tons of uranium recoverable at a cost of $35 to $60 per pound of uranium and an additional 7,300 tons of demonstrated subeconomic resources. Much of the uranium mineralization in central Somalia is in the form of carnotite ($K_2(UO_2)_2V_2O_8 \cdot 3H_2O$) deposited in the Merca claystones, limestones, and marls of Miocene Age. The Wabo carnotite deposits in Mudugh Province contain at least 5,000 tons of U_3O_8 equivalent with an average grade of 0.08% U_3O_8. No information was available on the vanadium content of the Galgudud ores.

The Galgudud deposit is controlled by the Somali Arab Mining Co. (SORAMICO), a joint venture between the Somalian Government and the Pan-Arab Mining Co. SORAMICO also has significant uranium holdings in a 85,000-square-kilometer area between Kolkodo and Modok. The Galgudud mill will have an annual capacity of 550 tons of contained uranium and will utilize an extraction process developed by Empresas Nucleares Brasileiras S.A. (NUCLEBRÁS), the state-owned company controlling the nuclear energy program in Brazil. Gutierrez built and was still operating the Osamu Utsumi Mine and processing plant for NUCLEBRÁS at Pocos de Caldas in the Brazilian State of Minas Gerais.

South Africa, Republic of.—Highveld produced 50,608 tons gross weight of slag containing about 25% V_2O_5 in calendar year 1984.[16] The vanadium slag was a byproduct of iron smelting operations at the company's Witbank integrated steelworks in the Transvaal. Highveld hesitated to bring its new No. 2 iron plant on line until the world market for steel improved. In February, the company resumed limited production of V_2O_5 at its Vantra Div. The Vantra facility, which has four rotary kilns and four multiple-hearth roasters, had been idle since May 1983. Only one of the four kilns was restarted. However, by June, all four of the roasters were in full operation because of increased orders. Production by the Vantra Div. was about 1,500 tons of pentoxide in 1984. The vanadium-bearing, titaniferous magnetite feed for both facilities came from the Mapochs Mine in the Bushveld Complex north of Roossenekal. More than 1.85 million tons of magnetite ore was mined at Mapochs, compared with 1.63 million tons in 1983.

U.S.S.R.—The Soviet Government was reportedly developing a commercial process for recovering vanadium, uranium, molybdenum, and related metals from oil shale ash.[17] In 1983, approximately 97% of Soviet oil shale production came from the Baltic Basin, located within the Estonian S.S.R. and the adjacent Leningrad District of the Russian Federated S.S.R.[18] The alkaline, metalliferous ash is generated when pulverized oil shale of Ordovician Age is used directly as a boiler fuel at two local 1,600-megawatt powerplants. More than 3 million tons of oil shale ash are used annually in Estonian agriculture to neutralize soil acidity. A significant amount of ash is also consumed in the production of portland cement, concrete, and silica bricks.

United Kingdom.—In early November, the British Government released a Parliamentary report announcing that it would liquidate its stockpile of strategic metals. The stocks, valued at an estimated $50 million, will be disposed of gradually over the next few years to avoid any disruption of the market. The stockpile was begun in 1982 when the United Kingdom decided to maintain stocks of materials critical to steel and other key industries. Few details of the stockpile quantities have ever been disclosed, but it reportedly includes 3-month supplies of V_2O_5 and ferrovanadium.[19]

Table 10.—Vanadium: World production from ores and concentrates, by country[1]

(Short tons of contained vanadium)

Country	1980	1981	1982	1983[p]	1984[e]
Production from ores, concentrates, slags:[2]					
Australia (in vanadium pentoxide product)[3]	--	77	26	--	--
Chile[e 4]	300	140	--	--	--
China (in vanadiferous slag product)[e]	5,000	5,000	5,000	5,000	5,000
Finland (in vanadium pentoxide product)	3,135	3,431	3,470	3,516	[5]3,377
Norway[e]	540	380	120	--	--
South Africa, Republic of:[r 6]					
Content of pentoxide and vanadate products[e]	7,168	4,648	3,981	4,117	6,628
Content of vanadiferous slag product[e 7]	9,260	9,260	8,930	5,620	7,170
Total	16,428	13,908	12,911	9,737	[5]13,798
U.S.S.R.[e]	10,500	10,500	10,500	10,500	10,500
United States (recoverable vanadium)	4,806	5,126	4,098	2,171	[5]1,617
Total	[r]40,709	[r]38,562	36,125	30,924	34,292
Production from petroleum residues, ashes, spent catalysts:[8]					
Japan (in vanadium pentoxide product)	710	687	754	778	770
United States (in vanadium pentoxide and ferrovanadium products)	1,520	1,900	1,513	893	[5]1,663
Total	2,230	2,587	2,267	1,671	2,433
Grand total	[r]42,939	[r]41,149	38,392	32,595	36,725

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

[1]In addition to 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 June 25, 1985.

[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

Argonne National Laboratory, Westinghouse Electric Corp., and the German Nuclear Research Center at Karlsruhe (Kernforschungszentrum Karlsruhe) have been evaluating vanadium-base alloys as a structural material in fusion power reactors for more than a decade.[20] Vanadium-base alloys have several advantages over the more conventional austenitic and ferritic steels proposed for the "first wall" and blanket system of the reactor. The blanket system is the largest, and probably the most complex, fusion reactor component and must operate in a corrosive and intense radiation environment at temperatures exceeding 600° C. In general, vanadium alloys have a relatively high thermal conductivity, a high radiation damage resistance, and a low coefficient of thermal expansion. V-15Cr-5Ti was recently chosen as the second-generation reference alloy for Argonne's evaluation of the vanadium alloy system. The titanium improves both the resistance of the alloy to radiation-induced swelling and its fabricability, while the chromium improves the creep strength and oxidation resistance. Related alloys under investigation include V-13Cr-3Ti, V-9Cr-3Fe-1Zr (Vanstar-7), V-7.5Cr-1.5Ti, and V-3Ti-1Si.

Martin Marietta Laboratories has developed a new analytical method for determining vanadium, sulfur, and other critical impurities in fuel oil ash.[21] The method, based on inductively coupled plasma atomic emission spectrometry, reportedly is quicker and more effective than atomic absorption. In a related development, the National Bureau of Standards issued a western phosphate rock reference material. The new analytical standard, SRM 694, assays 0.31% V_2O_5 and 0.01414% U by weight and is certified for 11 other inorganic constituents.

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[1]Physical scientist, Division of Ferrous Metals.

[2]The Mining Record. Atlas Reports Gold Discovery at its Gold Bar Properties. V. 96, No. 38, Sept. 19, 1984, p. 1.

[3]Chemical Marketing Reporter. Monsanto to Expand Capacity of Maleic Anhydride Facility; Cites Third-Generation Catalyst. V. 227, No. 19, May 13, 1985, pp. 5, 13.

[4]International Iron and Steel Institute, Committee on Raw Materials (Brussels, Belgium). Vanadium, Niobium, Molybdenum and the Steel Industry. 1984, pp. 1.1-5.83.

[5]Associação Brasileira dos Produtores de Ferro-Ligas (São Paulo, Brazil). Anuario da Industria Brasileira de Ferro-Ligas-1983 (Yearbook of the Brazilian Ferroalloys Industry-1983). 21 pp.

[6]Values can be converted from Canadian dollars (CAN$) to U.S. dollars at the rate of CAN$1.3188=US$1.00.

[7]Whiteway, P. Technology for Vanadium Extraction Moves Toward Commercial Feasibility. The North. Miner (Toronto, Canada), v. 70, No. 30, Oct 4, 1984, p. B9.

[8]Ehrlich, P. C. China Firm Will Handle All Nonferrous Exports. Am. Met. Mark., v. 93, No. 55, Mar. 21, 1985, pp. 1, 6.

[9]Rautaruukki Oy (Helsinki, Finland). 1984 Annual Report. Pp. 10, 34-35.

[10]Lobo, G. Ferro-alloys. Uncertain Future for Indian Producers. Met. Bull. Monthly, No. 159, Mar. 1984, pp. 96-97.

[11]Indian Bureau of Mines (Delhi, India). Ferro-Alloys. Ch. in Indian Minerals Yearbook for 1981. 1984, pp. 486-495.

———. Vanadium. Ch. in Indian Minerals Yearbook for 1981. 1984, pp. 907-912.

[12]Ministry of International Trade and Industry (Japan). Iron and Steel Statistics Monthly Report. V. 34, No. 3, Mar. 1985, p. 11.

[13]Japan Tariff Association. Japan Exports and Imports. V. 12, 1984, pp. 125-126, 312, 433.

[14]Financial Times (London). Desert Island Dream Turns Into Nightmare. No. 29,607, Apr. 24, 1985, p. 3.

[15]Mining Magazine. Somalia Uranium Contract? V. 151, No. 5, Nov. 1984, p. 381.

[16]Highveld Steel and Vanadium Corp. Ltd. (Witbank, Republic of South Africa). 1984 Annual Report. Pp. 4-22.

[17]Mining Magazine. Estonia's Oil Shales—Their Characteristics and Utilization. V. 152, No. 1, Jan. 1985, p. 100.

[18]———. Some Basic Trends in Soviet Oil Shale Mining. V. 152, No. 2, Feb. 1985, p. 184.

[19]Salak, J. UK Strategic Stockpile on Block. Am. Met. Mark., v. 92, No. 222, Nov. 14, 1984, pp. 1, 16.

[20]Smith, D. L., B. A. Loomis, and D. R. Diercks. Vanadium-Base Alloys for Fusion Reactor Applications. Pres. at 1st International Conference on Fusion Reactor Materials, Tokyo, Japan, Dec. 3-6, 1984, 44 pp; available from D. L. Smith, Argonne Natl. Lab., Argonne, IL.

[21]Javellana, M., I. Jawed, and D. Appler. Analysis of Fuel Ash Using ICP-AES. Am. Lab., v. 17, No. 3, Mar. 1985, pp. 28-32.

Vermiculite

By Arthur C. Meisinger[1]

U.S. production of vermiculite concentrate in 1984 increased 12% in quantity sold and used and 16% in value to 315,000 short tons and $31.5 million dollars, respectively. Exfoliated vermiculite sales from 43 plants increased 18% in quantity to 264,000 tons valued at $56.5 million.

W. R. Grace & Co., the largest domestic producer with mines in Montana and South Carolina, produced exfoliated vermiculite at 29 plants in 24 States.

World production of vermiculite increased 12% to an estimated 550,000 tons, after a 5-year decline.

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 45 exfoliating plants to which a request was sent, 43 plants were active and 37, or 86%, responded, representing 84% of the total exfoliated vermiculite sold and used shown in table 1. Plant data for the six 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)

	1980	1981	1982	1983	1984
United States:					
Sold and used by producers:					
Concentrate	337	320	316	282	315
Value	$23,500	$26,200	$28,500	$27,200	$31,500
Average value[1] dollars per ton	$69.73	$81.88	$90.19	$96.45	$100.00
Exfoliated	281	274	235	224	264
Value	$54,500	$58,600	$55,500	$52,200	$56,500
Average value[1] dollars per ton	$193.95	$213.87	$236.17	$233.04	$214.02
Exports to Canada	30	31	22	19	[e]20
Imports for consumption[e]	26	27	21	24	26
World: Production[2]	593	577	560	[p]493	[e]550

[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 increased 12% in quantity sold and used to 315,000 tons and 16% in value to $31.5 million.

The principal mining and beneficiating operations continued to be those of W. R. Grace at Libby, MT, and Enoree, SC. Vermiculite was also mined and processed by Patterson Vermiculite Co. near Encore, SC, and by Virginia Vermiculite Ltd. in Louisa County, VA.

Production of exfoliated vermiculite by 14 companies in 28 States increased 18% in quantity sold and used to 264,000 tons and 8% in value to $56.5 million. Output came from 43 plants, of which 29 were operated by W. R. Grace.

In descending order of exfoliated vermiculite output, the principal producing States were California, Ohio, Florida, South Carolina, Texas, New Jersey, and Illinois.

CONSUMPTION AND USES

Apparent domestic consumption of vermiculite concentrate increased 12% from 287,000 tons to 321,000 tons.

The quantity of exfoliated vermiculite sold and used as construction aggregate material in concrete, plaster, and premixes increased 35%. Insulation uses increased 7%, and agricultural uses increased slightly over those of 1983.

Table 2.—Exfoliated vermiculite sold and used in the United States, by end use

(Short tons)

End use	1983	1984
Aggregates:		
Concrete	46,600	51,600
Plaster	3,300	2,700
Premixes[1]	49,500	80,300
Total[2]	99,500	134,700
Insulation:		
Loose-fill	25,400	25,900
Block	33,800	38,500
Other[3]	4,200	3,300
Total	63,400	67,700
Agricultural:		
Horticultural	22,400	22,100
Soil conditioning	7,800	4,700
Fertilizer carrier	26,800	31,600
Total	57,000	58,400
Other[4]	3,900	3,100
Grand total[2]	224,000	264,000

[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 1984

Company	County	State
A-Tops Corp	Beaver	Pennsylvania.
Brouk Co	St. Louis	Missouri.
W. R. Grace & Co., Construction Products Div	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.
	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.
International Vermiculite Co	Macoupin	Illinois.
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-Intermountain Inc	Salt Lake	Utah.
Vermiculite of Hawaii Inc	Honolulu	Hawaii.
Vermiculite Products Inc	Harris	Texas.

[1]2 plants in county.

PRICES

The average value of vermiculite concentrate sold and used by U.S. producers increased slightly to $100 per ton, f.o.b. plant. The average value of exfoliated vermiculite, f.o.b. plant, decreased for the second straight year from $233 per ton to $214 per ton.

Engineering and Mining Journal quoted yearend prices for unexfoliated vermiculite as follows, per short ton: Montana and South Carolina, f.o.b. mine, $99.50 to $135.50; and the Republic of South Africa, c.i.f. Atlantic ports, $100 to $160.

FOREIGN TRADE

Imports of vermiculite concentrate from the Republic of South Africa were estimated to be 26,000 tons, up slightly from those of 1983. Exports to Canada were estimated to be 20,000 tons and represented 6% of total sales.

WORLD REVIEW

Estimated world production increased 12% to 550,000 tons, reversing a 5-year decline. The United States and the Republic of South Africa, together, accounted for 92% of the total production. Production of vermiculite concentrates in the Republic of South Africa increased 14%, and exports accounted for 91% of production.

[1]Industry economist, Division of Industrial Minerals.

Table 4.—Vermiculite: World production, by country[1]

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Argentina	10,920	3,557	3,697	4,355	4,000
Brazil	13,427	15,771	15,497	15,432	16,500
Egypt	800	800	309	331	360
India	[r]3,779	3,995	2,280	2,658	2,800
Japan[e]	19,000	19,000	19,000	19,000	19,000
Kenya[e]	[2]2,819	2,900	[r]1,700	NA	NA
Mexico	601	657	575	440	550
South Africa, Republic of	204,698	210,101	201,327	168,691	[2]191,536
Tanzania[e]	20	20	20	20	20
United States (sold and used by producers)	337,000	320,000	316,000	282,000	[2]315,000
Total	[r]593,064	576,801	560,405	492,927	549,766

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available.
[1]Excludes production by centrally planned economy countries. Table includes data available through July 9, 1985.
[2]Reported figure.

Zinc

By James H. Jolly[1]

Strikes and the permanent closure of a zinc mine near the end of 1983 resulted in decreased domestic zinc mine production in 1984, the fourth straight year of decline, and the lowest zinc output year in more than 60 years. Smelter production increased, owing mainly to the reopening of a Texas zinc smelter. World zinc mine and smelter production were at record-high levels; the U.S. zinc industry accounted for about 4% of world mine output and about 5% of world smelter output.

Domestic consumption of slab zinc was the highest since 1979 owing to continued overall improvement in the U.S. economy, especially in the area of housing, construction, and automobile manufacture. Zinc prices rose in the first half of 1984, continuing an upward price surge that occurred in the last quarter of 1983. The strong domestic demand for zinc in 1984 was met to a large extent by imports, which reached record-high levels in 1984. Canada supplied more than one-half of the imports; Peru and Mexico were also major suppliers. In the latter half of the year, demand waned, resulting in a sharp drop in zinc prices, reduced consumption levels, and a reduction in slab zinc imports.

Table 1.—Salient zinc statistics

(Metric tons unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production:					
Domestic ores, recoverable content	317,103	312,418	303,160	275,294	252,768
Value thousands	$261,671	$306,879	$257,116	$251,204	$270,833
Slab zinc:					
From domestic ores	231,850	259,835	193,284	210,315	197,912
From foreign ores	108,606	86,728	34,892	25,379	55,220
From scrap	29,396	50,192	74,288	69,390	78,113
Total	369,852	396,755	302,464	305,084	331,245
Secondary zinc[1]	274,967	290,658	210,681	279,237	320,456
Exports:					
Ores and concentrates (zinc content)	54,457	54,232	77,289	60,168	30,579
Slab zinc	302	323	341	427	760
Imports for consumption:					
Ores and concentrates (zinc content)	182,370	245,710	66,809	63,156	86,172
Slab zinc	410,163	612,007	456,233	617,679	639,228
Stocks of slab zinc, Dec. 31:					
Producer and consumer	92,151	126,581	111,777	112,940	118,834
Merchant	33,650	68,773	47,397	35,199	18,792
Government stockpile	342,380	340,581	340,578	340,577	340,577
Consumption:					
Slab zinc	811,146	840,875	709,491	805,891	848,903
All classes	1,142,409	1,189,369	953,111	1,120,548	1,214,558
Price: High Grade, cents per pound (delivered)	37.43	44.56	38.47	41.39	48.60
World:					
Production:					
Mine thousand metric tons	[r]5,954	[r]5,845	6,054	[p]6,160	[e]6,419
Smelter do	[r]6,049	[r]6,085	5,861	[p]6,201	[e]6,448
Price: Prime Western, London, cents per pound	34.47	38.34	33.74	34.73	40.46

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Excludes redistilled slab zinc.

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 "Slab Zinc" consumption survey. Of the 426 operations to which the survey request was sent, 318 responded, representing an estimated 86% of the total slab zinc consumption shown in tables 1, 15, 16, and 17 and an estimated 59% of total consumption of all classes shown in tables 1 and 15. Consumption for the remaining 108 nonrespondents was estimated using prior year consumption levels, trends in consumption, or other guidelines.

Legislation and Government Programs.—The National Defense Stockpile (NDS) goal for zinc was 1,292,739 metric tons, unchanged since May 1980. The total zinc inventory held by the Government at yearend 1984 was 343,240 tons including 2,625 tons of zinc in the form of brass. The zinc stockpile, other than brass, was composed of 183,175 tons of High Grade (HG) slab zinc, 121,750 tons of Prime Western (PW) slab zinc, and 35,653 tons of other grades of slab zinc.

Legislation to continue the suspension of import duties on zinc ore, concentrate, and scrap for an additional 5-1/2 years to December 31, 1989, was approved in October in Public Law 98-753, the Trade and Tariff Act of 1984. Because the above public law was enacted after the expiration of the previous legislation permitting the duty suspension, zinc ores, concentrates, and scrap were dutiable materials for about 4 months in 1984.

The Environmental Protection Agency (EPA) established final effluent discharge limitations and standards for smelters and refiners of nonferrous metals. Under the rules that took effect in April, smelters and refiners of zinc were under a 3-year deadline to remove 86% of toxic impurities from wastewater discharges and 90% of pollutants such as ammonia and fluoride.

In February, EPA issued a final rule limiting particulate emissions from new metals-processing plants or those plants whose construction began after August 24, 1982. The regulated plants are those that process ores into concentrates containing one or more of a number of metals, including zinc. The ruling was based on the best demonstrated technology and limited the concentration of particulate matter in stack emissions to 0.05 gram per dry standard cubic meter.

Legislative proposals to reauthorize and amend the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), which was due to expire on September 30, 1985, failed in 1984. One bill, House bill 5640, was approved in 1984 by the House of Representatives, but similar legislation in the Senate did not pass. The House bill proposed to continue the taxes on zinc chloride and zinc sulfate and would add zinc metal and zinc oxide to the list of taxable materials.

DOMESTIC PRODUCTION

MINE PRODUCTION

U.S. mine output of recoverable zinc was the lowest since 1921 owing mainly to strikes at zinc-producing mines in Missouri and Tennessee and to the closure of the Friedensville, PA, zinc mine in late 1983. Tennessee was the principal zinc-producing State in 1984, a position the State has held 24 times in the last 27 years. New York and Missouri were the second and third leading States in mine output. The leading U.S. zinc producers were ASARCO Incorporated; St. Joe Minerals Co., a subsidiary of Fluor Corp.; and Jersey Minière Zinc Co.

The 25 leading U.S. zinc-producing mines accounted for 99% of the recoverable zinc mined, with the 10 leading mines accounting for 84%.

In Tennessee, zinc was produced from zinc ore at eight underground mines and from iron-sulfur-copper-zinc ore at Copperhill. Asarco, operator of four mines—Young, New Market, Immel, and Coy—was the leading producer in the State. According to the company's annual report, Asarco milled 2.6 million tons of ore producing 61,050 tons of zinc in concentrate, slightly more than that produced in 1983. Ore reserves at the four mines were 6.32 million tons averaging 3.36% zinc at yearend.

Jersey Minière operated two mines, the Elmwood and Gordonsville, and was the second leading producer in Tennessee. Production was near capacity, 5,400 tons of zinc concentrate per month, until early August when the mines closed because of a strike. The strike was settled in mid-October, but full production was not attained until December. In May, Gulf + Western Industries Inc. (G+W) sold its 60% share in Jersey Minière to Union Zinc Co., its partner in the company. Union Zinc is a subsidiary of the Belgian company, Union Minière S.A.

The Beaver Creek Mine near Jefferson City, TN, which was sold to Inspiration Resources Corp. in July 1983 by G+W, resumed production in January after a 12-month shutdown. Ore was processed at the company's Jefferson City mill; however, the Idol and Jefferson City Mines, also part of the G+W sale, did not reopen.

Zinc produced in Missouri was a coproduct of lead at seven underground lead mines, all located along the Viburnum Trend. Because of extended strikes at six mines, zinc production was down 20% from that of 1983 and was the lowest recorded by the State since 1969. On April 1, 1984, union workers struck St. Joe's five lead mines and three mills, and on June 1, the Buick Mine, owned jointly by AMAX Lead & Zinc Inc. and Homestake Mining Co., was struck. Despite the strikes, the companies continued to operate the mines, although at reduced levels, using supervisory personnel and nonunion workers. The above strikes were settled December 9 and December 29, respectively; however, in settling, the unions accepted reductions in wages, holidays, cost-of-living adjustments (COLA), and health benefits.

The Magmont Mine, owned jointly by Cominco American Incorporated and Dresser Industries Inc., was the only operating Missouri lead mine not struck. According to Cominco, the company milled slightly more than 1 million tons of ore grading 2.1% zinc and produced a record high 30,000 tons of concentrate containing 18,000 tons of zinc. The record-high output was attributable to increased mining activity in the new Magmont West area, which contained higher-than-average zinc grades, and to the introduction of more efficient mining equipment. Ore reserves at yearend were 7.2 million tons averaging 6.5% lead, 1.2% zinc, and 0.36 ounce of silver per ton.

Output of zinc in concentrate at the Buick Mine fell about 30% owing mainly to the strike. In 1984, 1.36 million tons of ore grading 8.1% lead and 1.8% zinc were milled at Buick yielding 20,800 tons of zinc in concentrate. At yearend, ore reserves at the Buick Mine were 32.7 million tons grading 5.6% lead and 1.4% zinc.

St. Joe began initial production at its new lead-zinc-copper Viburnum No. 35 Mine at Bixby, MO. The ore was processed at the company's nearby Viburnum mill, which was expanded in 1983 to accommodate the new mine's anticipated 3,600-ton-per-day ore production. At capacity, St. Joe expected to produce 41,000 tons of lead and 5,000 tons of zinc annually at the new operation. Asarco continued underground development of its West Fork, MO, lead mine. When this development phase is completed, scheduled for early 1985, the company expected to be in a position to bring the mine on-stream within 9 months after a decision is made to begin production. The West Fork mill, which was completed in 1983, was capable of processing 3,450 tons of ore per day and producing 40,000 tons of lead, 7,000 tons of zinc, and 125,000 ounces of silver in concentrate annually. Ore reserves were estimated to be 14 million tons averaging 5.5% lead and 1.2% zinc, with silver and some copper.

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 3,900 tons per day. Zinc recovery from ore was about 94% with a concentrate grade of about 58% zinc. The concentrates were mainly processed at the company's zinc refinery at Monaca, PA. A toll arrangement with several foreign smelters that resulted in St. Joe receiving Special High Grade (SHG) slab zinc for concentrate, expired in April and was not renewed. The total ore reserves of St. Joe's New York mines were estimated to be 19.5 million tons averaging 10.8% zinc at yearend. Included in the total was about 1.8 million tons of ore grading 17% zinc at the Pierrepont Mine.[2]

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 Co. subsidiary, and from the Sunnyside gold mine owned by Standard Metals Corp. Asarco reported that it milled 194,000 tons of ore, slightly more than in 1983, resulting in production of 13,150 tons of zinc in concentrate plus 6,080 tons of lead, 363,000 ounces of silver, and 17,950 ounces of gold. Yearend ore reserves at the Leadville Mine were 960,000 tons, averaging 9.42% zinc, 4.49% lead, 0.2% copper, 2.82 ounces of silver per ton, and 0.11 ounce of gold per ton. Standard Metals reported production at a rate of about 900 tons of ore per day until September when an unexpected geological fault in the newly developed Portland vein made it impossible to continue normal operations. Because the fault will cause mining problems, ore production was expected to be sharply reduced in early 1985. Yearend ore reserves at the Sunnyside Mine were estimated to be 1.5 million tons averaging about 3.3% zinc, 2.3% lead, 0.3% copper, 1.5 ounces of silver per ton, and 0.2 ounce of gold per ton.

In Idaho, Hecla Mining Co.'s Lucky Friday Mine was, by far, the State's largest zinc producer. Minor zinc production also came from a few silver mines, and in the second half of 1984, from Hecla's Star Mine, which was leased by CS&C Mining Co. Hecla reportedly milled 233,000 tons of ore and produced 3,000 tons of zinc in concentrate at the Lucky Friday Mine during 1984. Ore reserves at the Lucky Friday were up 21% owing to extensive development work and, at yearend, totaled 569,300 tons averaging 13.2% lead, 1.6% zinc, and 19.3 ounces of silver per ton.

In Alaska, both the Red Dog and Greens Creek mining projects progressed toward development. Cominco and the NANA Regional Corp. planned to complete in 1985 the final detailed engineering programs at their Red Dog deposit in northwest Alaska on a schedule that would allow startup by 1989 if a decision to proceed was made in 1985. Red Dog reserves were estimated by Cominco to be 77 million tons of ore averaging 17.1% zinc, 5% lead, and 2.6 ounces of silver per ton. Plans called for the deposit, which is flat-lying and close to the surface, to be mined by open pit methods at a rate of 2 million tons per year when in full production. Capital costs of the project were estimated to be between $400 and $500 million. At yearend, the State government was considering legislation to provide about $150 million in financial assistance to construct port and road facilities to serve the Red Dog area.

Noranda Ltd. and its partners continued exploration of their Greens Creek silver-zinc-lead deposit on Admiralty Island. Early in 1984, the U.S. Forest Service approved the company's general plan of operations for the mine, paving the way for infrastructure development including a 14.8-mile road and marine terminal facilities. Ore reserves were estimated to be about 3.9 million tons averaging 9.31% zinc, 3.37% lead, 0.45% copper, 19.3 ounces of silver per ton, and 0.15 ounce of gold per ton. Surface drilling confirmed the presence of a new north ore zone supporting the contention that geological reserves could be in the order of 9 million tons. Plans called for mine startup in 1987 at a milling rate of 270 tons per day increasing to 750 tons per day as mine development and market conditions allowed.

Permitting and zoning problems continued to delay Exxon Minerals Co.'s plans to develop the huge zinc-copper Crandon deposit in Wisconsin. All permitting and zoning applications have been submitted; however, decisions on some permits were not expected until 1987, thereby delaying possible production until the early 1990's.

U.S. Minerals Exploration Co. and Centennial Minerals Ltd. completed a favorable feasibility study in 1984 on their Montana Tunnels silver-gold-zinc-lead deposit located about 35 miles north of Butte, MT. The companies were obtaining environmental operating permits and seeking financing at yearend. Ore reserves at Montana Tunnels were estimated to be 59 million tons averaging 0.67% zinc, 0.28% lead, 0.4 ounce silver per ton, and 0.03 ounce gold per ton. Plans called for development of an open pit mine in 1986 or 1987 producing about 5 million tons of ore per year resulting in an annual production of about 25,000 tons of zinc, 8,000 tons of lead, and significant amounts of silver and gold.

Silver King Mines Inc. continued development of its $20 million silver-zinc-lead-copper Ward Mountain Mine near Ely, NV. Silver King was completing two parallel 4,500-foot declines to the ore body and began site preparation for a 1,100-ton-per-day mill. The project, anticipated to come on-stream in 1986, was expected to have an annual production of about 17,000 tons of zinc in concentrate. Ore reserves were estimated by the company to be about 15.5 million tons averaging 5.5% zinc-lead, 1.4% copper, and 3 ounces of silver per ton.

SMELTER AND REFINERY PRODUCTION

Primary zinc production increased in 1984 owing mainly to the reopening of Asarco's zinc refinery at Corpus Christi, TX. Strikes at two smelters, AMAX's Sauget, IL, plant and Jersey Minière's Clarksville, TN, plant, were relatively short-lived and had little effect on U.S. zinc production.

Asarco reopened its 104,000-ton-per-year zinc refinery beginning in February as part of an agreement with labor unions in return for wage concessions and a suspension of COLA for 2 years. Metal production commenced in May; however, because of shortages of traditional zinc oxide fume feed materials, the company operated the plant at about 50% of capacity, resulting in zinc production of only 28,500 tons. Late in the year, Asarco announced plans to indefinitely suspend operations at the refinery in the second quarter of 1985 because of high costs and declining zinc prices. In anticipation of the closure, the company reportedly took a $120 million write-down against its 1984 results.

Jersey Minière's zinc refinery at Clarksville, TN, operated at near its 82,000-ton-per-year capacity until July, when output was cut to 75% of capacity because of weakening zinc demand, increasing stock levels, and falling zinc prices. A strike in August and September did not appreciably reduce refinery production. Additional purchases of concentrate were necessary because the company's mines, which supplied about one-half of the refinery's feed, were closed down.

St. Joe bought the National Zinc Co., including its 51,000-ton-per-year electrolytic zinc smelter at Bartlesville, OK, in August, and as a result, became the largest U.S. zinc-smelting company, with an annual capacity of 142,000 tons. Because St. Joe's 91,000-ton-per-year electrothermic zinc smelter at Monaca, PA, produced primarily PW galvanizing grades, dust, and oxide, the acquisition of an electrolytic zinc refinery that produces SHG and HG zinc was expected to allow the company to penetrate most zinc markets.

Zinc Oxide.—The sources of domestic zinc oxide production were 36% from ores and concentrates, about 31% from slab zinc, and 33% from secondary materials. French-process zinc oxide accounted for about 64% compared with 67% in 1983. Lead-free zinc oxide was produced at 11 plants, and leaded zinc oxide at 1 plant. The largest producers of zinc oxide were Asarco; The New Jersey Zinc Co. Inc. (NJZI), Pacific Smelting Co, and St. Joe.

Zinc oxide production at Asarco's two plants, located at Columbus, OH, and Hillsboro, IL, was 31,860 tons in 1984 compared with 29,500 tons in 1983. Asarco reportedly wrote down the value of its zinc oxide plants by $5 million against the company's 1984 results; however, Asarco planned to continue both operations.

In March, T. L. Diamond & Co. Inc. purchased the Hillsboro, IL, zinc oxide manufacturing facilities of the Sherwin-Williams Co. Sherwin-Williams acquired the facilities in 1980 from Eagle-Picher Industries Inc. but closed them in June 1983. The plant, which has a monthly zinc oxide production capacity of about 1,350 tons, resumed operations in mid-1984 as Eagle Zinc Co., a division of T. L. Diamond. Zinc sludges, drosses, skimmings, and residues were the principal raw materials for its zinc oxide production.

Pacific Smelting reported that it increased output of zinc oxide and other zinc products by 45% to 29,000 tons at its plants at Torrance, CA, and Memphis, TN. The zinc plants, which process zinc scrap and waste materials, operated at 60% of capacity in 1984 compared with 40% 1 year earlier.

In August, zinc production at NJZI's Sterling Mine in New Jersey and Palmerton, PA, zinc oxide plants was sharply reduced owing to a 3-week strike by union workers. The plant, which has a zinc oxide production capacity of about 82,000 tons, produced both French- and American-process zinc oxide.

Zinc Salts.—Zinc sulfate was produced by about 12 companies from secondary materials and concentrate. Zinc chloride was produced entirely from secondary materials by seven companies.

Slag Fuming Plants.—No domestic slag-fuming plants operated, although substantial quantities of zinc-bearing lead blast furnace slags continued to accumulate at lead smelters. Asarco's slag-fuming plants at East Helena, MT, and El Paso, TX, were expected to be closed permanently because the company wrote off all of their asset value against 1984 results.

Byproduct Sulfur.—Production of sulfur in byproduct sulfuric acid from five primary zinc plants and one zinc oxide plant was 144,700 tons, up from 125,500 tons in 1983. More zinc sulfide concentrates were processed, owing mainly to the reopening of a primary zinc refinery in Texas. The estimated value of the sulfuric acid produced was $14.5 million.

CONSUMPTION AND USES

Zinc consumption for most end-use categories improved. The construction industry accounted for about 43% of zinc consumption, followed by transportation, 21%; machinery, 11%; electrical, 9%; and chemical and other industries, 16%.

Galvanizing, mainly for sheet and strip, continued to be the principal use of slab zinc, consuming about 44%; followed by zinc-based alloys, 27%; brass and bronze alloys, 15%; rolled zinc, 7%; and other uses, 7%. Of the zinc metal grades, SHG accounted for 53% of the slab zinc consumed and was used mainly for the production of zinc-based alloys. The Bureau of the Mint used about 33,500 tons of SHG for penny production that, for the year, totaled 13.72 billion pennies. PW was second in slab zinc consumption and was used mainly for galvanizing.

Zinc-based diecasting alloys produced from refined metal and from scrap increased 6% over that of 1983, mainly in response to stronger demand in 1984 by the automotive industry. The estimated percentage distribution of zinc die-cast shipments in 1984 by market area, based mainly on 1983 data,[3] was as follows: automotive, 35%; builder's hardware, 27%; machinery and household appliances, 18%; electrical components, 13%; and other equipment, 7%.

The average U.S.-built automobile utilized an estimated 23.0 pounds of zinc diecastings, up from 22.6 pounds used in 1983 models, according to a yearend survey by Zinc Institute Inc. (ZI).[4] The small increase ended a 9-year decline in zinc die-cast usage in domestically manufactured automobiles. In addition to the above, an estimated 9.5 pounds of zinc diecastings were used in optional equipment in the 1984 models. Zinc die-cast usage in trucks and buses was not included in the survey; however, new trucks were estimated to have averaged about 20 pounds of aftermarket or optional equipment zinc diecastings.

The automobile industry increased its use of zinc for corrosion protection of its products. According to a ZI report,[5] the typical U.S.-built 1984 automobile contained 6.15 pounds of zinc as coating materials in the form of galvanized, electrogalvanized, galvannealed, and zincrometal coated steel. This represented a 0.63-pound gain over the 1983 model average of 5.52 pounds. If zinc-rich paint and a 35% offal factor from coated steel stampings is included, the zinc used for corrosion protection per domestic built car averaged about 10.6 pounds in 1984 compared with 9.74 pounds in 1983. Further increases in the quantities of zinc used for automobile corrosion protection were expected. A number of domestic steel companies, in response to announced automobile industry material requirements, were adding about 2.2 million tons of electrogalvanizing capacity to meet the anticipated demand.

Zinc consumption in copper-based alloys by brass mills, ingot makers, foundries, and powerplants increased to the highest levels since 1979. According to Copper Development Association Inc.'s data for 1984, the brass and bronze industry consumed 317,600 tons of zinc, the source of which was divided about equally between slab zinc and scrap materials.[6] Brass mills accounted for more than 85% of this category's zinc consumption.

The apparent consumption of zinc oxide was about 186,000 tons, up from 162,000 in 1983. Reported shipments of zinc oxide increased, with the largest tonnage increase going to the rubber industry. Reported zinc sulfate shipments were up; however, the agricultural sector, which accounted for 76% of reported zinc sulfate shipments, was down about 1,200 tons from that of 1983.

STOCKS

Slab zinc stocks held by domestic producers, consumers, and merchants were less at yearend 1984 than at the start of the year. Producers' stocks tended to be low in the first 4 months, but with the onset of weakening demand and falling zinc prices in the May-July period, producers' stocks rose sharply and remained high through December. Conversely, consumer and merchant stocks decreased after midyear, reflecting the changing market conditions. The consumers' stock position, particularly, reflected expectations of lower zinc prices. World stocks at yearend, exclusive of the NDS and the centrally planned economy countries, totaled about 628,000 tons, 40,000 tons less than at the end of 1983, according to the International Lead and Zinc Study Group (ILZSG).[7] World producers' stocks were up 75,000 tons to 420,000 tons at yearend but consumer, merchant, and London Metal Exchange (LME) stocks were down substantially.

Stocks of slab zinc at the LME ended 1984 at 29,300 tons, down from 96,700 tons 1 year earlier. The severe drop in stocks was caused largely by the initial phasing out of the longstanding standard, good ordinary brand (GOB) zinc contract and the phasing in of the LME's new HG zinc contract, which was inaugurated in September. GOB stocks tended to fall substantially in 1984 owing to the contract change, whereas replacement HG zinc stocks were not readily available during much of the year. The two zinc contracts were scheduled to operate in tandem until November 29, 1985; thereafter, GOB trading would be restricted to a cash position only and was anticipated to wither away in a short time because of inactivity.

PRICES

U.S. zinc prices rose in the first half of 1984 continuing the upward trend in prices that began in the last quarter of 1983. In early January, amid continuing strong demand and expectations of further market gains, North American producers raised quoted price for benchmark HG zinc metal from 49 to 51 cents per pound. In mid-March, the producers' price was increased to 53 cents per pound owing to continued positive market factors, including high bid prices at the February U.S. Mint tender for SHG metal. Because of high zinc prices, a number of domestic steel producers imposed surcharges on galvanized sheet products. The surcharge ranged up to $66 per ton, depending on the zinc coating weight and gauge of the sheet. Zinc prices began to weaken in May because of decreasing demand and consumer-anticipated reduced price levels in the summer months. Under pressure of dealer discounting, HG zinc prices fell 2 cents on June 20 to 51 cents per pound. Zinc prices continued to weaken through the summer, mainly in response to low price bidding at U.S. Mint tender in July and September, continued dealer discounting, and a buildup of producer stocks. On September 18, the producers' price for HG zinc fell 3 cents per pound to 45 cents. Producers retained this price throughout the remainder of the year; however, price discounting was widespread. The Metals Week price for U.S. HG zinc averaged about 51.3 cents for the first half of 1984 and 42.6 cents for the second half.

The European producer price (EPP) for zinc increased from $982 per metric ton to $1,090 in April. The EPP weakened in June, paralleling the drop in the U.S. market, and ended the year at $900 per ton. The LME price for GOB metal similarly paralleled the U.S. market; however, because of currency differences, the LME monthly average zinc price, in terms of British pounds, was higher in December than any previous month of 1984.

American- and French-process lead-free zinc oxide at the beginning of the year were quoted at 53 to 53.5 cents and 55 cents per pound, respectively. Because of strong demand, mainly by the rubber industry, zinc oxide prices declined only slightly in the latter half of 1984, unlike the steady erosion of metal prices during the same period. At yearend, the respective quoted prices were at the same level as at the beginning of 1984. Photoconductive zinc oxide was generally priced 1 to 3 cents higher than French-process zinc oxide.

The quoted price for zinc sulfate, granular monohydrate industrial grade, 36% zinc in bags in carload lots, was $26.50 to $29.00 per 100 pounds. Agricultural zinc sulfate in bulk was quoted at $20 per 100 pounds. Technical-grade zinc chloride, 50% solution, in tanks, was quoted at $12.25 to $18.20 per 100 pounds in the first half of 1984 and $12.25 to $18.40 in the last half. Standard pigment-grade zinc dust, types 1 and 2 in drums, was quoted at 59 to 62 cents per pound at the beginning of the year. The high quote rose to 64 cents in April and 67 cents in June, where it remained to yearend.

FOREIGN TRADE

Slab zinc imports in 1984 were at record-high levels, exceeding by 3,000 tons the previous high set in 1976. Almost 60% was imported in the first half of 1984; in the second half, imports declined because of falling demand. Zinc oxide imports were also at record-high levels in 1984.

Imports for consumption of ores and concentrates were up 36% over those of 1983 owing mainly to the reopening of Asarco's zinc refinery in Texas. Slightly more than one-half of the concentrates were imported in the fourth quarter of 1984 after legislation was passed to continue the duty suspension on concentrates. Exports of ores and concentrates declined sharply, owing mainly to the late-1983 closure of the Friedensville, PA, mine, whose output was largely exported, and to the termination by St. Joe of a toll concentrate processing contract with a Canadian smelter.

The penalty duty on slab zinc imports

from Spain, initially imposed in 1977 to counteract Government subsidized production and cost advantages, was lifted in October because U.S. producers failed to request another injury investigation. Because Spanish producers had filed on April 23, 1982, to request a hearing to have the penalty removed, the penalty duty suspension was made retroactive to that day.

Table 2.—U.S. import duties for zinc materials, January 1, 1984

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1984	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1984
Zinc oxide, dry	473.76	0.6% ad valorem	Free	5.5% ad valorem.
Ores and concentrates[1]	602.20	0.44 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	1.7% ad valorem	1.5 cents per pound.	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	3.3% 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 slab zinc was an estimated record high 6.4 million tons in 1984, up marginally over the previous record-high year, 1979, and 0.2 million tons over that of 1983. In the market economy countries, slab zinc consumption was about 4.7 million tons, up about 100,000 tons from the 1983 level and the third highest ever recorded. Consumption was about the same as in 1983 or slightly lower in Africa, Asia, and Oceania, and up in Europe and the Americas. Consuming countries exhibiting substantial increases in consumption were the United States, the Federal Republic of Germany, Peru, France, and Brazil. India was the only country showing an appreciable drop in consumption.

World mine output increased 0.2 million tons to 6.4 million tons. Canada, Spain, Mexico, and Ireland produced significantly more zinc, whereas the United States and Australia produced significantly less, mainly because of labor problems during the year. World zinc mine capacity at yearend was about 8.2 million tons per year, up about 120,000 tons from that of 1983, owing largely to expansions and the opening of new mines in Canada, Mexico, Peru, and Thailand. Net losses in mine capacity occurred principally in the United States.

World primary smelter capacity was about 7.8 million tons at yearend 1984, up about 65,000 tons. The increase was principally due to the opening of a 60,000-ton-per-year zinc plant in Thailand. New smelter capacity under construction in Brazil, Canada, Italy, Norway, and Yugoslavia was expected to add about 180,000 tons to world capacity in the next 2 years.

According to ILZSG, stocks of slab zinc in the market economy countries were 668,000 tons at the beginning of 1984, fell 56,000 tons by the end of March, rose steadily through August to a high of 691,000 tons, and ended the year at 628,000 tons.

World prices for zinc increased in the first half of 1984, led by strong demand in the United States and supply tightness on the LME due, in part, to large purchases of zinc by China and the U.S.S.R. The buildup of zinc stocks in the middle of the year, and reduced demand in Europe and the United States, resulted in falling prices and reduced smelter production in the second half of 1984.

In Europe, the European Commission (EC) imposed fines on six zinc producers for implementing anticompetitive market practices between 1964 and 1976. The EC's plan to reduce excess zinc smelting capacity in the European Economic Community was abandoned in 1984 mainly because of improved zinc market conditions and governmental reluctance to close smelters because of strategic or employment reasons. Late in the year, Union Minière announced a restructuring of its French zinc operations. The company planned to double the capacity of its 100,000-ton-per-year zinc smelter at Arby and close the 100,000-ton-per-year smelter at Viviez. In another action, the EC approved a number of galvanizing projects at steel mills; however, preference was given to these projects that represented only modernization without adding to overall galvanizing capacity.

Australia.—Australia was the world's third largest mine producer of zinc. Although production was substantially down from the record-high production of 1983 because of labor strikes at a number of operations, mine output in 1984 was the second highest on record. Many mines recorded lower production; however, production was up at the Mount Isa, Elura, and Teutonic Bore Mines. Concentrate exports were up for the sixth straight year. Smelter output was the highest since 1979. Exports of slab zinc were up for the fourth straight year.

North Broken Hill Holdings Ltd. (NBHH) became a major factor in the Australian zinc industry in August following its acquisition of EZ Industries Ltd. (EZI), Australia's third largest zinc producer. The two companies had been large stockholders in each other, and NBHH was a significant supplier of concentrate to EZI's zinc refinery in Tasmania for many years. EZI's zinc properties acquired by NBHH included the West Coast Mine in Tasmania, the newly opened Elura Mine in New South Wales, the 214,000-ton-per-year Risdon zinc refinery in Tasmania, and one-third interest in the developing Golden Grove zinc-copper deposit in Western Australia. For the fiscal year ending June 30, NBHH's North Mine at Broken Hill produced about 28,700 tons of zinc in concentrate, down about 22% from that of 1983 owing to a strike and the mining of lower grade ores. At the end of June, ore reserves at the North Mine totaled 4 million tons at a minable grade of 12.8% lead, 10.3% zinc, and 6.6 ounces of silver per ton. An additional 2.3 million tons of slightly lower grade probable ore was also identified.

In Tasmania, EZI milled 499,000 tons of ore from its three West Coast Mines, and 163,000 tons of purchased ore from the Que River Mine, producing 128,400 tons of concentrate containing about 66,900 tons of zinc in the fiscal year ending June 30. Output was down 14% from fiscal year 1983 owing to a 2-month labor strike. EZI's Elura Mine completed its first full year of production in fiscal year 1984 milling 711,000 tons of ore yielding 88,466 tons of zinc concentrate and 44,702 tons of silver-lead concentrate. The concentrates contained about 47,700 tons of zinc, 24,800 tons of lead, and 1.2 million ounces of silver. At the end of June, Elura's ore reserves were 26.5 million tons grading 8.3% zinc and 5.6% lead with 4.7 ounces of silver per ton.

Aberfoyle Ltd., 47% owned by Cominco, produced 198,000 tons of ore at its Que River Mine in Tasmania in 1984 compared with 222,000 tons in 1983. Production as well as ore shipments to EZI's mill at Rosebery were affected by strikes at the mine. Aberfoyle, drilling 2 miles north of Que River at Hellyer, discovered a new zinc-lead-silver deposit containing an estimated 16.3 million tons of ore grading about 18.2% combined zinc and lead with 4.7 ounces of silver per ton and some gold. Underground exploration of the deposit was planned to start in 1985. Aberfoyle's ore reserves at the Que River deposit at yearend were 1.9 million tons grading 12.1% zinc, 7.0% lead, and 6.6 ounces of silver per ton.

In the fiscal year ending June 30, MIM Holdings Ltd. produced a record high 184,636 tons of zinc in concentrate in treating 4.1 million tons of ore averaging 6.8% zinc at its Mount Isa Mine in Queensland. Mount Isa concentrates were largely exported. Zinc-lead ore reserves at the Mount Isa Mine at the end of the fiscal year were 42 million tons averaging 6.7% zinc, 5.9% lead, and 4.9 ounces of silver per ton. MIM announced the discovery of a new silver-lead-zinc ore body near its Hilton deposit, 12 miles north of Mount Isa. The new ore body, known as Hilton North, was thought to be potentially economic and of the same magnitude as the Hilton deposit, which has 2 million tons of in-place ore reserves averaging 10.5% zinc, 6.2% lead, and 4.5 ounces of silver per ton and 43 million tons of similar grade probable ore reserves. Trial mining was scheduled to start at the Hilton deposit in 1986.

Conzinc Riotinto of Australia Ltd. (CRA) had a combined production of zinc in concentrate of 151,000 tons at its two companies, Zinc Corp. Ltd. (ZC) and New Broken Hill Consolidated Ltd. (NBHC), located at Broken Hill, New South Wales. Zinc production was 53,000 tons less than in 1983 owing to strikes and the processing of lower grade ores. At yearend, ZC had 10.5 million tons of proved ore reserves grading 10% lead, 9.5% zinc, and 2.9 ounces of silver per ton, and NBHC had 18.3 million tons of ore reserves grading 11.5% zinc, 7.5% lead, and 1.9 ounces of silver per ton.

Woodlawn Mines Ltd., a joint venture of St. Joe, Phelps Dodge Corp., and NBHC, milled about 535,000 tons of ore producing 39,000 tons of zinc in 71,000 tons of concentrate at its open pit Woodlawn Mine in New South Wales. At yearend, Woodland's reserves of complex ore were 1.0 million tons averaging 13.2% zinc, 4.6% lead, 1.9% copper, and 1.9 ounces of silver per ton. Open pit production was expected to end in 1987 with the exhaustion of reserves. Woodland was continuing exploration to determine the feasibility of mining the deeper extensions of the ore body by underground methods. In September 1984, Phelps Dodge announced that it was selling the company's one-third share in Woodland to NBHC for $5 million.

Nicron Resources Ltd., 74%; Lachlan Resources NL, 16%; and Petrocarb Exploration NL, 10%; planned to develop, for about $10 million, the Woodcutters zinc-lead-silver deposit in the Northern Territory. Ore reserves were estimated to be 1.1 million tons averaging 14% zinc, 7.7% lead, and 5.7 ounces of silver per ton. Plans called for open pit production to start in 1986 followed by underground mining in a few years. The annual open pit production was expected to average about 23,000 tons of zinc, 11,000 tons of lead, and 600,000 ounces of silver.

Refined metal output at EZI's Risdon zinc refinery was 185,819 tons, only marginally higher than for fiscal year 1983 despite having improved hydroelectric power availability. Strikes at mines supplying concentrate and several work stoppages at the refinery limited production. Australia's other two zinc refineries operated at near capacity in 1984.

Brazil.—Cia. Paraibuana de Metais planned to begin a $15 million expansion in early 1985 at its zinc plant at Juis de Fora, Minas Gerais. The project would double capacity to 60,000 tons per year by 1987. Cia. Industriel e Mercantil Inga S.A. began a $12 million expansion to increase the capacity of its Itaguai zinc smelter to 24,000 tons per year by 1986. As a result of these expansions, Brazil's refined zinc annual capacity was expected to increase to 149,000 tons in 1987 from 110,000 tons in 1984.

Canada.—Mine production was up sharply in 1984 and accounted for about one-fifth of world output. The increase was attributable to a full year's operation at the Pine Point zinc-lead mine in the Northwest Territories, which in 1983 was closed during the first half of the year, and to higher production levels at several of the larger zinc mines. The principal zinc producers in 1984 were Cominco, Noranda, and Kidd Creek Mines Ltd. More than one-half of the zinc production came from four mines: Noranda's Brunswick Mining and Smelting Corp. Ltd. (BMS) No. 12 Mine in New Brunswick, Kidd Creek's mine at Timmins, Ontario, and Cominco's Pine Point and Polaris Mines in the Northwest Territories.

Refined zinc production was at an alltime high of 685,000 tons, up considerably from the 617,000 tons produced in 1983. The four primary smelters operated at about 98% of combined capacity in 1984.

BMS, 64% owned by Noranda, milled 3.56 million tons of ore at the No. 12 Mine, slightly more than the 3.41 million tons milled in 1983. Zinc production in concentrate totaled 258,100 tons or about 21% of total Canadian production in 1984. BMS's ore reserves at yearend were 79.5 million tons grading 9.15% zinc, 3.72% lead, 0.31% copper, and 8.86 ounces of silver per ton. An additional 25 million tons of similar grade probable ore reserves was also indicated.

Kidd Creek operated at full capacity in 1984, milling a record high 4.51 million tons of zinc-copper ore, compared with 4.15 million tons milled in 1983. Zinc mine output was an estimated 210,000 tons of which about one-half was produced for sale in 1984. Kidd Creek produced 122,000 tons of refined zinc at its 127,000-ton-per-year zinc plant. A program to upgrade the cell house in the zinc plant was expected to increase the capacity to 134,000 tons per year in 1986. At yearend, ore reserves at the Kidd Creek Mine were 67.6 million tons averaging 4.9% zinc, 3.2% copper, and 2.1 ounces of silver per ton.

Zinc production at the open pit Pine Point Mine was 161,200 tons contained in 274,700 tons of concentrate from milling 2.3 million tons of ore. All of the zinc concentrate was shipped to Cominco's zinc smelter at Trail, British Columbia. Because pit development was limited, a study was underway to determine the feasibility of underground mining of ore zones deeper than 300 feet in the western part of the mine. A decision on underground mining viability was expected by mid-1985. At yearend, ore reserves were 22 million tons averaging 6.0% zinc and 2.7% lead. In December, Cominco sold a number of shares in Pine Point Mines Ltd., reducing its ownership to 51% from 69%.

The Polaris zinc-lead mine, the world's

most northerly metal mine, on Little Cornwallis Island, Northwest Territories, completed its second full year of production. In 1984, 819,000 tons of ore was milled, yielding 107,400 tons of zinc and 28,400 tons of lead in 211,000 tons of concentrates. The concentrate production was shipped mainly to Europe in the 12-week Arctic summer season when the sea was open for navigation. Polaris' ore reserves were 20 million tons averaging 14.3% zinc and 3.8% lead at yearend.

Cominco mined and milled a record high 2.47 million tons of ore at its Sullivan Mine at Kimberley, British Columbia, producing 170,000 tons of concentrate containing 84,460 tons of zinc. Zinc production was 39% higher than that of 1983. Improved mechanization, higher mill throughput, and the milling of higher grade ores accounted for the production increase. In 1984, ongoing changes in mining techniques resulted in 60% of the ore production being handled by mobile rubber-tired mining equipment. At yearend, ore reserves at the Sullivan Mine were 40 million tons averaging 6.3% zinc, 4.4% lead, and 1.1 ounces of silver per ton.

Rio Algom Ltd. was developing its East Kemptville tin-zinc-copper open pit mine in Nova Scotia. Production was expected to start in early 1986 at an annual rate of 4,500 tons of tin, 2,400 tons of zinc, and 1,500 tons of copper. Plans called for the mining of 14,000 tons of material per day—9,000 tons of ore and 5,000 tons waste and low-grade rock. The 56 million tons of ore reserves were expected to result in a 17-year mine life.

Several mines, including the Polaris and Sullivan Mines, closed temporarily late in the year because of weak zinc markets. The Buchans Mine in Newfoundland, operated by Asarco, was closed permanently in October upon depletion of ore reserves. In 1984, Buchans' zinc production in concentrate totaled 7,100 tons from processing 92,000 tons of ore. Sherritt Gordon Mines Ltd. considered closing the Ruttan copper-zinc mine in Manitoba but decided to continue operations because of improved productivity and receipt of a $7.5 million development loan from the Provincial government. In 1984, Sherritt's Ruttan operation produced 9,600 tons of zinc and 19,400 tons of copper in milling 1.4 million tons of ore. At yearend, Ruttan's ore reserves were 19.3 million tons averaging 1.46% copper and 1.30% zinc. Sheritt's Fox copper-zinc mine, also in Manitoba, produced 9,520 tons of zinc compared with 7,600 tons in 1983, but was expected to close permanently at yearend 1985 owing to depletion of ore reserves. Cyprus Anvil Mining Corp., a subsidiary of Dome Petroleum Ltd., continued an extensive, Government-supported, overburden removal project at its zinc-lead-silver mine near Faro in the Yukon in 1984 in preparation for mining when market conditions become satisfactory.The mine typically had an annual output of about 135,000 tons of zinc until it was closed in June 1982 because of high cost. At yearend 1984, Dome announced its intention to sell the company's 87.5% interest in Cyprus Anvil.

Mexico.—México Desarrollo Industrial Minera S.A. (MEDIMSA) completed construction of a new 4,400-ton-per-day concentrator at the San Martin silver-zinc-copper-lead mining complex in May. The new mill increased the total milling capacity to 6,800 tons per day and made the San Martin Mine the largest underground mining operation in Mexico. The expansion increased the mine's annual zinc production capacity from 23,000 tons to 68,000 tons. In early 1985, MEDIMSA planned to begin initial production at its new lead-zinc-silver Rosario Mine in Sinaloa State at a rate of 550 tons of ore per day. Annual production was projected to be 7,000 tons of zinc and 8,000 tons of lead with appreciable silver. During 1985, MEDIMSA also planned to complete the expansion of mining and milling facilities at its Charcos silver-zinc-copper-lead mine in San Luis Potosí State raising capacity to 3,500 tons per day from 1,300 tons. The expansion was expected to increase the mine's annual zinc and lead production capacity to 38,000 tons and 10,000 tons, respectively.

Peru.—Zinc mine output continued to increase in 1984 mainly owing to expansions of mines containing high silver values. Centromin Perú S.A., a Government-owned company, was carrying out a $61 million expansion program to increase the mining and milling capacities of the Casapalca and Andaychagua Mines. At Casapalca, the project consisted of a 770-ton-per-day increase in mine and concentrator ore capacity to 2,700 tons per day. The expansion was expected to increase annual zinc, lead, and silver output by 8,000 tons, 5,000 tons, and 900,000 ounces, respectively. Ore reserves at Casapalca were estimated to be 10.4 million tons grading 3.4% zinc, 1.7% lead, 0.4% copper, and 5.8 ounces of silver per ton. The Andaychagua project consisted of developing a new underground mining operation at the lower levels of Centromin's existing San Cristobal Mine and erecting a new 900-ton-per-day concentrator at the site to process the increased ore tonnage. The Andaychagua project was expected to yield annually 16,000 tons of zinc, 4,000 tons of lead, and 1.3 million ounces of silver. The Andaychagua ore reserves were estimated to be 1.7 million tons averaging 5.1% zinc, 1.1% lead, and 5.2 ounces of silver per ton.

Sociedad Minera Gran Bretaña S.A. completed construction of its 500-ton-per-day Contonga Mine and began initial production in 1984. Annual production was expected to be 5,000 tons of zinc, 2,000 tons of lead, and appreciable copper and silver. Ore reserves were 2.5 million tons averaging 5.5% zinc, 3.2% lead, 0.4% copper, and 4.7 ounces of silver per ton.

TECHNOLOGY

The Bureau of Mines and the U.S. Geological Survey published reconnaissance studies on the potential for zinc and other mineral resources in wilderness areas and other Federal Lands.[8] The Bureau also published an inventory of the amount and type of mill tailings created from lode-mine metals—copper, lead, zinc, gold, and silver—on a State and county basis between the years 1911 and 1981.[9] Mine waste and mill tailings disposal practices and technological advances and changes in the milling were discussed.

The Bureau of Mines dismantled and shredded four makes of Japanese automobiles to determine whether their materials composition, including zinc in die casts, rolled metal, brass, and other forms, would present problems for the current technology to process junk automobiles for metal recovery.[10] The study indicated that recycling Japanese automobiles would not present any special handling or processing problems to the steelmaking or secondary metal recyclers.

A method for increasing the leaching rate of bulk superalloy scrap to facilitate recycling and recovery of critical metals such as nickel, cobalt, and chromium was investigated.[11] Superalloy scrap was melted with zinc resulting in a brittle intermetallic compound. The zinc was distilled away leaving a friable residue that was more easily leached with acid. Zinc-rich flue dusts generated by nonferrous metal smelters and electric arc steelmaking furnaces were investigated for direct use for electrogalvanizing wire.[12] Commercial trials resulted in a zinc coating with improved properties when compared with coatings obtained by standard electrogalvanizing methods using virgin zinc.

Zinc-based solders containing over 90% zinc were developed to make copper and brass automobile radiators lighter and stronger, and better able to compete with aluminum radiators.[13] Zinc solders replaced lead-tin solders providing both weight and cost savings. A Bureau of Mines process to solder aluminum and aluminum alloys was developed that enables tin-lead solders to wet readily and spread over the areas to be joined.[14] The cleaned aluminum substrate was bonded to a minute layer of zinc applied with an electroless zincate solution. A nickel-copper alloy coating applied over the zinc provided the suitable surface for the solder.

Steel mills continued to add or modify galvanizing and zinc-coating lines in 1984. Electrogalvanizing capacity was increasing worldwide especially in the United States where more than 2 million tons of additional capacity, costing about $500 million, was expected by yearend 1986. A number of steel companies including two in the United States obtained licenses to produce Galfan-coated sheet. Galfan, composed of 95% zinc and 5% aluminum with some mischmetal, was replacing standard galvanizing, especially in Europe, and was in competition with a Bethlehem Steel Corp. product, Galvalume, a 55% aluminum-43.3% zinc-1.6% silicon coating alloy, used mainly in the steel sheet market. In 1984, there were 13 Galvalume licensees worldwide with an estimated capacity of 2 million tons, up fivefold since 1976.[15] Galvalume capacity was expected to rise to 3 million tons by 1986.

A comprehensive coverage of zinc-related investigations and an extensive review of current world literature on zinc extraction, uses, products, and research were contained in quarterly issues of Zinc Abstracts published by the Zinc Development Association, London, England.[16]

[1]Physical scientist, Division of Nonferrous Metals.
[2]Mining Magazine. St. Joe's Balmat Mines. V. 150, No. 3, Mar. 1984, pp. 230-235.
[3]Zinc Institute. U.S. Markets for Zinc Diecastings 1979-1983. 1983, 10 pp.
[4]———. U.S. Automotive Market for Zinc Diecastings 1978-1984. 1984, 2 pp.
[5]———. U.S. Market for Zinc Coatings 1982-1984. 1984, 3 pp.
[6]Copper Development Association Inc. Annual Data 1985. 1984, 20 pp.
[7]International Lead and Zinc Study Group. Lead and Zinc Statistics. V. 25, No. 5, May 1985, p. 40.
[8]March, S. P., S. J. Kropschot, and R. G. Dickinson (ed.). Wilderness Mineral Potential. U.S. Geol. Survey Prof. Paper 1300, 2 v., 1984, 1183 pp.
[9]Coppa, L. V. Copper, Lead, Zinc, Gold, and Silver Waste Disposal Activities and Practices in the United States. BuMines OFR 4-85, Nov. 1984, 195 pp.; NTIS PB85-154706.
[10]Sterner, J. W., D. K. Steele, and M. B. Shirts. Hand Dismantling and Shredding of Japanese Automobiles To Determine Material Contents and Metal Recoveries. BuMines RI 8855, 1984, 25 pp.
[11]DeCesare, R. Bureau of Mines Recycling Research. J. Met., v. 36, No. 7, July 1984, pp. 44, 143-144.
[12]Dattilo, M. Recycling Zinc Wastes for Electrogalvanizing. Pres. at the Fed. of Mater. Soc. Meeting, Recycling Opportunities and Constraints, Washington, DC, July 17-19, 1984. Available from M. Dattilo, Rolla Research Center, U.S. Bureau of Mines, Rolla, MO 65401.
[13]American Metal Market. Red Metal Radiators Seen Better With Zinc Solders. V. 65, No. 45, Mar. 5, 1984, p. 8.
[14]Falke, W. L., A. Y. Lee, and L. A. Neumeier. Development of a Soft-Soldering System for Aluminum. BuMines RI 8747, 1983, 15 pp.
[15]Metal Bulletin (London). Galvalume Gears Up. No. 6953, Jan. 15, 1985, p. 25.
[16]Zinc Development Association. Zinc Abstracts. V. 42, Nos. 1-4, 1984, 392 pp.

Table 3.—Mine production of recoverable zinc in the United States, by month

(Metric tons)

Month	1983	1984
January	25,190	23,031
February	23,046	24,804
March	25,631	26,627
April	23,054	21,607
May	22,474	23,294
June	21,137	19,749
July	20,163	20,528
August	24,043	16,751
September	23,072	14,927
October	23,938	21,260
November	21,853	21,169
December	21,693	19,021
Total	275,294	252,768

Table 4.—Mine production of recoverable zinc in the United States, by State

(Metric tons)

State	1980	1981	1982	1983	1984
Arizona	W	138	--	--	--
California	--	W	--	--	--
Colorado	13,823	W	W	W	W
Idaho	27,722	W	W	W	W
Illinois	W	W	W	W	W
Kentucky	--	W	W	W	W
Missouri	62,886	52,904	63,680	57,044	45,458
Montana	71	25	W	--	--
Nevada	2	W	--	--	--
New Jersey	28,859	16,198	16,800	16,475	W
New Mexico	W	W	--	--	--
New York	33,629	36,889	52,237	56,748	W
Pennsylvania	22,556	24,732	24,762	16,792	--
Tennessee	111,754	117,684	121,306	109,958	116,526
Utah	W	1,576	--	--	W
Virginia	12,038	9,731	--	--	--
Wisconsin	W	--	--	--	--
Total	317,103	312,418	303,160	275,294	252,768

W Withheld to avoid disclosing company proprietary data; included in "Total."

Table 5.—Production of zinc and lead in the United States in 1984, by State and class of ore, from old tailings, etc., in terms of recoverable metals

(Metric tons)

State	Zinc ore			Lead ore			Zinc-lead ore		
	Gross weight (dry basis)	Zinc	Lead	Gross weight (dry basis)	Zinc	Lead	Gross weight (dry basis)	Zinc	Lead
Arizona	--	--	--	W	--	W	--	--	--
Colorado	--	--	--	--	--	--	W	W	W
Idaho	--	--	--	W	--	W	--	--	--
Illinois	--	--	--	--	--	--	--	--	--
Kentucky	W	W	--	--	--	--	--	--	--
Missouri	--	--	--	4,748,910	45,458	278,329	--	--	--
Montana	--	--	--	--	--	--	--	--	--
Nevada	--	--	--	--	--	--	--	--	--
New Jersey	W	W	--	--	--	--	--	--	--
New York	W	W	W	--	--	--	--	--	--
Tennessee	W	W	W	--	--	--	--	--	--
Utah	W	W	W	--	--	--	--	--	--
Total	5,186,887	185,827	1,991	4,748,960	45,458	278,407	(1)	(1)	(1)
Percent of total zinc or lead	XX	74	1	XX	18	86	XX	(1)	(1)

State	Copper-zinc, copper-lead, copper-zinc-lead ores			All other sources[2]			Total		
	Gross weight (dry basis)	Zinc	Lead	Gross weight (dry basis)	Zinc	Lead	Gross weight (dry basis)	Zinc	Lead
Arizona	--	--	--	W	--	W	W	--	W
Colorado	--	--	--	W	W	W	W	W	W
Idaho	--	--	--	W	W	W	W	W	W
Illinois	--	--	--	(3)	W	W	(3)	W	W
Kentucky	--	--	--	--	--	--	W	W	--
Missouri	--	--	--	--	--	--	4,748,910	45,458	278,329
Montana	--	--	--	W	--	W	W	--	W
Nevada	--	--	--	W	--	W	W	--	W
New Jersey	--	--	--	--	--	--	W	W	--
New York	--	--	--	--	--	--	W	W	W
Tennessee	W	W	--	--	--	--	[4]6,071,125	[4]116,526	W
Utah	--	--	--	--	--	--	W	W	W
Total	(1)	(1)	--	27,233,011	21,484	41,499	37,168,858	[5]252,768	321,897
Percent of total zinc or lead	XX	(1)	--	XX	8	13	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 ore in Colorado and zinc recovered from copper-zinc ore in Tennessee to avoid disclosing company proprietary data. Also includes zinc and lead recovered from copper, gold, silver, and fluorspar ores and from mill tailings and miscellaneous cleanups.

[3]Excludes tonnages of fluorspar from which zinc and lead were recovered as byproducts.

[4]Includes items in Tennessee withheld to avoid disclosing company proprietary data.

[5]Includes zinc recovered from classes of ore.

Table 6.—Twenty-five leading zinc-producing mines in the United States in 1984, in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Balmat	St. Lawrence, NY	St. Joe Resources Co	Zinc ore.
2	Elmwood-Gordonsville	Smith, TN	Jersey Minière Zinc Co	Do.
3	Buick	Iron, MO	AMAX Lead Co. of Missouri	Lead ore.
4	Immel	Knox, TN	ASARCO Incorporated	Zinc ore.
5	Young	Jefferson, TN	do	Do.
6	Magmont	Iron, MO	Cominco American Incorporated.	Lead ore.
7	Pierrepont	St. Lawrence, NY	St. Joe Resources Co	Zinc ore.
8	Zinc Mine Works	Jefferson, TN	United States Steel Corp	Do.
9	Sterling	Sussex, NJ	The New Jersey Zinc Co. Inc	Do.
10	Leadville unit	Lake, CO	ASARCO Incorporated	Lead-zinc ore.
11	New Market	Jefferson, TN	do	Zinc ore.
12	Coy	do	do	Do.
13	Sunnyside	San Juan, CO	Standard Metals Co	Gold ore.
14	Beaver Creek	Jefferson, TN	Inspiration Resources Corp	Zinc ore.
15	Fletcher	Reynolds, MO	St. Joe Lead Co	Lead ore.
16	Viburnum No. 29	Washington, MO	do	Do.
17	Lucky Friday	Shoshone, ID	Hecla Mining Co	Silver ore.
18	Rosiclare	Hardin and Pope, IL.	Ozark-Mahoning Co	Fluorspar.
19	Viburnum No. 28	Iron, MO	St. Joe Lead Co	Lead ore.
20	Brushy Creek	Reynolds, MO	do	Do.
21	Copperhill	Polk, TN	Tennessee Chemical Co	Copper-zinc ore.
22	Viburnum No. 35	Iron, MO	St. Joe Lead Co	Lead ore.
23	Black Pine	Granite, MT	Black Pine Mining Co	Silver ore.
24	Eisenhower	Pima, AZ	Eisenhower Mining Co	Copper ore.
25	Mission	do	ASARCO Incorporated	Do.

Table 7.—Primary and redistilled secondary slab zinc produced in the United States

(Metric tons)

	1980	1981	1982	1983	1984
Primary:					
From domestic ores	231,850	259,835	193,284	210,315	197,912
From foreign ores	108,606	86,728	34,892	25,379	55,220
Total	340,456	346,563	228,176	235,694	253,132
Redistilled secondary:					
At primary smelters	13,113	14,438	42,418	40,545	44,930
At secondary smelters	16,283	35,754	31,870	28,845	33,183
Total	29,396	50,192	74,288	69,390	78,113
Grand total (excludes zinc recovered by remelting)	369,852	396,755	302,464	305,084	331,245

Table 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grade

(Metric tons)

Grade	1980	1981	1982	1983	1984
Special High	148,384	137,210	112,648	95,395	123,325
High	24,552	51,990	31,076	78,511	71,892
Continuous Galvanizing	45,275	55,008	57,739	50,661	48,200
Controlled Lead	18,650	38,660	7,612	10,231	9,384
Prime Western	132,991	113,887	93,389	70,286	78,444
Total	369,852	396,755	302,464	305,084	331,245

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) 1983	1984
Electrolytic:			
AMAX Zinc Co. Inc	Sauget, IL	76,000	76,000
ASARCO Incorporated[1]	Corpus Christi, TX	104,000	104,000
Bunker Ltd.[2]	Kellogg, ID	103,000	103,000
Jersey Minière Zinc Co	Clarksville, TN	82,000	82,000
St. Joe Resources Co	Bartlesville, OK	51,000	51,000
Electrothermic:			
St. Joe Resources Co	Monaca, PA	91,000	91,000

[1]Zinc plant closed in Oct. 1982, reopened in May 1984.
[2]Zinc plant closed in Dec. 1981.

Table 10.—Secondary slab zinc plant capacity in the United States, by company

Company	Plant location	Capacity (metric tons) 1983	1984
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		

(Capacity of 95,000 metric tons in 1983 and 1984 is the combined total for all plants listed.)

Table 11.—Stocks and consumption of new and old zinc scrap in the United States in 1984, 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	Consumption: Old scrap	Consumption: Total	Stocks, Dec. 31
Smelters and distillers:						
New clippings	23	877	873	--	873	27
Old zinc	280	1,430	--	1,310	1,310	400
Remelt zinc	135	5,957	5,957	--	5,957	135
Engravers' plates	53	634	--	621	621	66
Rod and die scrap	992	3,049	--	3,049	3,049	992
Diecastings	1,620	12,804	--	12,838	12,838	1,586
Fragmentized diecastings	3,100	25,423	--	25,514	25,514	3,009
Remelt die-cast slab	642	12,524	--	12,524	12,524	642
Skimmings and ashes	37,543	88,715	93,354	--	93,354	32,904
Sal skimmings	21	2,816	2,637	--	2,637	200
Die-cast skimmings	1,802	6,139	5,930	--	5,930	2,011
Galvanizers' dross	12,758	44,140	48,882	--	48,882	8,016
Flue dust	3,154	6,435	6,354	--	6,354	3,235
Chemical residues	295	2,678	2,678	--	2,678	295
Other	63	1,371	1,371	--	1,371	63
Total	62,481	214,992	168,036	55,856	223,892	53,581
Chemical plant, foundries, other manufacturers:						
Old zinc	10	24	--	24	24	10
Diecastings	18	552	--	552	552	18
Skimmings and ashes	1,609	4,010	4,731	--	4,731	888
Sal skimmings	2,617	2,310	3,326	--	3,326	1,601
Die-cast skimmings	--	182	182	--	182	--
Galvanizers' dross	2	100	100	--	100	2
Flue dust	497	5,093	5,283	--	5,283	307
Chemical residues	9	476	476	--	476	9
Other	1	1,116	1,117	--	1,117	--
Total	4,763	13,863	15,215	576	15,791	2,835

Table 11.—Stocks and consumption of new and old zinc scrap in the United States in 1984, by class of consumer and type of scrap —Continued

(Metric tons, zinc content)

Class of consumer and type of scrap	Stocks, Jan. 1	Receipts	Consumption			Stocks, Dec. 31
			New scrap	Old scrap	Total	
All classes of consumers:						
New clippings	23	877	873	--	873	27
Old zinc	290	1,454	--	1,334	1,334	410
Remelt zinc	135	5,957	5,957	--	5,957	135
Engravers' plates	53	634	--	621	621	66
Rod and die scrap	992	3,049	--	3,049	3,049	992
Diecastings	1,638	13,356	--	13,390	13,390	1,604
Fragmentized diecasting	3,100	25,423	--	25,514	25,514	3,009
Remelt die-cast slab	642	12,524	--	12,524	12,524	642
Skimmings and ashes	39,152	92,725	98,085	--	98,085	33,792
Sal skimmings	2,638	5,126	5,963	--	5,963	1,801
Die-cast skimmings	1,802	6,321	6,112	--	6,112	2,011
Galvanizers' dross	12,760	44,240	48,982	--	48,982	8,018
Flue dust	3,651	11,528	11,637	--	11,637	3,542
Chemical residues	304	3,154	3,154	--	3,154	304
Other	64	2,487	2,488	--	2,488	63
Total	67,244	228,855	183,251	56,432	239,683	56,416

Table 12.—Production of zinc products from zinc-based scrap in the United States

(Metric tons)

Product	1980	1981	1982	1983	1984
Redistilled slab zinc	29,396	50,192	74,288	69,390	78,113
Zinc dust	35,557	39,626	25,296	[r]34,773	40,697
Remelt zinc	229	195	69	66	71
Remelt die-cast slab	3,568	6,722	3,905	3,109	3,380
Zinc die and diecasting alloys	4,146	6,902	5,366	6,535	6,112
Galvanizing stocks	2,461	2,612	2,507	2,801	2,368
Secondary zinc in chemical products	55,890	62,557	61,827	59,085	66,474

[r]Revised.

Table 13.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Metric tons)

	1983	1984
KIND OF SCRAP		
New scrap:		
Zinc-based	152,653	182,976
Copper-based	119,590	134,699
Magnesium-based	131	130
Total	272,374	317,805
Old scrap:		
Zinc-based	51,255	55,447
Copper-based	24,431	24,763
Aluminum-based	349	334
Magnesium-based	218	220
Total	76,253	80,764
Grand total	348,627	398,569
FORM OF RECOVERY		
As metal:		
By distillation:		
Slab zinc[1]	69,390	78,113
Zinc dust	[r]34,773	40,697
By remelting	2,867	2,438
Total	[r]107,030	121,248

See footnotes at end of table.

Table 13.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery —Continued

(Metric tons)

	1983	1984
FORM OF RECOVERY —Continued		
In zinc-based alloys	9,644	9,492
In brass and bronze	r172,065	200,539
In aluminum-based alloys	454	466
In magnesium-based alloys	349	350
In chemical products:		
Zinc oxide (lead free)	33,196	40,072
Zinc sulfate	14,975	13,687
Zinc chloride	10,207	12,398
Miscellaneous	707	317
Total	r241,597	277,321
Grand total	348,627	398,569

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)	Value: Average per pound
1980	42,640	$41,202	$0.438
1981	43,734	53,801	.558
1982	37,516	49,327	.596
1983	r40,508	r45,849	.513
1984	46,487	67,846	.662

rRevised.
[1]Does not include zinc dust produced for internal plant use.

Table 15.—U.S. consumption of zinc

(Metric tons)

	1980	1981	1982	1983	1984
Slab zinc	811,146	840,875	709,491	805,891	848,903
Ores and concentrates (zinc content)[1]	58,986	60,643	35,515	38,287	47,637
Secondary (zinc content)[2]	272,277	287,851	208,105	276,370	318,018
Total	1,142,409	1,189,369	953,111	1,120,548	1,214,558

[1]Includes ore used directly in galvanizing.
[2]Excludes redistilled slab and remelt zinc.

Table 16.—U.S. consumption of slab zinc in 1984, by industry and grade

(Metric tons)

Industry	Special High Grade	High Grade	Continuous Galvanizing Grade	Controlled Lead Grade	Prime Western	Remelt	Total
Galvanizing	59,362	51,206	53,783	39,794	169,740	1,738	375,623
Zinc-based alloys	230,505	2,057	--	--	22	48	232,632
Brass and bronze	62,211	45,221	160	213	13,940	3,849	125,594
Rolled zinc	41,452	--	--	15,434	--	--	56,886
Zinc oxide	37,038	--	--	--	--	--	37,038
Other	18,573	1,789	--	--	768	--	21,130
Total	449,141	100,273	53,943	55,441	184,470	5,635	848,903

Table 17.—U.S. consumption of slab zinc, by industry and product

(Metric tons)

Industry and product	1980	1981	1982	1983	1984
Galvanizing:					
Sheet and strip	220,744	248,006	204,519	230,541	222,872
Wire and wire rope	22,748	22,119	17,180	18,328	18,430
Tubes and pipe	37,075	39,418	34,322	34,907	39,463
Fittings (for tubes and pipe)	7,394	6,369	5,707	5,990	4,446
Tanks and containers	3,297	5,781	6,507	4,195	4,044
Structural shapes	33,376	33,667	28,816	29,822	35,494
Fasteners	3,189	3,693	2,898	2,614	2,518
Pole-line hardware	4,078	3,788	2,955	3,013	3,326
Fencing, wire cloth, netting	16,022	17,722	17,330	15,916	12,644
Other and unspecified uses	31,304	30,484	21,810	27,853	32,386
Total	379,227	411,047	342,044	373,179	375,623
Brass and bronze products:					
Sheet, strip, plate	37,730	42,006	31,718	43,083	55,583
Rod and wire	32,554	36,639	26,551	32,387	34,231
Tubes	4,702	6,440	3,465	4,058	4,750
Castings and billets	2,808	2,880	2,211	7,499	9,726
Copper-based ingots	17,190	20,167	13,278	16,405	19,446
Other copper-based products	3,842	4,854	3,915	4,503	1,858
Total	98,826	112,986	81,138	107,935	125,594
Zinc-based alloys:					
Diecasting alloys	248,024	234,957	191,607	204,820	216,306
Dies and rod alloys	--	--	--	--	1,666
Slush and sand-casting alloys	6,203	8,408	6,147	8,071	14,660
Total	254,227	243,365	197,754	212,891	232,632
Rolled zinc	21,100	[1]23,156	[1]37,168	[1]56,291	[1]56,886
Zinc oxide	27,047	25,657	32,374	36,201	37,038
Other:					
Light-metal alloys	11,137	8,183	8,326	12,538	14,922
Miscellaneous[2]	19,582	16,481	10,687	6,856	6,208
Total	30,719	24,664	19,013	19,394	21,130
Grand total	811,146	840,875	709,491	805,891	848,903

[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 1984, by State

(Metric tons)

State	Galvanizers	Brass mills[1]	Die-casters[2]	Other[3]	Total
Alabama	13,207	1,735	--	--	14,942
Arkansas	W	--	--	W	W
California	23,658	2,256	W	W	41,884
Colorado	W	--	W	W	1,454
Connecticut	1,880	9,463	W	W	17,584
Delaware	W	--	--	--	W
Florida	3,990	--	--	--	3,990
Georgia	W	--	W	--	W
Hawaii	W	--	--	--	W
Illinois	49,942	18,772	37,391	15,874	121,979
Indiana	62,657	W	W	W	99,283
Iowa	W	--	W	W	W
Kansas	--	--	W	--	W
Kentucky	16,564	--	--	--	16,564
Louisiana	W	--	W	--	3,036
Maine	W	--	--	--	W
Maryland	12,919	--	--	--	12,919
Massachusetts	2,966	W	--	W	3,865
Michigan	W	11,934	42,996	W	55,922
Minnesota	502	--	--	--	502
Mississippi	W	--	--	--	W
Missouri	W	--	--	W	3,211
Nebraska	W	--	--	W	8,744
New Jersey	1,500	5,492	7,014	1,839	15,845
New York	18,644	17,753	80,370	1,552	118,319
North Carolina	W	--	W	W	W
Ohio	51,801	W	40,612	W	102,686
Oklahoma	3,042	--	--	641	3,683
Oregon	W	W	--	W	1,071
Pennsylvania	47,650	6,847	W	W	83,086
Rhode Island	--	--	W	W	W
South Carolina	2,125	--	--	--	2,125
Tennessee	853	--	W	W	49,546
Texas	11,487	W	W	W	11,652
Utah	W	W	--	--	1,889
Virginia	W	W	W	W	W
Washington	W	--	--	W	2,702
West Virginia	W	--	--	W	18,461
Wisconsin	848	767	W	W	8,498
Undistributed	47,655	46,726	24,197	95,150	17,829
Total[4]	373,890	121,745	232,580	115,056	843,271

W Withheld to avoid disclosing company proprietary data; included with "Undistributed."
[1]Includes brass mills, brass ingot makers, and brass foundries.
[2]Includes producers of zinc-based 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)

	1983	1984
Production:[1]		
Photoengraving plate	W	W
Strip and foil	W	W
Total rolled zinc[2]	54,980	55,633
Exports	957	975
Imports	319	850
Available for consumption	58,029	52,343

W Withheld to avoid disclosing company proprietary data; included in "Total rolled zinc."
[1]Figures represent net production. In addition, 39,251 tons in 1983 and 40,855 tons in 1984 were rerolled from scrap originating in fabricating plants operating in connection with zinc-rolling mills.
[2]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)

	1983		1984	
	Production	Shipments	Production	Shipments
Zinc oxide	129,596	135,054	150,623	146,918
Zinc sulfate	39,287	34,986	37,408	37,112
Zinc chloride[2]	r21,128	r20,896	25,664	26,705

rRevised.
[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)

	1983				1984			
	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	34,531	36,201	33,196	103,928	43,450	37,038	40,072	120,560
Zinc sulfate	W	--	15,910	15,910	W	--	15,150	15,150
Zinc chloride[2]	--	--	r10,207	r10,207	--	--	12,398	12,398

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	1980	1981	1982	1983	1984
Agriculture	6,930	7,328	3,929	2,569	2,380
Ceramics	5,702	7,822	5,215	5,987	7,472
Chemicals	17,551	20,561	19,432	19,217	23,611
Paints	12,165	12,346	9,283	9,716	8,117
Photocopying	9,604	10,308	9,516	10,239	9,246
Rubber	61,796	69,364	62,923	67,971	79,390
Other	22,028	21,222	17,136	19,355	16,702
Total	135,776	148,951	127,434	135,054	146,918

Table 23.—Distribution of zinc sulfate shipments

(Metric tons)

Year	Agriculture	Other	Total
1981	30,928	6,951	37,879
1982	29,882	9,040	38,922
1983	29,373	5,613	34,986
1984	28,162	8,950	37,112

Table 24.—Stocks of slab zinc in the United States, December 31

(Metric tons)

	1980	1981	1982	1983	1984
Primary producers	18,190	41,124	30,381	20,750	42,025
Secondary producers	4,362	3,540	3,831	3,149	4,303
Consumers	69,599	81,917	77,565	89,041	72,506
Merchants	33,650	68,773	47,397	35,199	18,792
Total	125,801	195,354	159,174	148,139	137,626

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
1983	43,685	10,077	4,510	5,700	24,922	147	89,041
1984	40,296	6,310	3,963	2,284	19,437	216	72,506

Table 26.—Average monthly U.S., LME,[1] and European producer prices for Prime Western zinc and equivalent

(Metallic zinc, cents per pound)

Month	1983			1984		
	United States[2]	LME cash	European producer	United States[2]	LME cash	European producer
January	38.61	31.68	36.29	49.22	43.41	44.45
February	38.62	30.88	34.02	50.61	45.26	47.63
March	37.90	30.75	34.02	51.07	47.16	47.63
April	38.00	31.61	34.02	51.90	45.52	49.44
May	38.11	33.34	34.02	52.77	45.38	49.44
June	39.46	32.56	35.38	52.45	42.67	48.90
July	40.01	33.54	35.38	49.52	38.70	45.34
August	40.56	36.67	36.88	47.85	37.81	44.91
September	42.98	37.98	39.92	46.42	39.31	43.12
October	46.11	38.93	40.53	44.19	38.09	40.64
November	47.55	38.97	41.96	43.60	38.67	40.82
December	48.74	38.85	43.09	43.62	38.87	40.82
Average	41.39	34.73	37.18	48.60	40.46	45.30

[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	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Unwrought zinc and zinc alloys:						
Argentina	--	--	(1)	$3	--	--
Australia	2	$8	12	46	(1)	$2
Belgium-Luxembourg	5	16	(1)	2	(1)	1
Canada	260	573	416	762	88	222
Chile	--	--	3	57	398	419
Costa Rica	21	35	12	21	5	12
Dominican Republic	2	3	2	4	7	8
Ecuador	1	4	--	--	(1)	1
Egypt	2	6	--	--	1	4
El Salvador	--	--	2	3	6	12
France	3	10	1	2	6	12
Germany, Federal Republic of	--	--	1	2	16	35
Guatemala	3	6	--	--	1	1
Honduras	--	--	1	4	--	--
Hong Kong	(1)	1	--	--	2	25
Israel	3	14	--	--	1	3
Italy	(1)	1	2	14	2	20
Japan	75	83	28	76	166	220
Korea, Republic of	1	28	15	56	108	96
Leeward and Windward Islands	--	--	1	2	(1)	6
Mexico	175	507	4	17	73	137
Netherlands	5	27	--	--	(1)	1
New Zealand	(1)	3	1	7	5	21
Panama	5	16	10	17	40	63
Peru	(1)	10	(1)	1	5	10
Philippines	3	6	(1)	1	1	3
Saudi Arabia	50	171	108	277	6	14
Singapore	1	3	40	131	2	4
South Africa, Republic of	4	11	3	8	--	--
Spain	(1)	1	--	--	22	24
Switzerland	60	253	72	377	2	6
Taiwan	442	490	288	260	361	332
United Arab Emirates	--	--	6	12	--	--
United Kingdom	73	293	41	181	8	34
Venezuela	1	18	4	14	2	4
Other	r7	r51	r16	r38	14	46
Total	1,204	2,648	1,089	2,395	1,348	1,798
Wrought zinc and zinc alloys:						
Argentina	22	56	17	38	19	53
Australia	6	15	8	26	6	13
Austria	4	14	5	17	--	--
Bahamas	(1)	3	8	12	46	53
Belgium-Luxembourg	(1)	1	2	14	1	6
Bermuda	(1)	1	--	--	(1)	1
Brazil	16	43	--	--	37	71
Canada	893	1,512	1,221	1,762	769	1,571
Chile	1	2	3	4	--	--
Colombia	40	96	14	42	24	56
Denmark	--	--	(1)	15	--	--
Dominican Republic	(1)	1	9	10	8	29
Ecuador	15	63	9	30	12	35
Egypt	(1)	1	11	25	1	4
El Salvador	8	21	12	36	3	14
Finland	3	1	2	14	--	--
France	18	23	5	9	4	6
Germany, Federal Republic of	--	--	1	2	1	1
Guatemala	3	10	1	3	1	5
Guyana	2	8	5	11	5	9
Hong Kong	1	3	3	4	1	2
India	166	157	9	22	19	21
Iran	--	--	4	7	--	--
Israel	12	26	--	--	1	9
Italy	5	13	--	--	1	3
Jamaica	--	--	3	10	--	--
Japan	153	156	39	55	15	25
Korea, Republic of	(1)	3	(1)	1	(1)	2
Kuwait	(1)	1	--	--	--	--
Leeward and Windward Islands	2	4	25	22	43	33
Libya	--	--	119	340	1	1
Mexico	221	400	147	395	387	932
Morocco	--	--	2	5	--	--
Netherlands	1	1	--	--	2	2
Netherlands Antilles	1	1	2	16	19	23
New Zealand	1	3	--	--	--	--
Nicaragua	--	--	25	42	4	14
Pakistan	5	31	3	8	1	4
Panama	3	8	1	3	4	10

See footnotes at end of table.

Table 27.—U.S. exports of zinc and zinc alloys, by country —Continued

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Wrought zinc and zinc alloys — Continued						
Peru	9	$28	4	$6	--	--
Philippines	15	45	34	108	12	$33
Portugal	(1)	2	--	--	--	--
Saudi Arabia	56	153	28	72	9	16
Singapore	76	188	4	20	3	15
Somalia	--	--	5	5	--	--
South Africa, Republic of	49	133	13	42	95	203
Spain	30	74	6	22	--	--
Sri Lanka	5	18	4	12	1	2
Switzerland	(1)	3	--	--	46	130
Taiwan	17	51	72	123	92	177
Trinidad and Tobago	4	21	--	--	15	42
United Arab Emirates	1	4	1	12	2	5
United Kingdom	113	268	90	218	33	142
Uruguay	8	16	--	--	4	13
Venezuela	10	54	5	12	4	21
Zimbabwe	--	--	--	--	36	79
Other	r28	r63	r22	r153	28	61
Total	2,023	3,799	2,003	3,805	1,815	3,947

rRevised.
1Less than 1/2 unit.

Table 28.—U.S. exports of zinc

Year	Ores and concentrates Quantity (metric tons)	Ores and concentrates Value (thousands)	Blocks, pigs, anodes, etc. Unwrought Quantity (metric tons)	Unwrought Value (thousands)	Unwrought alloys Quantity (metric tons)	Unwrought alloys Value (thousands)
1982	77,289	$32,534	341	$547	863	$2,101
1983	60,168	22,868	427	801	662	1,594
1984	30,579	13,353	760	975	588	823

Year	Wrought zinc and zinc alloys: Sheets, plates, strips Quantity (metric tons)	Sheets, plates, strips Value (thousands)	Angles, bars, pipes, rods, etc. Quantity (metric tons)	Angles, bars, pipes, rods, etc. Value (thousands)	Waste and scrap (zinc content) Quantity (metric tons)	Waste and scrap Value (thousands)	Dust (blue powder) Quantity (metric tons)	Dust Value (thousands)
1982	995	$2,351	1,028	$1,448	r29,424	r$25,309	2,066	$3,207
1983	957	2,142	1,046	1,663	r28,255	r15,389	1,914	3,000
1984	975	2,421	840	1,526	39,146	20,360	2,933	3,511

rRevised.

Table 29.—U.S. exports of zinc ores and concentrates, by country

(Zinc content)

Country	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
Algeria	3,724	$1,887	--	--
Bulgaria	9,934	3,900	3,028	$1,801
Canada	39,781	15,061	19,102	8,360
Dominican Republic	(1)	1	--	--
Ecuador	(1)	1	--	--
El Salvador	1	3	--	--
India	--	--	20	13
Jamaica	19	21	38	56
Korea, Republic of	115	99	33	19
Mexico	--	--	2,574	866
Netherlands	29	16	--	--
Philippines	(1)	2	--	--
Saudi Arabia	4	3	--	--
Spain	3,500	630	--	--
Sweden	--	--	1	3
Taiwan	22	15	--	--
U.S.S.R	--	--	5,783	2,235
Yugoslavia	3,039	1,229	--	--
Total	60,168	22,868	30,579	13,353

[1]Less than 1/2 unit.

Table 30.—U.S. general imports of zinc, by country

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Australia	2,848	$872	2,261	$1,113	2,577	$1,264
Canada	10,574	4,570	13,715	3,370	34,717	14,631
Chile	21	10	27	15	--	--
Colombia	20	3	--	--	--	--
Germany, Federal Republic of	7,925	4,431	6,552	1,067	--	--
Honduras	6,303	2,117	12,632	3,920	10,352	4,365
Mexico	15,381	6,376	17,887	4,518	20,125	6,650
Peru	6,272	2,498	9,136	3,208	17,610	7,100
South Africa, Republic of	--	--	--	--	10,186	2,633
Total	49,344	20,877	62,210	17,211	95,567	36,643
BLOCKS, PIGS, OR SLABS[1]						
Algeria	6,499	5,578	2,051	1,846	403	374
Argentina	2,002	1,547	--	--	--	--
Australia	26,336	20,272	30,537	23,331	23,188	23,292
Austria	--	--	102	87	--	--
Belgium-Luxembourg	1,555	1,461	5,820	3,787	3,366	2,750
Brazil	10,500	9,680	--	--	3,280	4,260
Canada	239,839	200,731	307,156	263,145	340,380	351,715
China	258	210	--	--	--	--
Congo	--	--	--	--	1,311	1,032
Finland	20,774	16,514	25,402	20,614	15,953	16,197
France	5,377	4,682	8,932	6,858	12,923	12,807
Germany, Federal Republic of	4,702	3,621	29,675	23,645	27,930	27,543
India	--	--	--	--	99	84
Italy	6,500	6,853	11,913	9,483	13,719	12,270
Japan	741	643	--	--	3,000	3,050
Mexico	21,819	16,521	56,029	44,433	56,221	55,352
Netherlands	7,121	5,688	21,544	16,546	17,296	16,284
Netherlands Antilles	--	--	100	85	--	--
Nigeria	--	--	2,553	2,073	--	--
Norway	9,723	8,063	9,197	7,277	13,348	12,790
Peru	48,565	35,639	45,318	34,729	34,025	32,117
Poland	476	450	917	1,082	600	607
South Africa, Republic of	--	--	1,000	644	993	1,054
Spain	6,573	5,599	18,728	14,453	16,907	16,476

See footnote at end of table.

Table 30.—U.S. general imports of zinc, by country —Continued

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
BLOCKS, PIGS, OR SLABS[1] —Continued						
Sweden	--	--	143	$115	4,000	$3,937
Switzerland	--	--	--	--	100	78
Tanzania	--	--	370	261	173	173
United Kingdom	4,770	$3,750	9,602	7,387	5,685	5,251
Yemen (Sanaa)	--	--	127	100	--	--
Yugoslavia	503	442	1,558	1,247	2,467	2,251
Zaire	22,408	15,943	24,593	18,623	32,329	25,769
Zambia	401	329	--	--	2,476	2,291
Total	447,442	364,216	613,367	501,851	632,172	629,804

[1]In addition, in 1984, 1,414 tons of zinc anodes was imported from Belgium-Luxembourg, Brazil, Canada, Denmark, the Federal Republic of Germany, India, Italy, Japan, Mexico, the Netherlands, Norway, Sweden, Switzerland, Taiwan, and the United Kingdom.

Table 31.—U.S. imports for consumption of zinc, by country

Country	1982 Quantity (metric tons)	1982 Value (thousands)	1983 Quantity (metric tons)	1983 Value (thousands)	1984 Quantity (metric tons)	1984 Value (thousands)
ORES AND CONCENTRATES (zinc content)						
Australia	2,971	$988	858	$114	1,683	$307
Canada	22,827	9,234	17,165	4,895	27,467	9,533
Chile	21	10	27	15	--	--
Colombia	20	3	--	--	--	--
Germany, Federal Republic of	7,925	4,431	6,552	1,067	--	--
Honduras	6,303	2,116	11,709	2,965	10,118	4,102
Mexico	20,534	7,853	17,988	4,536	20,113	6,639
Peru	6,208	2,497	8,857	2,956	16,605	5,972
South Africa, Republic of	--	--	--	--	10,186	2,633
Total	66,809	27,132	63,156	16,548	86,172	29,186
BLOCKS, PIGS, OR SLABS[1]						
Algeria	6,499	5,578	2,051	1,846	403	374
Argentina	2,002	1,547	--	--	--	--
Australia	26,334	20,272	30,537	23,331	23,188	23,292
Austria	--	--	102	87	--	--
Belgium-Luxembourg	1,555	1,461	5,820	3,787	3,366	2,750
Brazil	8,500	7,761	--	--	3,280	4,260
Canada	239,839	200,731	307,156	263,145	340,490	351,836
China	258	210	--	--	--	--
Congo	--	--	--	--	1,311	1,032
Finland	20,774	16,514	20,651	16,305	20,704	20,506
France	5,376	4,682	8,932	6,858	12,923	12,807
Germany, Federal Republic of	4,702	3,621	29,675	23,645	27,930	27,543
India	--	--	--	--	99	84
Italy	6,500	6,853	11,913	9,483	13,719	12,270
Japan	6,852	5,106	4,305	3,425	3,000	3,050
Mexico	23,161	17,480	59,568	46,706	58,416	57,058
Netherlands	7,497	5,933	21,544	16,546	17,296	16,284
Netherlands Antilles	--	--	100	85	--	--
Nigeria	--	--	2,553	2,073	--	--
Norway	10,104	8,445	9,966	7,847	13,348	12,790
Peru	48,569	35,638	45,318	34,729	34,025	32,117
Poland	476	450	917	1,082	600	607
South Africa, Republic of	--	--	1,000	644	993	1,054
Spain	9,149	8,027	18,978	14,691	16,907	16,476
Sweden	--	--	143	115	4,000	3,937
Switzerland	--	--	--	--	100	78
Tanzania	--	--	370	261	173	173
United Kingdom	4,769	3,750	9,602	7,387	5,685	5,251
Yemen (Sanaa)	--	--	127	100	--	--
Yugoslavia	503	442	1,558	1,247	2,467	2,251
Zaire	22,413	15,943	24,793	18,463	32,329	25,769
Zambia	401	329	--	--	2,476	2,291
Total	456,233	370,773	617,679	503,888	639,228	635,940

[1]In addition, in 1984, 1,414 tons of zinc anodes was imported from Belgium-Luxembourg, Brazil, Canada, Denmark, the Federal Republic of Germany, India, Italy, Japan, Mexico, the Netherlands, Norway, Sweden, Switzerland, Taiwan, and the United Kingdom.

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)
1982	66,809	$27,132	456,233	$370,773	700	$694	2,653	$1,232
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

	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)	
1982	7,104	$3,134	11	$6	5,864	$6,925	$409,896
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

[1]Unwrought alloys of zinc were imported as follows, in metric tons: 1982—136 ($75,269); 1983—49 ($34,907); and 1984—118 ($100,047).

[2]In addition, the value of manufactures of zinc imported was as follows: 1982—$532,674; 1983—$542,571; and 1984—$926,981.

Table 33.—U.S. imports for consumption of zinc pigments and compounds

	1983		1984	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Zinc oxide	31,588	$26,415	35,741	$35,516
Zinc sulfide	835	899	982	1,455
Lithopone	1,308	725	1,455	793
Zinc chloride	1,147	892	1,226	855
Zinc sulfate	3,223	1,497	2,855	1,574
Zinc cyanide	90	170	150	304
Zinc hydrosulfite	268	464	288	477
Zinc compounds, n.s.p.f.	2,417	3,647	9,735	7,204

Table 34.—Zinc: World mine production (content of concentrate and direct shipping ore unless noted), by country[1]

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Algeria	15.4	20.0	22.0	12.1	[2]14.6
Argentina	33.4	[r]35.1	36.4	36.6	37.0
Australia	495.3	518.3	664.8	703.2	634.0
Austria	19.1	18.2	19.1	19.4	20.9
Bolivia	50.3	47.0	45.7	47.1	40.5
Brazil	[r]67.0	[r]71.0	71.0	73.0	72.0
Bulgaria[e]	70.0	65.0	66.0	[r]68.0	68.0
Burma	4.1	3.6	5.4	4.5	[2]5.3
Canada	[r]1,058.7	1,096.0	1,036.1	987.7	[2]1,213.0
Chile	1.1	1.5	5.7	6.0	[2]18.9
China[e]	160.0	160.0	160.0	160.0	160.0
Colombia	.3	[r].3	([3])	([3])	--
Congo (Brazzaville)[e]	3.5	3.0	3.0	3.0	3.0
Czechoslovakia	7.2	6.8	6.9	7.1	7.0
Ecuador	.6	.7	.9	.1	.1
Finland	58.4	53.5	54.6	55.9	[2]60.0
France	35.8	37.4	37.0	34.2	36.4
Germany, Federal Republic of	120.8	110.7	105.8	113.9	[2]92.5
Greece	27.1	27.0	20.4	21.3	21.5
Greenland	85.7	79.7	80.0	73.1	[2]71.3
Guatemala	--	3.0	1.0	--	--
Honduras	16.0	16.2	24.6	38.0	[2]41.5
Hungary[e]	2.8	[r]1.3	[r]1.5	[r]2.4	2.3
India	26.5	29.1	29.1	40.4	47.0
Iran[e]	30.0	35.0	40.0	39.9	50.4
Ireland	228.7	120.3	167.2	186.0	206.1
Italy	58.4	43.9	39.6	42.6	[2]38.9

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	1980	1981	1982	1983[p]	1984[e]
Japan	238.1	242.0	251.4	255.7	[2]252.7
Korea, North[e]	140.0	140.0	140.0	140.0	140.0
Korea, Republic of	56.8	[r]56.2	58.2	56.0	53.0
Mexico	235.8	206.6	242.3	266.3	289.4
Morocco[e]	6.1	7.9	11.2	[r]7.2	[2]11.0
Namibia	31.9	29.6	32.2	33.5	[2]27.9
Nigeria[e]	--	.1	.1	.1	.1
Norway	[r]27.6	[r]28.5	31.8	32.3	28.7
Peru	487.6	498.9	507.1	576.4	[2]558.4
Philippines	6.8	5.3	3.0	2.3	[2]2.2
Poland	187.8	146.5	145.0	149.0	153.0
Romania[e]	[r]50.0	[r]50.0	[r]45.0	[r]45.0	44.0
South Africa, Republic of	79.1	87.2	91.5	110.0	[2]106.1
Spain	183.1	182.0	167.0	167.7	225.6
Sweden	167.4	180.9	185.0	202.9	[2]205.9
Thailand	--	--	--	--	[2]25.2
Tunisia	7.6	7.5	7.1	7.7	7.5
Turkey	23.3	30.7	31.5	11.1	20.8
U.S.S.R.[e]	785.0	790.0	800.0	805.0	810.0
United Kingdom	4.4	10.9	10.2	9.0	[2]7.2
United States	[r]348.0	[r]343.0	326.5	296.7	[2]277.5
Vietnam[e]	6.5	6.0	6.0	7.0	7.0
Yugoslavia[4]	95.3	88.6	83.8	86.8	87.0
Zaire	67.0	63.3	82.1	74.7	75.0
Zambia	[r]42.9	[r]39.7	52.5	41.6	[2]41.4
Total	[r]5,954.3	[r]5,845.0	6,054.3	6,159.5	6,418.8

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through July 9, 1985.
[2]Reported figure.
[3]Revised to zero.
[4]Content in ore hoisted.

Table 35.—Zinc: World smelter production, by country[1]

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Algeria, primary	30.0	31.0	[e]31.0	31.1	31.2
Argentina, primary	38.7	26.8	28.9	32.0	35.0
Australia:					
Primary[2]	301.0	295.9	291.4	298.5	[3]302.1
Secondary[e]	5.0	4.5	4.5	4.5	4.5
Total[e]	306.0	300.4	295.9	303.0	306.6
Austria, primary and secondary	22.1	22.7	23.0	23.0	[3]22.5
Belgium, primary and secondary	247.6	234.7	228.3	262.6	[3]270.7
Brazil:					
Primary	78.3	91.9	95.5	99.9	[3]106.9
Secondary	17.7	19.0	14.4	11.0	12.0
Total	96.0	110.9	109.9	110.9	118.9
Bulgaria, primary and secondary[e]	90.0	90.0	90.0	90.0	90.0
Canada, primary	591.6	619.0	512.0	617.0	685.0
China, primary and secondary[e]	160.0	160.0	160.0	[r]175.0	185.0
Czechoslovakia, primary and secondary[e]	9.6	9.0	9.2	9.2	9.2
Finland, primary	146.7	139.8	143.9	155.3	[3]158.7
France:					
Primary[e]	232.8	232.1	223.8	231.8	238.8
Secondary[e]	20.0	25.0	20.0	18.0	20.0
Total	252.8	257.1	243.8	249.8	[3]258.8
German Democratic Republic, primary and secondary[e]	[r]16.0	16.0	17.0	[r]16.5	17.0

See footnotes at end of table.

Table 35.—Zinc: World smelter production, by country[1] —Continued

(Thousand metric tons)

Country	1980	1981	1982	1983[p]	1984[e]
Germany, Federal Republic of:					
Primary	342.8	331.5	303.4	328.7	325.6
Secondary	27.8	35.1	31.6	27.8	[3]30.8
Total	370.6	366.6	335.0	356.5	[3]356.4
Greece, secondary	.3	NA	NA	NA	NA
Hungary, secondary[e]	.6	.2	.6	.6	.6
India:					
Primary	43.6	57.4	52.6	53.3	55.8
Secondary[e]	.3	.2	.2	.2	.2
Total	43.9	57.6	52.8	53.5	56.0
Italy, primary and secondary	206.4	180.9	158.7	155.6	[3]155.8
Japan:					
Primary	629.7	575.6	549.0	579.0	[3]644.4
Secondary	105.5	94.6	113.4	122.3	[3]110.1
Total	735.2	670.2	662.4	701.3	[3]754.5
Korea, North, primary[e]	120.0	120.0	120.0	120.0	120.0
Korea, Republic of, primary	79.1	83.9	99.2	108.0	[3]108.5
Mexico, primary	143.9	126.5	127.0	175.7	185.3
Netherlands, primary and secondary	169.5	177.4	186.0	187.5	185.0
Norway, primary	79.4	80.3	79.0	90.7	[3]94.2
Peru, primary	63.8	126.2	160.7	154.0	[3]149.0
Poland, primary and secondary	217.0	167.1	165.4	170.3	176.0
Portugal, primary[e]	2.0	4.6	3.6	[3]3.8	[3]5.8
Romania, primary and secondary	45.9	45.2	44.0	42.0	41.0
South Africa, Republic of, primary	81.4	[r]87.2	79.7	84.4	88.4
Spain, primary	[r]151.7	179.5	181.8	189.9	[3]205.4
Thailand, primary	([4])	--	--	--	3.0
Turkey, primary	12.6	18.1	14.9	14.3	19.5
U.S.S.R.:[e]					
Primary	815.0	820.0	830.0	835.0	850.0
Secondary	80.0	85.0	90.0	95.0	95.0
Total	895.0	905.0	920.0	930.0	945.0
United Kingdom, primary and secondary	86.7	81.7	79.3	87.7	[3]85.6
United States:					
Primary	340.5	346.6	228.2	235.7	[3]253.1
Secondary	29.4	50.2	74.3	69.4	[3]78.1
Total	369.9	396.8	302.5	305.1	[3]331.2
Vietnam, primary[e]	5.5	5.5	5.0	6.0	6.0
Yugoslavia:					
Primary[e]	77.5	86.4	76.8	77.0	81.6
Secondary[e]	7.0	10.0	10.0	11.0	11.0
Total	84.5	96.4	86.8	88.0	[3]92.6
Zaire, primary	43.8	57.6	64.4	62.4	65.0
Zambia, primary	32.7	33.3	39.2	37.9	[3]29.2
Grand total	[r]6,048.5	[r]6,085.2	5,860.9	6,200.6	6,447.6
Of which:					
Primary	[r]4,484.1	[r]4,576.7	4,341.0	4,621.4	4,847.5
Secondary	293.6	323.8	359.0	359.8	362.3
Undifferentiated	[r]1,270.8	1,184.7	1,160.9	1,219.4	1,237.8

[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 undistributed (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 9, 1985.

[2]Excludes zinc dust.

[3]Reported figure.

[4]Less than 50 metric tons.

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 40% 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.

Domestic Data Coverage.—Domestic mine production data for zircon are developed by the Bureau of Mines from one separate 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 materials manufactured to U.S. Navy specifications, the U.S. Department of Energy had an inventory, as of December 31, 1984, of about 39 short tons of zirconium sponge, 994 tons of zirconium ingots and shapes, 1 ton of zirconium scrap, 33 tons of hafnium ingots and shapes, 3 tons of hafnium crystal bar, 5 tons of hafnium oxide, and 1 ton of hafnium scrap.

Table 1.—Salient U.S. zirconium statistics

(Short tons)

	1980	1981	1982	1983	1984
Zircon:					
Production	W	W	W	W	W
Exports	7,727	11,630	11,011	13,222	9,528
Imports	113,784	91,108	68,465	44,487	66,436
Consumption[e 1]	140,000	150,000	93,000	100,000	130,000
Stocks, yearend: Dealers and consumers[2]	69,473	33,385	[e]48,595	[r e]36,498	[e]32,861
Zirconium oxide:					
Production[3]	10,218	8,251	5,059	[e]4,118	[e]7,373
Exports	2,389	782	1,017	698	422
Imports	309	235	332	451	793
Consumption[e]	10,100	8,600	5,600	3,400	5,800
Stocks, yearend: Producers[3]	1,216	1,483	1,357	[r e]895	[e]1,183

[e]Estimated. [r]Revised. 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 PRODUCTION

Zircon was recovered, along with titanium minerals, by E. I. du Pont de Nemours & Co. Inc. at Starke and Highland, FL, and by Associated Minerals (USA) Ltd. Inc. at Green Cove Springs, FL. The combined zircon capacity of these plants was estimated to be 100,000 tons per year. Production data were withheld from publication to avoid disclosing company proprietary data.

Five firms produced 47,075 tons of milled (ground) zircon from domestic and imported zircon, and five companies, excluding those that produce the oxide as an intermediate product in making zirconium sponge metal, produced 7,373 tons of zirconium dioxide. Two companies produced zirconium sponge, ingot, and alloys; and hafnium sponge and crystal bar.

Associated Minerals Consolidated USA sold its zirconia manufacturing plant at Bow, NH, to Ferro Corp. The plant uses the plasma arc process to produce a high-purity zirconia that is used mostly (60%) in ceramic colors but also in electronic glazes, special refractories, and chemical derivatives. The facility will be operated by Ferro's Transelco Div.[3]

Table 2.—Producers of zirconium and hafnium materials in 1984

Company	Location	Materials
ZIRCONIUM MATERIALS		
American Minerals	Camden, NJ	Refractories and zircon.
Associated Minerals (USA) Ltd. Inc	Green Cove Springs, FL	Zircon.
The Carborundum Co	Falconer, NY	Refractories.
C-E Cast Industrial Products	Long Beach, CA	Milled zircon.
C-E Refractories, a division of Combustion Engineering Inc.	St. Louis, MO	Refractories.
Do	Vandalia, MO	Do.
CIBA-GEIGY Corp., Drakenfeld Colors	Washington, PA	Ceramic colors and milled zircon.
Continental Mineral Processing Corp	Sharonville, OH	Milled zircon.
Corhart Refractories Co	Buckhannon, WV	Refractories.
Do	Corning, NY	Do.
Do	Louisville, KY	Do.
Didier-Taylor Refractories Corp	Cincinnati, OH	Do.
Do	South Shore, KY	Do.
E. I. du Pont de Nemours & Co. Inc	Wilmington, DE	Zircon and foundry mixes.
Elkem Metals Co	Alloy, WV	Alloys.
Ferro Corp	Cleveland, OH	Ceramics and ceramic colors.
Foote Mineral Co	Cambridge, OH	Alloys.
A. P. Green Refractories Co., Remmey Div	Philadelphia, PA	Refractories.
Harbison-Walker Refractories Co	Mount Union, PA	Do.
Harshaw Chemical Co. Inc	Cleveland, OH	Oxide.
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	Milled zircon.
Magnesium Elektron Inc	Flemington, NJ	Alloys, chemicals, oxide.
Norton Co	Huntsville, AL	Oxide.
Reading Alloys	Robesonia, PA	Alloys.
Ronson Metals Corp	Newark, NJ	Baddeleyite (oxide).
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, alloys, chloride.
Teledyne Wah Chang Albany	Albany, OR	Oxide, chloride, sponge, ingot, powder, crystal bar, mill products.
Thiokol Corp., Ventron Chemicals Div	Beverly, MA	Alloys and powder.
Transelco, a division of Ferro Corp	Dresden, NY	Chemicals, ceramics, oxide.
Do	Bow, NH	Chemicals and oxide.
TRW Inc	Cleveland, OH	Zircon ores.
Western Zirconium Co	Ogden, UT	Oxide, sponge, ingot, mill products.
Zedmark Inc	Butler, PA	Refractories.
Zircar Products Inc	Florida, NY	Fibrous ceramics.
ZIRCOA Products	Cleveland, OH	Oxide and ceramics.
HAFNIUM MATERIALS		
Teledyne Wah Chang Albany	Albany, OR	Oxide, sponge, ingot, crystal bar.
Western Zirconium Co	Ogden, UT	Do.

CONSUMPTION AND USES

About 40% of the domestic zircon produced in 1984 was used in proprietary mixtures as foundry sand. 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 in the United States, by end use

(Short tons)

End use	1983	1984
Zircon refractories[2]	17,000	24,500
AZS refractories[3]	4,000	8,200
Zirconia[4] and AZ abrasives[5]	8,500	15,300
Alloys[6]	4,500	4,400
Foundry applications	49,000	49,500
Other[7]	17,000	28,100
Total	100,000	130,000

[1]Based on incomplete reported data.
[2]Dense and pressed zircon brick and shapes.
[3]Fused cast and bonded alumina-zirconia-silica-based refractories.
[4]Excludes oxide produced by zirconium metal producers.
[5]Alumina-zirconia-based abrasives.
[6]Excludes alloys above 90% zirconium.
[7]Includes chemicals, metallurgical-grade zirconium tetrachloride, sandblasting, welding rods, and miscellaneous uses.

Research on calcia, magnesia, and yttria transformation toughened zirconias was intense. 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 sixth consecutive year, there were no new orders for commercial nuclear powerplants. By midyear, eight plants had been canceled and seven plants had been postponed indefinitely.[4] 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	1983	1984
AZ abrasives	W	W
AZS refractories[3]	900	900
Other refractories	1,400	2,900
Chemicals	600	700
Glazes, opacifiers, colors	500	1,300
Total	3,400	5,800

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	1983	1984
Zircon concentrate held by dealers and consumers excluding foundries	31,026	25,653
Milled zircon held by dealers and consumers excluding foundries	r5,472	7,208
Zirconium:[2]		
Oxide	r895	1,183
Sponge, ingot, scrap, alloys	686	785
Refractories	5,443	17,281
Hafnium: Sponge and crystal bar	35	30

rRevised.
[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 1983	90-98	94-102	106-110
December 1984	83-90	86- 94	98-101

Table 7.—Published yearend prices of zirconium and hafnium materials

Specification of material	1983	1984
Zircon:		
Domestic, standard grade, f.o.b. Starke, FL, bulk, per short ton[1]	$165.00	$165.00
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]	$99.00- 108.00	$91.00- 99.00
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	.90	.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	3.31- 3.82
Insulating, unstabilized, 325° F, same basis, per pound	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]	.87	.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	50.00- 137.50	75.00- 150.00
Sponge, per pound	12.00- 17.00	12.00- 17.00
Sheets, strip, bars, per pound	18.00- 40.00	20.00- 40.00
Hafnium: Sponge, per pound[5]	70.00- 125.00	80.00- 130.00

[1]E. I. du Pont de Nemours & Co. Inc. price list Dec. 1983 (effective Jan. 1, 1984); and Dec. 1984 (effective Jan. 1, 1985).
[2]Industrial Minerals (London). No. 195, Dec. 1983, p. 88; and No. 207, Dec. 1984, p. 78.
[3]Chemical Marketing Reporter. V. 225, No. 1, Jan. 2, 1984 (effective Dec. 30, 1983), p. 51; and v. 226, No. 27, Dec. 31, 1984 (effective Dec. 28, 1984), p. 28.
[4]Ronson Metals Corp. Baddeleyite price lists. Jan. 1, 1984, and Jan. 1, 1985.
[5]American Metal Market. V. 92, No. 4, Jan. 6, 1984, p. 6; and v. 92, No. 250, Dec. 28, 1984, p. 7.

Table 8.—U.S. exports of zirconium ore and concentrate, by country

Country	1983		1984	
	Short tons	Value	Short tons	Value
Algeria	56	$38,990	56	$28,050
Argentina	1,639	552,148	523	184,361
Brazil	1,482	288,021	--	--
Canada	677	220,707	391	128,552
Colombia	640	284,945	487	247,990
Ecuador	79	49,770	147	79,922
Germany, Federal Republic of	4,017	1,026,241	2,197	827,562
India	53	31,120	15	10,883
Italy	104	41,553	--	--
Japan	3,493	365,297	3,643	389,940
Mexico	364	98,433	1,105	302,334
United Kingdom	62	15,234	38	5,239
Venezuela	359	201,735	762	352,029
Other	r197	r102,137	164	89,717
Total	13,222	3,316,331	9,528	2,646,579

rRevised.

Table 9.—U.S. exports of zirconium, by class and country

Class and country	1983		1984	
	Short tons	Value	Short tons	Value
Zirconium and zirconium alloys, wrought:				
Belgium-Luxembourg	30	$3,226,250	47	$3,854,895
Canada	197	11,409,237	181	10,566,721
France	3	169,669	12	291,188
Germany, Federal Republic of	67	2,891,956	88	5,240,786
Italy	7	769,920	2	48,188
Japan	272	13,903,658	259	12,418,815
Korea, Republic of	9	592,836	9	411,756
Sweden	49	1,894,766	13	400,851
United Kingdom	13	550,894	33	1,299,754
Other	r7	r307,679	4	279,717
Total	654	35,716,865	648	34,812,671
Zirconium and zirconium alloys, unwrought and waste and scrap:				
Chile	--	--	20	693,440
France	2	65,817	(1)	5,667
Germany, Federal Republic of	4	26,250	9	74,364
Japan	81	3,498,325	108	6,704,625
Netherlands	3	65,595	3	13,038
United Kingdom	2	79,096	17	116,019
Other	r1	r61,900	3	102,928
Total	93	3,796,983	160	7,710,081

rRevised.
1Less than 1/2 unit.

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

Country	1983		1984	
	Short tons	Value	Short tons	Value
Argentina	12	$56,617	18	$56,261
Belgium-Luxembourg	(1)	640	16	22,222
Brazil	15	111,732	19	66,491
Canada	71	257,405	52	182,928
France	57	196,340	13	46,313
Germany, Federal Republic of	28	75,284	19	82,222
Hong Kong	3	15,684	5	10,491
Italy	58	158,511	37	115,801
Jamaica	13	23,000	--	--
Japan	108	264,754	62	192,127
Mexico	107	202,340	47	113,212
Netherlands	19	47,448	11	31,923
Sweden	16	46,341	16	65,241
Taiwan	12	34,480	17	54,974
United Kingdom	159	338,185	70	131,532
Other	r20	r69,633	20	91,025
Total	698	1,898,394	422	1,262,763

rRevised.
1Less than 1/2 unit.

Table 11.—U.S. imports for consumption of zirconium ores, by country

Country	1982		1983		1984	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	56,092	$5,142	36,140	$3,385	44,214	$5,289
Austria[1]	59	7	118	13	--	--
Belgium-Luxembourg	--	--	--	--	461	87
Canada[1]	705	70	1,176	122	1,451	151
South Africa, Republic of[2]	11,603	919	7,053	897	20,309	2,016
Other	6	6	([3])	3	1	5
Total	68,465	6,144	44,487	4,420	66,436	7,548

[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.

Table 12.—U.S. imports for consumption of zirconium and hafnium in 1984, by class and country

Class and country	Short tons	Value
Zirconium, wrought:		
Canada	2	$66,932
France	323	15,739,305
Japan	5	32,962
Sweden	1	150,115
Other	1	39,562
Total	332	16,028,876
Zirconium, unwrought and waste and scrap:		
Canada	22	120,689
France	26	70,843
Germany, Federal Republic of	12	98,405
Japan	19	126,740
Netherlands	4	12,544
Sweden	5	21,023
United Kingdom	127	187,193
Total	215	637,437
Zirconium alloys, unwrought:		
Canada	4	20,308
Germany, Federal Republic of	4	133,063
United Kingdom	10	77,359
Total	18	230,730
Zirconium oxide:		
Australia	19	3,462
France	144	263,076
Germany, Federal Republic of	16	122,722
Japan	14	161,617
South Africa, Republic of	262	148,750
Switzerland	([1])	2,297
United Kingdom	338	1,824,612
Total	793	2,526,536
Zirconium compounds:		
Canada	1	1,677
France	50	116,090
Germany, Federal Republic of	3	132,138
Japan	3	32,408
South Africa, Republic of	359	381,200
United Kingdom	70	238,399
Other	([1])	5,000
Total	486	906,912
Hafnium, unwrought and waste and scrap: France	1	115,220

[1]Less than 1/2 unit.

WORLD REVIEW

Australia led the world in the production of zircon in 1984. 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.—Consolidated Rutile Ltd. announced a decision to expand the mining of zircon and rutile on North Stradbroke Island. A dredge and wet concentrator, with a capacity of 2,800 tons per hour, were to be constructed to mine the Gordon ore bodies located on the southern part of the island. The development was scheduled to be completed by June 1985.[5]

The Commonwealth Scientific and Industrial Research Organization (CSIRO) and ICI Australia concluded an agreement to develop the capability to manufacture zirconia and zirconium chemicals for both the domestic and export markets.[6] CSIRO and ICI Australia each contributed A$1 million in resources in the first year of the collaborative research and development project to define a suitable manufacturing process for the production of zirconia. A pilot plant was to be constructed, and process trials were planned for the second half of 1985.[7]

Applications, world ceramic markets, and the impact of future development of "sunrise minerals" in Australia were reviewed. Sunrise minerals were defined as common, readily available, natural and synthetic minerals, which as a result of new technology can be processed into high-added-value, high-performance ceramic materials with superior mechanical, thermal, electrical, and chemical properties.[8]

South Africa, Republic of.—Palabora Mining Co. Ltd. constructed and placed in service two new plants in Transvaal to satisfy customer requirements for a wider range of baddeleyite products. In addition, the zirconium sulfate tetrahydrate plant was modified to increase the efficiency of producing chemicals used in both the chemical and leather industries.[9]

Sri Lanka.—Zircon, ilmenite, and rutile were the three main mineral sands mined and exported by the Ceylon Mineral Sands Corp. Mining activities were centered at Pulmoddai on the northeast coast. Reserves were estimated at 3 to 4 million tons, although preliminary estimates from a recent survey appear to be much greater. The mineral composition of reserves at Pulmoddai was reported to be ilmenite 70% to 72%, zircon 8% to 10%, rutile 8%, and monazite 0.8%. Present annual production of zircon is 8,000 tons per year.[10]

Table 13.—Zirconium concentrate: World production, by country[1]

(Short tons)

Country	1980	1981	1982	1983[p]	1984[e]
Australia	541,837	[r]478,673	509,792	421,419	460,000
Brazil	3,759	6,614	5,507	15,201	14,300
China[e]	15,400	16,500	16,500	16,500	16,500
India[2]	16,336	13,669	[e]13,000	[e]13,000	13,000
Malaysia[3]	[r]609	1,441	2,367	2,809	2,800
South Africa, Republic of[e]	88,000	110,000	140,000	140,000	140,000
Sri Lanka	3,341	3,600	6,381	6,306	6,600
Thailand	67	115	216	219	220
U.S.S.R.[e]	80,000	80,000	90,000	90,000	90,000
United States	W	W	W	W	W
Total	[r]749,349	[r]710,612	783,763	705,454	743,420

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total."

[1]Includes data available through May 14, 1985.

[2]Data are for fiscal year beginning Apr. 1 of that stated.

[3]Exports (production not officially reported; exports believed to closely approximate total output).

TECHNOLOGY

Zirconia-bonded zirconia fiber insulation structures were reported to provide the highest operating-temperature capability of any oxide-fiber insulation. The freestanding oxide-fiber structures reportedly allowed routine furnace operations at temperatures up to about 1,800° C. Insulation structures were manufactured in a wide variety of geometric shapes by a vacuum-molding process. The fiber insulation structures contained 80% to 85% porosity, making them lightweight and easily installed and giving them a low thermal mass, which allowed faster cycle times and reduced costs in service.[11]

The preparation and crystallization of fine zirconia powders was studied. Amorphous hydrated hafnium-free zirconia was precipitated from a zirconium tetrachloride solution with 3 normal ammonium hydroxide. This material was hydrothermally processed at 100 megapascals for 24 hours at temperatures from 200° to 600° C. The freeflowing powders obtained consisted of unagglomerated uniform-sized single crystallites necessary for the preparation of high-quality technical ceramics.[12]

The use of magnesium oxide and partially stabilized zirconia (PSZ) as a die material for the hot extrusion of metals was described. PSZ reportedly possesses the mechanical and thermal properties necessary to withstand extrusion conditions and provide exceptional dimensional control and long die life. PSZ exhibits the hot hardness and resistance to deformation normally associated with ceramic materials, but owing to its unique crystal structure, it also has the thermal stability, thermal shock resistance, and fracture toughness needed to survive extrusion conditions. PSZ also has a nonwetting, nonabrasive surface that gives an improved surface finish to the extruded product.[13]

It was reported that aluminum oxide and PSZ dioxide composites can be cold pressed and sintered to strengths as high as 290,000 pounds per square inch. The production process removed agglomerates from commercial powders to ensure well-mixed dispersions of the two phases. Potential uses for the composites were given as extrusion dies, bearings, cutting tools, corrosion-resistant nozzles, and components for internal combustion and adiabatic diesel engines.[14]

A review of current and potential applications of PSZ, silicon carbide, and silicon nitride was presented. Material preparation, fabrication techniques, and material properties were discussed.[15]

The fabrication of PSZ-toughened alumina ceramics by slip casting was reported. The alumina and PSZ particles were reduced to the optimum size of less than 1 micrometer. An organic dispersant prevented particle agglomeration in the slip. The ceramic bodies produced by slip casting and firing reportedly had a fracture strength of 125,000 pounds per square inch.[16]

It was reported that U.S. Air Force B-1B strategic bomber crews will be shielded from thermonuclear flashblindness with cockpit-darkening panels and protective portholes capable of reducing incoming light to 0.003% of original intensity. The windows and portholes are constructed of polarized lead lanthanum zirconate titanate (PLZT), an optically transparent ceramic material with electro-optic properties. When energized by a 24- to 32-volt circuit, the PLZT reacts to intense light by turning opaque. The reaction time of PLZT is 150 microseconds, less time than it takes the human eye to blink.[17]

A review of thermal barrier coatings (TBC) for protecting turbine blades and other engine components was presented. The ceramic most commonly used as a TBC is zirconia with added cubic phase stabilizers. The oxide is bonded to the superalloy with an oxidation and hot-corrosion-resistant metallic bond coating. A major advance was the development of a PSZ coating containing about 6% yttrium oxide and having an operating temperature limit of 850° to 900° C. The PSZ was attached to the blade with a nickel-chromium-aluminum-yttrium metallic bond coat. Test results showed a need to design TBC components in an integrated manner rather than adding a coating to an existing airfoil design.[18]

It was reported that powder metal (P/M) parts were being made from zirconium and zirconium alloys for applications in the chemical industry. Parts are being made by cold isostatic pressing, hot isostatic pressing, and mechanical pressing. The use of P/M processing reduced costs by an estimated 25% to 30% compared with conventional machining. It was planned to extend the use of zirconium alloy P/M parts to the nuclear energy industry.[19]

A process for resistance-weld-bonding thin sheets of corrosion-resistant metals such as zirconium to fabricated substrates was reported. The welding technique reportedly uses a proprietary metallic intermediate to overcome metallurgical incompatibilities between the cladding metals and the fabricated substrates. The finished cladding was reported to withstand temperatures to 350° C and pressures down to a full vacuum.[20]

[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. USA. Zirconia Unit Sold. No. 199, Apr. 1984, p. 16.

[4]Fairgreive, D. S. Zirconium: U.S. Nuclear Slump Continues To Depress Market. Eng. and Min. J., v. 186, No. 3, Mar. 1985, pp. 69-70.

[5]Mining Journal. Consolidated Rutile. Island Mining. V. 303, No. 7782, Oct. 12, 1984, p. 262.

[6]Industrial Minerals (London). World of Minerals. Australia. CSIRO and ICI To Manufacture Zirconia. No. 203, Aug. 1984, p. 9.

[7]CSIRO. CSIRO and ICI To Develop Zirconia Manufacture in Australia. CSIRO News Release No. 13, 2 pp. Background: CSIRO-ICI Australia Zirconia Agreement, 3 pp.

[8]Shepherd, N., and W. Etheridge. Sunrise Minerals. Aus. Inst. of Min. and Metall. Bull. No. 8, Nov.-Dec. 1984, pp. 41-43.

[9]Industrial Minerals (London). World of Minerals. South Africa. Baddeleyite Increases at PMC. No. 202, July 1984, p. 13.

[10]U.S. Embassy, Colombo, Sri Lanka. Mineral Development in Sri Lanka. State Dep. Airgram A-38, Aug. 22, 1984.

[11]Materials Engineering. Zirconia Fiber Insulation Permits Higher Operating Temperatures. V. 100, No. 5, Nov. 1984, p. 42.

[12]Yoshimura, M., and S. Somiya. Fine Zirconia Powders by Hydrothermal Processing. Report of the Research Laboratory of Engineering Materials, No. 9, Nov. 1984, pp. 53-64.

[13]Gulati, S. T., J. N. Hansson, and J. D. Helfinstine. Zirconium Oxide: A New Die Material for Hot Extrusion. Met. Prog., v. 125, No. 2, Feb. 1984, pp. 21-28.

[14]Metal Progress. Trends in Plastics, Ceramics, and Composites Technology. V. 125, No. 1, Jan. 1984, p. 90.

[15]Neil, J. T. The Big Three in Structural Ceramics. Mat. Eng., v. 99, No. 3, Mar. 1984, pp. 37-46.

[16]Chemical and Engineering News. Science/Technology Concentrates. New Process Makes Ultrastrong Ceramics. V. 62, No. 16, Apr. 16, 1984, p. 25.

[17]Aviation Week and Space Technology. B-1B Cockpit To Be Fitted With Nuclear Flash Shield. V. 120, No. 9, Feb. 27, 1984, pp. 60-61.

[18]Levine, S. R., and R. A. Miller. Ceramic-coated Metals Can Survive Contact With Hot Working Fluid. Res. and Dev., v. 26, No. 3, Mar. 1984, pp. 122-125.

[19]American Metal Market/Metalworking News. Alloys. Teledyne Wah Chang To Extend P/M Processing. V. 92, No. 128, July 2, 1984, p. 19.

[20]Chemical Engineering. Unique Method Lays Thinner Clads of Exotic Metals. V. 91, No. 24, Nov. 26, 1984, p. 43.

Other Metals

By Staff, Divisions of Nonferrous and Ferrous Metals

CONTENTS

ARSENIC[1]

Demand for arsenic trioxide increased markedly during 1984 as a result of increased use of arsenical wood preservatives and increased use of arsenicals in agriculture. The increase in agricultural demand was due to a return to production of land withheld from cotton planting under an agriculture program for acreage diversion for some 1983 crops. Supplies of arsenic trioxide were more than adequate to meet increased demand, and prices either declined from, or remained at, the low 1983 levels. In June, ASARCO Incorporated announced plans to close its Tacoma, WA, smelter by mid-1985.

Domestic Data Coverage.—Refined arsenic trioxide was produced by two U.S. companies. The major producer voluntarily reported its production to the Bureau of Mines, but to prevent disclosure of proprietary data, the production data have been withheld.

Legislation and Government Programs.—In 1983, the Environmental Protection Agency (EPA) proposed regulations governing arsenic emissions from copper smelters processing high-arsenic feed materials, copper smelters processing low-arsenic feed materials, and glass manufacturing plants. The proposed regulations would have required additional emissions controls on 14 glass furnaces, 6 copper smelters processing low-arsenic feed materials, and Asarco's Tacoma, WA, smelter, the only smelter processing high-arsenic feed materials. The public comment period for the proposed standards, which had been extended twice at public request, ended on January 31, 1984. As a result of information submitted by commentators, EPA reevaluated low-arsenic copper smelters and significantly changed some of its estimates of emissions and of the costs of controlling them. Inorganic arsenic emissions estimates were revised downward, and control cost estimates for converter operations and matte and slag tapping operations were generally revised upward. EPA then reopened the public comment period, for consideration of its revised estimates, from September 20, 1984, until November 5, 1984.[2] It appeared likely that fewer low-arsenic smelters would require additional controls under the revised estimates. In addition, with the announced closing of the Tacoma smelter by June 1985, it appeared that the proposed regulations for high-arsenic smelters would be eliminated from the final regulations.

In a reevaluation of emissions estimates for glass manufacturing plants, EPA determined that the devices specified in the 1983 proposed standards for controlling emissions of particulate arsenic from glass furnaces would have limited effectiveness when used with soda-lime glass furnaces. These furnaces emitted a higher proportion of arsenic in the vapor phase than did furnaces producing other types of glass. The comment period was reopened from March 20, 1984, until April 19, 1984, to receive comments concerning emissions from plants that produce soda-lime glass. In reopening the comment period, EPA proposed three alternative regulatory options for soda-lime furnaces that would be subject to any add-on control requirements that may be included in the final standard.[3]

After a review of regulations proposed in 1981 for the wood preservative uses of creosote, pentachlorophenol, and arsenical compounds, EPA issued, on July 11, 1984, its final regulatory position on the use of these substances. It restricted use of the three preservatives to certified applicators, but excepted the brush-on application of inorganic arsenicals for commercial construction purposes. In addition, EPA specified other regulations, such as the requirement that workers at wood treatment plants wear respirators if the ambient arsenic level is unknown or exceeds the 10-microgram-per-cubic-meter exposure level, and the requirement that wood pressure treaters provide consumer information sheets on the safe handling and disposal of treated wood.[4] As a result of court challenges filed by the wood preservation industry, implementation of the regulations was postponed until after EPA hearings that were scheduled for September 1985.

DOMESTIC PRODUCTION

Arsenic trioxide and commercial-grade arsenic metal were produced at Asarco's Tacoma, WA, copper smelter. Arsenic trioxide was recovered there principally as a byproduct of the smelting of imported high-arsenic copper concentrates and ores, mainly from the Philippines and Chile, 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.

Arsenic trioxide production at Tacoma was limited by the necessity of complying with Federal and local regulations on atmospheric emissions of sulfur dioxide and arsenic. In June, Asarco announced plans to terminate copper smelting at Tacoma by June 30, 1985. The company cited low copper prices, a shortage of suitable concentrates, and the estimated $150 million cost of meeting proposed Federal, State, and local sulfur dioxide emissions standards as the reasons for closure. Although closure of the smelter would eliminate most of Tacoma's arsenic source material, Asarco planned to keep the arsenic plant operating, at substantially reduced levels, in order to process arsenic-bearing residues generated at other Asarco nonferrous smelters.[5] Asarco reportedly was exploring alternatives to its roasting process for refining arsenic trioxide.

In addition to purchasing refined arsenic trioxide, Koppers Co. Inc., a major producer of arsenical wood preservatives, produced high-purity arsenic trioxide at its plant in Conley, GA, from low-grade material imported from Canada. Arsenic trioxide was processed into arsenic acid, which was marketed or consumed internally in the production of chromated copper arsenate (CCA) wood preservatives.

In January, Williams Strategic Metals Inc., Wheat Ridge, CO, reportedly began producing relatively small quantities of arsenic acid directly from arsenic-bearing lead smelter flue dusts at its plant in Wyoming. The recovery process involved an oxidative leach at elevated temperature and pressure to dissolve the trivalent arsenic and convert it to pentavalent arsenic, making direct recovery of arsenic acid possible.[6]

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. Two companies, Canyonlands and Metallonics Inc., San Jose, CA, processed new gallium arsenide scrap from the electronics industry for gallium recovery. Arsenic was not recovered from the scrap. The arsenical residues were treated as a toxic waste.

CONSUMPTION AND USES

Arsenic compounds, principally arsenic trioxide, accounted for 97% of the arsenic consumed in 1984. Six producers of agricultural chemicals and two producers of wood preservatives accounted for most of the domestic consumption of arsenic trioxide, which was the starting material for the production of most arsenic compounds. Arsenic acid, produced from arsenic trioxide, was used directly, or as intermediary product. The estimated end-use distribution of arsenic was 57% in industrial chemicals (principally wood preservatives), 32% in agricultural chemicals (principally herbicides and desiccants), 6% in glass, 3% in metallic form in nonferrous alloys, and 2% in other uses (animal feed additives, pharmaceuticals, etc.).

Arsenical wood preservatives for pressure treating wood represented the largest single end use for arsenic trioxide. In the preparation of CCA wood preservatives, arsenic acid is mixed with copper oxide and chromic acid to form a leach-resistant, waterborne preservative for pressure treating wood. As a preservative, it controls fungi, insects, bacteria, and marine borers, and, depending on the type of wood, may serve to extend the service life of wood by a factor of at least 15.[7]

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. To a lesser extent, arsenical herbicides were used in noncrop areas such as railroad rights-of-way. Agricultural demand for arsenic increased markedly over the 1983 level, owing to expiration of the U.S. Department of Agriculture's program of payment-in-kind (PIK), which had reduced cotton planting during 1983. Cotton planting in 1984 was at about the same level as in 1982.

Arsenic trioxide and arsenic acid are used in the glass industry primarily as fining agents to remove tiny, dispersed air bubbles, and also as decolorizing agents. Use in recent years has been limited to the pressed and blown glass sector, use in the flat and container glass industry having been virtually eliminated. Arsenic acid has become the preferred form of arsenic owing to dusting problems associated with the handling of arsenic trioxide. During 1984, arsenicals were used by an estimated 15 glass plants manufacturing pressed and blown glass products such as tableware, lead glass, optical glass, and glass ceramics such as ceramic cookware and stove tops.

The bulk of metallic arsenic was used in copper- and lead-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 metric 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. The first commercially available gallium arsenide integrated circuits (IC) were introduced in 1983. 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 application.

PRICES

The price of domestically produced arsenic trioxide, guaranteed minimum 95% purity, remained constant thoughout the year at $0.33 per pound for carload quantities, as supplies remained plentiful despite an increase in demand. Prices for arsenic trioxide imported from Mexico declined in stages to $0.42 per pound by March.

The yearend price of domestically produced arsenic metal, marketed in 250-pound drums or 2,000-pound pallets, declined to 210 cents pound. High-purity arsenic metal for electronics usage was sold in evacuated or argon-filled ampules to inhibit oxidation. Domestic material guaranteed to be 99.999% pure, or better, sold for $100 per kilogram. Substantial premiums were paid for some imported material of higher guaranteed purity.

Table 1.—Arsenic price quotations

(Cents per pound, yearend)

	1982	1983	1984
Trioxide, domestic, 95% As_2O_3, f.o.b. Tacoma, WA	40	33	33
Trioxide, Mexican, 99.13% As_2O_3, f.o.b. Laredo, TX	59	45	42
Metal, domestic, 99% As	245	225	210

Table 2.—U.S. imports for consumption of arsenicals, by class and country

Class and country	1982		1983		1984	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Arsenic trioxide:						
Australia	71	$121	37	$8	--	--
Belgium-Luxembourg	1,030	1,205	946	848	843	$654
Bolivia	22	43	--	--	16	4
Canada	3,352	786	2,525	542	4,767	1,468
China	1,280	1,998	17	36	--	--
France	1,992	2,479	667	706	1,261	849
Germany, Federal Republic of	16	19	1	6	([1])	1
Hong Kong	1	1	--	--	--	--
Japan	--	--	([1])	1	--	--
Korea, Republic of	186	289	--	--	68	51
Mexico	2,276	3,341	2,531	2,700	3,115	2,820
Namibia	--	--	16	11	--	--
Netherlands	36	42	--	--	--	--
South Africa, Republic of	--	--	17	18	--	--
Sweden	4,192	4,717	3,430	3,528	3,914	3,608
Taiwan	50	75	--	--	--	--
U.S.S.R	30	68	--	--	--	--
United Kingdom	29	24	--	--	--	--
Zimbabwe	34	33	--	--	--	--
Total[2]	14,599	15,241	10,186	8,406	13,985	9,454
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	699	865	2,277	2,304	2,420	1,973
Total	699	865	2,385	2,394	2,506	2,047
Arsenic sulfide:						
Canada	18	4	([1])	([1])	20	3
Japan	--	--	1,127	1,522	([1])	1
Other	([1])	5	--	--	--	--
Total	18	9	1,127	1,522	20	4
Arsenic metal:						
Belgium-Luxembourg	--	--	([1])	7	--	--
Canada	4	297	6	328	21	712
China	31	133	128	428	102	350
France	--	--	--	--	([1])	4
Germany, Federal Republic of	1	47	1	111	2	215
Japan	([1])	3	([1])	30	1	127
Netherlands	--	--	--	--	5	19
Sweden	100	523	108	435	158	614
United Kingdom	r([1])	r41	r([1])	r62	15	87
Total[2]	136	1,044	243	1,401	304	2,127
Lead arsenate:						
Netherlands	--	--	--	--	12	26
Peru	170	321	17	35	54	105
Other	([1])	([1])	([1])	2	7	14
Total	170	321	17	37	73	145
Sodium arsenate:						
Israel	476	104	--	--	--	--
Other	1	5	([1])	2	1	3
Total	477	109	([1])	2	1	3
Arsenic compounds, n.e.c.:						
Canada	--	--	--	--	17	588
Sweden	([1])	5	17	22	17	20
United Kingdom	362	591	9	108	1	165
Other	([1])	20	([1])	28	([1])	29
Total[2]	362	616	26	158	35	801

r Revised.
[1] Less than 1/2 unit.
[2] Data may not add to totals shown because of independent rounding.

FOREIGN TRADE

In response to an increase in demand, imports of arsenic trioxide increased by 37% over that of 1983. Imports of arsenic acid remained high for the second consecutive year, indicating arsenic acid's increased importance in world trade.

Imports of arsenic trioxide from Canada were largely impure arsenic trioxide 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. Following its decision to discontinue smelting operations at Tacoma, Asarco declared a force majeure on its smelter contract, set to expire in 1986, with Lepanto Consolidated Mining Co. Inc. in the Philippines. In October, Asarco received its last shipment of high-arsenic Lepanto concentrates.

Table 3.—U.S. import duties for arsenicals

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
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	4.2% ad valorem	3.7% ad valorem	25% ad valorem.

WORLD REVIEW

The announced closing of Asarco's Tacoma smelter, the market economy countries' largest producer of arsenic trioxide, was not expected to result in a shortage of arsenic trioxide. Several new facilities, which were under construction or experiencing startup difficulties during 1983, were reportedly producing refined arsenic trioxide by yearend 1984.

Canada.—Cominco's plant in Yellowknife, Northwest Territories, which had been commissioned in 1982 and which had been experiencing startup difficulties, reportedly shipped a small quantity of refined trioxide into the United States during 1984. When fully operational, the refinery was expected to have a capacity of 5,000 tons per year.

Chile.—The El Indio Mine roaster and arsenic trioxide refinery came on-stream during the fourth quarter of 1983. Problems with production consistency, which had required the trioxide to be further refined elsewhere, were remedied, and during 1984, El Indio reportedly began production of marketable-grade, 97% minimum purity arsenic trioxide. The refinery was expected to have a capacity of 300 to 400 tons per month of arsenic trioxide.

Japan.—Japan was a leading world producer of high-purity arsenic, with at least three companies, Furukawa Mining Co. Ltd., Mitsubishi Metal Corp., and Rasa Industries Co. Ltd., producing high-purity arsenic metal. Furukawa, a leading world producer and Japan's largest high-purity arsenic producer, reportedly doubled its production capacity in 1983 to 30 tons per year. Furukawa was also a leading producer of gallium arsenide wafers. Sumitomo Electric Industries Ltd. developed capabilities for growing large, dislocation-free gallium arsenide crystals and was reported to be the largest world producer of gallium arsenide. In September 1983, Sumitomo Metal Mining Co. Ltd. started up a new arsenic trioxide plant. The plant, with a reported capacity of 700 tons per year of arsenic trioxide, processed arsenical residues from the company's Toyo copper refinery.[8]

Philippines.—A roaster, built to handle Lepanto high-arsenic copper concentrates, was completed at the Philippine Associated Smelting and Refining Corp. complex on Leyte, and production reportedly began during the second half of the year. The roaster and associated arsenic plant had an estimated capacity of 8,000 tons per year of 96%-minimum-purity arsenic trioxide.

Table 4.—Arsenic trioxide:[1] World production, by country[2]

(Metric tons)

Country[3]	1980	1981	1982	1983[p]	1984[e]
Bolivia	81	127	261	107	130
Canada[4]	--	--	--	--	1,000
Chile[5]	--	--	--	--	3,500
France[e]	5,300	5,200	5,100	[6]4,700	5,000
Germany, Federal Republic of[e]	360	360	360	360	360
Japan	284	95	[e]100	[r e]300	500
Korea, Republic of	NA	170	306	560	NA
Mexico	6,932	6,517	4,740	4,557	4,500
Namibia[7]	1,288	1,370	1,895	1,126	[6]2,504
Peru[8]	2,475	2,164	1,663	1,110	1,100
Portugal[e]	200	196	200	190	180
Sweden[e 9]	[r]6,500	[r]6,900	[r]7,200	[r]5,300	5,900
U.S.S.R.[e]	7,700	[r]7,750	[r]7,800	[r]7,900	8,000
United States	W	W	W	W	W
Zimbabwe	79	21	--	--	--
Total	[r]31,199	[r]30,870	29,625	26,210	32,674

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[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 4, 1985.

[3]Austria, Belgium, 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. The Philippines may have had some arsenic output in 1984 from the Pasar copper smelter, but available data are not adequate to make reliable estimates of output levels, if any.

[4]Production of refined arsenic trioxide by Cominco Ltd. only; estimated from imports into the United States. Figure does not include low-grade residues 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]Output of arsenic trioxide for sale plus the arsenic trioxide equivalent of the output of metallic arsenic for sale.

TECHNOLOGY

As part of its research program for developing hydrometallurgical methods for treating complex ores and concentrates, the Bureau of Mines investigated an oxidative-electrolysis process for leaching sulfide materials. Oxidative-electrolysis leaching on a variety of feed materials, including an enargite (Cu_3AsS_4) concentrate that contained 10% arsenic, was performed in cells equipped with ion selective membranes to separate the anodic and cathodic reactions. Iron and arsenic ions dissolved in the anolyte were precipitated by increasing the pH. Two methods were investigated for recovering arsenic from the precipitate as marketable arsenic products.[9]

Advances continued to be made in the development of gallium arsenide IC technology. Because of their high speed compared with silicon-based devices, gallium arsenide IC's are likely to play a major role in the international race to produce a new "fifth generation" of computers, the ultrafast supercomputer.[10] Several Japanese electronics companies were reportedly making gallium arsenide chips for the 3-year-old supercomputer project sponsored by the Japanese Ministry of International Trade. Similar research programs were underway in the United States and Europe.[11] Early in the year, Sumitomo Electric in Japan announced that it had succeeded in growing large-diameter, dislocation-free gallium arsenide single crystals for IC production. Development of gallium arsenide IC's had been hampered by the presence of dislocations in the crystal, which reduced the efficiency of the electronic devices. Use of the new material will reportedly make possible high-yield production of large-scale IC chips. Commercial production was expected to begin in 1985.[12]

A research project being conducted at the University of Washington to study how arsenic gets into the bodies of residents living in the vicinity of Asarco's Tacoma smelter received more than $900,000 in funding from the U.S. Centers for Disease Control in Atlanta. The research, to be conducted over 2 years, was to focus on residents living within a 2-mile radius of the smelter.[13] Anaconda Minerals Co. agreed to finance the more than $1 million estimated cost for evaluating contamination hazards associated with its dismantled Montana smelter. The smelter site was on the EPA national priority list of hazardous waste sites that were targeted for cleanup. Part of the evaluation was to focus on the storage of an estimated 250,000 tons of high-arsenic flue dusts.[14]

CESIUM AND RUBIDIUM[15]

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. Cesium was used commercially in electronic, photoelectric, and medical applications. Rubidium, usually in the form of chemical compounds, 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-use 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 the 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 for cesium and rubidium compounds rose 7.5% in 1984, reportedly because of higher costs of production. Metal prices, on the other hand, did not change from the 1983 levels. At yearend, cesium metal was $275 per pound for technical-grade and $325 per pound for high-purity metal. Rubidium metal prices were $300 per pound for technical-grade and $375 for high-purity metal.

Table 5.—Prices of selected cesium and rubidium compounds in 1984

Compound	Base price per pound[1]	
	Technical grade	High-purity grade
Cesium bromide	$36.80	$74.70
Cesium carbonate	36.80	74.70
Cesium chloride	39.20	78.00
Cesium fluoride	46.80	86.00
Cesium hydroxide	44.40	83.90
Rubidium carbonate	89.80	134.40
Rubidium chloride	90.90	135.50
Rubidium fluoride	97.80	141.90
Rubidium hydroxide	97.80	141.90

[1]Price is for quantities of less than 100 pounds, f.o.b. Revere, PA, excluding packaging costs. Prices effective as of Oct. 1, 1984.

Source: Cabot Corp. (KBI Div.).

FOREIGN TRADE

The increase in imports was attributed to an increase in demand and the strengthening of the U.S. dollar against foreign currencies. Trade data on raw materials and metal were not available.

Table 6.—U.S. imports for consumption of cesium compounds, by country

Country	1983				1984			
	Cesium chloride		Cesium compounds, n.s.p.f.		Cesium chloride		Cesium compounds, n.s.p.f.	
	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value
Austria	--	--	13	$685	--	--	--	--
Canada	--	--	2,406	2,093	--	--	520	$4,100
Germany, Federal Republic of	13,655	$507,876	2,930	94,532	25,050	$741,468	18,206	626,885
Israel	--	--	--	--	--	--	100	30,000
Japan	--	--	--	--	--	--	210	60,087
Netherlands	220	10,949	--	--	110	6,465	231	11,980
Sweden	--	--	--	--	18	884	--	--
United Kingdom	--	--	3	397	--	--	9,207	69,925
Total	13,875	518,825	5,352	97,707	25,178	748,817	28,474	802,977

Table 7.—U.S. import duties for cesium and rubidium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
Ore and concentrate	601.66	Free	Free	Free.
Cesium	415.10	6.5% ad valorem	5.3% ad valorem	25% ad valorem.
Cesium chloride	418.50	4.8% ad valorem	4.0% ad valorem	Do.
Other cesium compounds	418.52	4.4% ad valorem	do	Do.
Rubidium	415.40	4.2% ad valorem	3.7% ad valorem	Do.
Rubidium compounds	423.00	do	do	Do.

WORLD REVIEW

The Tantalum Mining Corp. of Canada Ltd. mine at Bernic Lake, Province of Manitoba, Canada, the major world source of the cesium ore pollucite and the rubidium ore lepidolite, remained on standby throughout 1984. The mine suspended operations at the end of 1982 owing to weak markets and large inventories.[16]

TECHNOLOGY

Generation of high-energy alcohols for use as octane enhancers or as fuels themselves is one of the goals of the current intense investigations of catalytic reactions for hydrogenating carbon monoxide to aliphatic alcohols. Recent work showed that cesium is the most effective promoter of the copper-zinc oxide-aluminum oxide catalytic system, designed to yield 2-methyl-1-propanol. This compound is of interest because of its high energy density compared with that of methanol, and its high octane number. It is also a convenient source of isobutene used in polymer synthesis.[17]

GERMANIUM[18]

Domestic production and consumption of refined germanium were estimated at the same levels as those of 1983. Infrared systems and fiber optics continued to be the major markets for germanium. In 1984, germanium was added to the list of materials included in the National Defense Stockpile.

Domestic Data Coverage.—Domestic refinery production data for germanium are estimated by the Bureau of Mines based on discussions with domestic producers.

Legislation and Government Programs.—On July 6, the Federal Emergency Management Agency announced that germanium was a strategic and critical material to be included in the National Defense Stockpile with a goal of 30,000 kilograms.[19]

On June 27, the EPA proposed effluent limitations guidelines and standards under the Clean Water Act to limit effluent discharges to the waters of the United States and the introduction of pollutants into publicly owned treatment works from particular nonferrous metals manufacturing facilities. The primary and secondary germanium and gallium subcategory, 1 of 24 subcategories covered by this regulation, included proposed limits on effluent discharges from both new and existing plants.

Daily and monthly average maximum germanium contents of effluents emanating from these plants were proposed.[20]

DOMESTIC PRODUCTION

Domestic refinery production from both primary and secondary materials for the year was estimated to be 20,000 kilograms. Based on the published U.S. producer price for refined germanium metal, the approximate value of the production was $21 million.

Refined germanium products were produced by Eagle-Picher Industries Inc., Quapaw, OK; KBI Div. of Cabot, Revere, PA; Atomergic Chemetals Co., Plainview, NY; and Rare Materials International (formerly Bunker Rare Metals), Irving, TX.

On May 10, Gulf + Western Industries Inc. (G+W) announced the sale of its 60% interest in Jersey Minière Zinc Co. to Union Zinc Co., the U.S. subsidiary of G+W's Belgian partner, Union Minière SA. Included in the sale were the zinc refinery at Clarksville, TN, and two operating zinc mines also situated in Tennessee, the Gordonsville and Elmwood Mines. Germanium-rich residues were produced as a byproduct of processing zinc ores from these mines and were shipped to Métallurgie Hoboken-Overpelt SA (MHO) in Belgium, which is partially owned by Union Minière, for germanium recovery and refining.

Musto Explorations Ltd. of Vancouver, Canada, reported that development work continued on a germanium-gallium project at the Apex Mine in St. George, UT. In addition to expansion and rehabilitation of this abandoned copper mine, dump material from previous operations was reclaimed and shipped to a processing plantsite where it was being stockpiled. Construction of a workshop, warehouse, and laboratory was completed, and work was begun on the main processing building. Upon completion, scheduled for May 1985, this plant was expected to process approximately 100 tons of ore per day. Production of germanium dioxide for the first 3 years of the project was expected to be 17,900 kilograms per year of contained germanium.

CONSUMPTION AND USES

The apparent consumption of germanium was estimated at 35,000 kilograms, the same level as that of 1983. The estimated consumption pattern by end uses of germanium in 1984 was as follows: infrared systems, 60%; fiber optics, 15%; gamma-ray, X-ray, and infrared detectors, 10%; semiconductors, 5%; and other, 10%.

The largest end use for germanium continued to be in infrared optics, especially by the military for 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 mapping and fire alarms.

A growing market for germanium in recent years has been in fiber optics telecommunications systems. Fiber optics can be used as replacements for conventional wire telecommunication systems and is finding increased use because it can be installed in existing underground conduits where space is often at a premium. Fiber optic systems provide a compact, short-circuit-free transmission medium that is not susceptible to distortion by an electromagnetic field and cannot be tapped by currently available technology. Although not used in all fiber optic systems, germanium in 1984 was an important constituent in many fiber optic cables. Although there was no apparent increase in demand for germanium in fiber optic systems during the year, the reported capacity expansions by fiber manufacturers and the announced plans for installation of new fiber optic systems indicated that potential growth in this end use could be significant.

Corning Glass Works announced plans to expand manufacturing capacity for optical waveguide fibers at its Wilmington, NC, facility. The expansion would reportedly bring Corning's total waveguide capacity to over 1 million kilometers of fiber per year in 1986.[21] In 1984, SpecTran, a developer and manufacturer of optical communications fiber, reported that it had begun operations at its newly expanded facility at Sturbridge, MA. The expansion would reportedly double its fiber manufacturing capacity.[22] Siecor Optical Cable Plant announced that it had begun operations at its newly expanded plant in Hickory, NC. By 1986, Siecor reported that it would be able to produce over 1 million kilometers of cabled fiber per year.[23] In 1984, Sumitomo Electric announced that it planned to build a fiber optics research and development facility in Research Triangle Park, NC, and Moses Lake Industries, the U.S. subsidiary of Japan's Tama Chemical, announced plans to construct a fiber optics facility at Moses Lake, WA, near Seattle.[24]

Sante Fe Southern Corp. and Norfolk Southern Corp. announced plans to construct and operate a fiber optics system along 8,000 miles of right-of-way. The venture, known as Fibertrak, would reportedly link 53 cities coast-to-coast.[25] Union Pacific System, a unit of Union Pacific Corp., announced that it has signed agreements with American Telephone & Telegraph Co.'s (AT&T), AT&T Communication Unit interstate division; LDX Net Inc.; MCI Telecommunications Corp., a unit of MCI Communications Corp.; and United Telecom Communications Inc. to allow these companies to install fiber optic cable covering a total of 6,700 miles along Union Pacific's right-of-way in 14 States. The agreement covered rights-of-way in Arkansas, California, Colorado, Idaho, Kansas, Louisiana, Missouri, Nebraska, Nevada, Oregon, Tennessee, Texas, Utah, and Wyoming.[26] Two companies, Market Link (a joint venture of London-based Cable & Wireless and Tel-Optic) and TransAtlantic Video, announced plans to construct trans-atlantic optical fiber systems to carry voice and data for corporate customers.

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 published domestic producer prices for germanium metal and germanium dioxide were unchanged throughout 1984 at $1,060 and $660 per kilogram, respectively. Competition from imported material led to 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 indicated that most of the increase in imported material was scrap containing various amounts of germanium. The estimated germanium content of the imported material was calculated to be approximately 6,000 kilograms. This figure excludes the germanium content of 104,580 kilograms (gross weight) of very low-value imported material from Belgium-Luxembourg, as reported by the Bureau of the Census.

Table 8.—U.S. imports for consumption of germanium, by class and country

Class and country	1983		1984	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Unwrought and waste and scrap:				
Belgium-Luxembourg	4,540	$1,737,715	108,508	$4,258,829
Canada	--	--	47	91,512
China	651	455,784	--	--
France	1,328	635,696	3,600	1,493,087
Germany, Federal Republic of	303	3,531,509	1,438	594,313
Italy	1,683	635,507	--	--
Japan	10	2,600	--	--
Netherlands	1,843	774,095	249	111,283
Singapore	910	542,463	--	--
Switzerland	448	188,612	--	--
United Kingdom	4,075	617,274	1,432	230,977
Total	15,791	9,121,255	115,274	6,780,001
Wrought:				
Belgium-Luxembourg	4,061	1,256,342	1,023	509,373
Canada	--	--	1	745
China	10	10,027	--	--
Germany, Federal Republic of	1,040	115,761	133	34,411
Singapore	--	--	273	180,248
United Kingdom	14	23,256	15	34,482
Total	5,125	1,405,386	1,445	759,259

Source: Bureau of the Census.

Table 9.—U.S. import duties for germanium metal and germanium dioxide

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1984	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1984
Germanium dioxide	423.00	4.2% ad valorem	3.7% ad valorem	25% ad valorem.
Metal, unwrought and waste and scrap	628.25	do	do	Do.
Metal, wrought	628.30	6.8% ad valorem	5.5% ad valorem	45% ad valorem.

WORLD REVIEW

World production was estimated at 75,000 kilograms. Germanium was produced by MHO, Belgium; Société Minière et Métallurgique de Peñarroya, 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 were also located in China, Japan, and the U.S.S.R.

Germanium metal production in Japan reached 8,211 kilograms, an increase of 25% compared with 1983 production levels. Japanese germanium dioxide production was reported to be 10,872 kilograms in 1984 compared with 10,546 kilograms in 1983.[27]

TECHNOLOGY

A simple gold-mask technique was reportedly developed for use in the fabrication of germanium nuclear radiation detectors. A layer of gold deposited over the contacts of the detectors acts as a mask for chemical etching and surface treatments. The gold also serves as a reliable, low-resistance electrical connection to the underlying germanium contact. These detectors reportedly can be used in medical imaging, gamma-ray astronomy, and high-energy physics.[28]

Sumitomo Electric announced the development of optical fibers that are strongly resistant to large amounts of radiation. The new product has a fluoride mixture as its core instead of the germanium used for conventional fiber optics. Because of the fiber's reported resistance to gamma rays, it could be used for information processing systems at nuclear powerplants.[29]

A report describing a method for determining germanium in coal ash and fly ash by the use of inductively coupled plasma atomic emission spectrometry (ICP-AES) was published. ICP-AES, with use of a high-resolution spectrometer, reportedly provided germanium determination virtually free of spectral interferences.[30]

INDIUM[31]

Indium was produced by Indium Corp. of America, Utica, NY; NJZ Alloys Inc., a joint venture of New Jersey Zinc Co. and Indium, at a plant in Palmerton, PA; Williams Strategic, Wheat Ridge, CO; and the Arconium Corp., Providence, RI. Both NJZ and Williams Strategic sent their indium product to Indium for further refining and marketing. Domestic production in 1984 remained about the same as in 1983, 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 consumption increased slightly, primarily as a result of a continuing general economic improvement. Usage 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 uses, 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 coatings, 40%; and research and other uses, 20%.

PRICES

The producer price of indium was $2.65 per troy ounce at the beginning of the year but was lowered sharply to $1.43 per troy ounce later in January. The price was raised in several stages by April to a year's high of $3.60 per troy ounce, then later declined in two stages to end the year at

$3.10 per troy ounce.

FOREIGN TRADE

Imports of indium leveled off after several years of sharp increases. Belgium-Luxembourg was the leading supplier in 1984, followed by France and the United Kingdom.

Table 10.—U.S. imports for consumption of indium, by class and country

(Thousand troy ounces and thousand dollars)

Class and country	1982 Quantity	1982 Value	1983 Quantity	1983 Value	1984 Quantity	1984 Value
Unwrought and waste and scrap:						
Belgium-Luxembourg	141	452	218	556	263	837
Canada	14	124	33	135	26	98
China	--	--	(1)	10	7	19
France	83	226	278	521	231	844
Germany, Federal Republic of	--	--	(1)	1	13	43
Hong Kong	--	--	(1)	12	--	--
Ireland	24	59	--	--	--	--
Italy	165	292	259	435	101	207
Japan	114	323	3	24	9	40
Netherlands	23	69	16	37	78	242
Peru	26	96	49	129	84	273
Switzerland	--	--	32	77	58	125
Taiwan	--	--	--	--	8	42
Tunisia	--	--	--	--	6	19
United Kingdom	95	486	182	780	130	1,575
Total[2]	685	2,127	1,071	2,719	1,015	4,365
Wrought:						
Canada	--	--	--	--	(1)	62
Germany, Federal Republic of	--	--	(1)	1	(1)	1
Hong Kong	--	--	(1)	5	--	--
Japan	(1)	2	1	11	2	40
Peru	--	--	--	--	1	3
Togo	--	--	--	--	(1)	2
United Kingdom	1	57	1	59	4	104
Total	1	59	2	76	7	212

[1]Less than 1/2 unit.
[2]Data may not add to totals shown because of independent rounding.

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

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1984	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1984
Unwrought, waste, and scrap	628.45	0.8% ad valorem	Free	25.0% ad valorem.
Wrought indium	628.50	5.6% ad valorem	3.6% ad valorem	45.0% ad valorem.
Indium compounds	423.96	1.9% ad valorem	Free	25.0% ad valorem.

WORLD REVIEW

World production remained about the same as in 1983. Major world refiners included Cominco in Canada, MHO in Belgium, Peñarroya in France, Nippon Mining Co. Ltd. in Japan, Minero Perú Comercial in Peru, and Mining and Chemical Products Ltd. in the United Kingdom.

TECHNOLOGY

Research continued on applications for indium in the solar cell field. Systems investigated included gallium-indium-arsenide, indium phosphate, and copper-indium-diselenide.[32]

In the field of fiber optics, an indium phosphide system was investigated for possible use as an emitter to operate in a desired wavelength range.[33]

RHENIUM[34]

Rhenium was processed by one domestic firm in 1984. Consumption of rhenium increased an estimated 16% over that of 1983 to 10,200 pounds. Imports increased from 6,570 pounds in 1983 to 8,752 pounds in 1984. 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 $250 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 23 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)

	1980	1981	1982	1983	1984
Mine production[1]	14,200	15,800	11,200	8,100	8,600
Recovered[2]	W	W	W	W	W
Consumption[e]	7,300	6,600	5,900	8,800	10,200
Imports (metal)	513	580	176	623	1,962
Imports for consumption of ammonium perrhenate	4,991	9,089	5,193	5,947	6,790
Stocks, Dec. 31	W	W	W	W	W

[e]Estimated. 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 10 mines located 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 1984. Four other past producers—Kennecott Copper Co. Inc., M&R Refractory Metals Inc., Molycorp Inc., and S.W. Shattuck Chemical Co.—remained idle owing to the relatively low price for rhenium.

CONSUMPTION AND USES

Domestic consumption of rhenium increased an estimated 16% over that of 1983 to 10,200 pounds. 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 1984. 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 include the production of benzene, toluene, and xylenes.

About 9% 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 the manufacturing of 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 $250 per pound.

FOREIGN TRADE

U.S. imports for consumption of rhenium totaled 8,752 pounds, an increase of 33% over that of 1983. Ammonium perrhenate, with 6,790 pounds of metal content, was the main form of rhenium imported. This represented a 14% increase over that of 1983. The value of these imports was about $1.1 million. About 71% of the imports of ammonium perrhenate originated from Chile, 17% from Italy, and 12% from the Federal Republic of Germany. Imports of rhenium metal totaled 1,962 pounds, which represented a 215% increase over that of 1983. The value of these imports totaled $449,459.

Table 13.—U.S. import duties for rhenium materials

Item	TSUS No.	Most favored nation (MFN) Jan. 1, 1984	Most favored nation (MFN) Jan. 1, 1987	Non-MFN Jan. 1, 1984
Unwrought metal	628.9000	4.2% ad valorem	3.7% ad valorem	25% ad valorem.
Wrought metal	628.9500	6.8% ad valorem	5.5% ad valorem	45% ad valorem.
Ammonium perrhenate	417.4420	3.4% ad valorem	3.1% ad valorem	25% ad valorem.

Table 14.—U.S. imports for consumption of ammonium perrhenate, by country

(Rhenium content)

Country	1982 Quantity (pounds)	1982 Value (thousands)	1983 Quantity (pounds)	1983 Value (thousands)	1984 Quantity (pounds)	1984 Value (thousands)
Chile	4,609	$669	4,057	$712	4,827	$740
Germany, Federal Republic of	584	134	1,890	419	805	131
Italy	--	--	--	--	1,158	181
Total	5,193	803	5,947	1,131	6,790	1,052

Table 15.—U.S. imports for consumption of rhenium metal, by country

Country	1982 Gross weight (pounds)	1982 Value	1983 Gross weight (pounds)	1983 Value	1984 Gross weight (pounds)	1984 Value
France	--	--	--	--	2	$920
Germany, Federal Republic of	174	$87,413	613	$174,000	1,836	423,032
Italy	--	--	--	--	100	19,500
United Kingdom	--	556	--	--	2	417
Other[1]	2	--	10	6,000	22	5,590
Total	176	87,969	623	180,000	1,962	449,459

[1]Includes Austria, Singapore, Sweden, and Switzerland.

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 from prophyry 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 9,400 pounds of rhenium, were exported.

Chile.—Chilean recovery of rhenium was estimated at 8,000 pounds, the largest amount produced by a market economy country. Rhenium was recovered by the independent converting facility Molibdenos y Metales S.A. on a toll basis.

SELENIUM[35]

Both domestic production and demand decreased in 1984 compared with 1983 levels. However, production was much lower than demand, while imports increased substantially. The imbalance between production and demand as well as reportedly speculative buying resulted in a sharp increase in the price of selenium.

Domestic Data Coverage.—Domestic data for selenium are developed by the Bureau of Mines from a voluntary survey of U.S. operations. The four domestic refiners of selenium responded to a survey of their stocks, primary refined production, and shipments of selenium to consumers. Their reported figures represent 100% of the data shown for those items in table 16.

Table 16.—Salient selenium statistics

(Kilograms of contained selenium unless otherwise specified)

	1980	1981	1982	1983	1984
United States:					
Production, primary refined	[1]140,880	251,949	242,996	353,860	W
Shipments to consumers	140,960	207,854	307,610	374,030	224,401
Exports, metal, waste and scrap	81,769	60,523	117,267	93,368	122,929
Imports for consumption	283,709	311,566	347,329	297,029	376,946
Apparent consumption	342,901	458,898	537,672	577,691	478,418
Stocks, yearend, producer[2]	284,394	292,558	254,210	152,790	139,159
Dealers' price, average per pound, commercial-grade[3]	[4]$10.95-$12.66	$4.38	$3.53	$3.87	$9.02
World: Refinery production	[r]1,275,644	[r]1,274,938	1,144,495	[p]1,407,311	[e]1,180,729

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.
[1]Production includes net production of granular selenium, a semirefined form of selenium.
[2]Granular selenium, a semirefined form of selenium, is included in stocks.
[3]Metals Week.
[4]Producers' price of commercial and high-purity grades. In 1981, producers ceased listing published prices.

DOMESTIC PRODUCTION

The majority of 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.

During 1984, primary selenium was recovered from both domestic and imported materials at four U.S. copper refineries: AMAX Copper Inc., at Carteret, NJ; Asarco, at Amarillo, TX; Kennecott, at Magna, UT; and Phelps Dodge Refinery Corp., at El Paso, TX. Production at the AMAX refinery was reduced sharply in 1983 and future production was expected to be minimal. The Phelps Dodge refinery started operating its new selenium refinery unit during the first quarter. 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 four 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

After increasing for 3 consecutive years, apparent consumption in 1984 of refined selenium decreased 17% from the 1983 level. Requirements for consumption were met from increased net imports and stocks as production declined from 1983. Consumption of selenium decreased 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 on the drums of plain paper electrophotographic copiers. Demand was strong in 1984 and contributed significantly to overall consumption. Use of selenium as a semiconductor in the production of selenium rectifiers decreased markedly with the advent of low-cost silicon rectifiers.

The continued recovery of the U.S. automobile and construction industries contributed to a strong demand for selenium-containing pigments. These 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 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.

STOCKS

Producer stocks declined as stocks of granular selenium, a semirefined form of selenium, were processed into refined products. Stocks declined for the third consecutive year, to the lowest level since 1976. At the 1984 rate of consumption, yearend producer stocks represented less than a 4-month supply.

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.

During January and February, the dealers' price for commercial-grade selenium ranged from $4.00 to $5.10 per pound. In March, the price increased sharply to a peak of $12.00 per pound. The increase resulted from strong demand, speculative buying, and decreased production. For the remainder of the year, the price ranged from $9.00 to $11.50 per pound. The average annual price was $9.02, 2-1/3 times that of 1983.

FOREIGN TRADE

Decreased domestic production and shipments failed to meet the U.S. demand. As a consequence, imports increased by 27%, and 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, with an increase of 53% over 1983 imports. Belgium, the Federal Republic of Germany, Japan, and the United Kingdom were the other major import sources. Approximately 75,000 kilograms of the imported selenium, primarily from the United Kingdom, was refined from scrap that had been exported from the United States for processing.

Exports increased to the highest level since 1979, when exports peaked at 151,000 kilograms. In 1984, the United Kingdom was the recipient of about one-third of the exported selenium materials, primarily scrap. Exports to the Federal Republic of Germany and Japan increased almost sevenfold and threefold, respectively, and accounted for most of the increased exports.

Table 17.—U.S. exports of selenium metal, waste and scrap in 1984, by country

Country	Quantity (kilograms of contained selenium)	Value
Argentina	1,089	$10,200
Belgium-Luxembourg	322	5,141
Brazil	254	8,100
Canada	2,462	39,365
Chile	5,517	24,313
Colombia	7,831	198,864
France	1,758	38,173
Germany, Federal Republic of	13,769	139,413
Jamaica	91	3,000
Japan	27,255	186,992
Mexico	1,799	28,750
Netherlands	6,822	82,744
Switzerland	7,983	71,060
Thailand	499	11,000
United Kingdom	45,480	739,450
Total	[1]122,929	1,586,565

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

Table 18.—U.S. imports for consumption of selenium in 1984, by class and country

Class and country	Quantity (kilograms of contained selenium)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	47,483	$1,084,424
Canada	130,317	2,786,063
Chile	3,498	64,015
Germany, Federal Republic of	23,364	402,088
Japan	46,074	1,904,155
Netherlands	2,755	64,610
Peru	2,994	32,605
Philippines	5,000	59,525
Sweden	1,032	26,258
United Kingdom	80,844	964,306
Total	343,361	7,388,049
Selenium dioxide:		
Belgium-Luxembourg	35	529
Germany, Federal Republic of	5,598	121,704
Sweden	71	4,500
United Kingdom	29	1,586
Total	5,733	128,319
Selenium salts:		
France	6,399	6,397
Korea, Republic of	4,429	6,197
Taiwan	50	400
United Kingdom	193	6,821
Total	11,071	19,815
Sodium selenite:		
Canada	460	17,223
Germany, Federal Republic of	1,154	28,745
Japan	450	29,592
Spain	1,150	20,939
United Kingdom	9,968	249,974
Total	13,182	346,473
Other selenium compounds:		
Germany, Federal Republic of	13	1,548
Japan	2,574	133,671
Netherlands	42	482
Sweden	170	2,107
United Kingdom	800	33,400
Total	3,599	171,208
Grand total	376,946	8,053,864

Table 19.—U.S. import duties for selenium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
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	4.2% ad valorem.	3.7% ad valorem.	25% ad valorem.

WORLD REVIEW

Estimated world production of selenium increased slightly over the 1983 level, and was higher than the estimated world demand of about 1,300 metric tons.

Canada.—Noranda Mines Ltd.'s Canadian Copper Refiners Div. (CCR) operated Canada's largest selenium recovery plant at its Montreal East refinery. This plant processed imported selenium scrap as well as copper anode slimes. Inco Ltd. was Canada's second largest producer of selenium at its Copper Cliff refinery in Ontario.

Although Canada was a major world producer of selenium, it consumed less than

5% of its production, primarily in the glass industry. Most of its selenium production was exported, the United States being the largest recipient.

Japan.—Japan was the world's largest producer of refined selenium, derived primarily from imported copper concentrates. Mitsubishi was the largest selenium producer in Japan, with an estimated capacity of 200 tons per year at its Osaka precious metals plant, which treats copper anode slimes. At least three other Japanese companies, Mitsui Mining and Smelting Co. Ltd., Nippon Mining, and Sumitomo Metal, produced primary selenium.

Some of the selenium material exported to the United States was refined from U.S. scrap that had been exported previously to other countries for processing.

Table 20.—Selenium: World refinery production, by country[1]

(Kilograms of contained selenium)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Belgium[e]	60,000	60,000	60,000	60,000	60,000
Canada[3]	377,203	350,010	234,000	352,000	448,000
Chile	17,100	33,665	23,011	43,869	40,000
Finland	17,250	9,122	10,020	11,172	11,000
India	4,148	4,104	5,351	3,684	4,000
Japan	471,311	428,081	410,490	433,122	[4]464,524
Mexico	46,000	12,000	29,000	24,000	26,000
Peru	22,908	22,478	20,851	19,553	19,850
Sweden	51,000	44,000	[e]44,000	[e]44,000	45,000
United States	140,880	251,949	242,996	353,860	W
Yugoslavia	45,140	35,600	42,323	[r][e]40,000	45,000
Zambia[5]	22,704	23,929	22,453	22,051	[4]17,355
Total	[r]1,275,644	[r]1,274,938	1,144,495	1,407,311	1,180,729

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; excluded from "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 4, 1985.

[2]In addition to the countries listed, Australia, the Federal Republic of Germany, and the U.S.S.R. produced refined selenium, but output was not reported, and available information was 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]1980 data for 9-month period ending Mar. 31, 1981; 1981-84 data for fiscal year ending Mar. 31. In addition to refined selenium produced, Zambia exported significant quantities of selenium contained in anode slimes.

TECHNOLOGY

The Selenium-Tellurium Development Association sponsored the Third International Symposium on industrial use of selenium and tellurium, in Stockholm, Sweden, in October. The purpose of the symposium was to present and discuss the recent developments in use, technology, and markets. The program covered the industrial uses of selenium in the areas of photoelectric devices, metallurgy, pigments, glass, and other applications. Sessions were held on the increasing role that selenium plays in semiconductors, nutrition, and agriculture. Health and safety aspects were also covered. The role of selenium as an essential nutrient for humans and animals was discussed, as well as research on selenium's role as an anticarcinogen and as an agent in preventing heart disease.

TELLURIUM[36]

Production of tellurium increased in 1984. However, much of the increased production stemmed from refining producer stocks rather than from primary copper production, of which tellurium is a byproduct. Both consumption and imports increased over the 1983 levels. Increased consumption in 1984 led to an increase in prices.

Domestic Data Coverage.—Domestic tellurium refinery production data were obtained from the only domestic producer on a voluntary survey form. The figures have been withheld to prevent disclosing company proprietary data.

Table 21.—Salient U.S. tellurium statistics[1]

(Kilograms of contained tellurium unless otherwise specified)

	1980	1981	1982	1983	1984
Refinery production	W	W	W	W	W
Shipments to consumers	W	W	W	W	W
Imports for consumption	29,420	37,953	16,602	11,829	35,382
Apparent consumption	80,685	85,202	45,978	56,639	107,311
Stocks, yearend, producer	W	W	W	W	W
Producers' price, yearend, commercial grade	[2]$19.77	$14.00	$10.00	$9.00	$11.00-$11.50

W Withheld to avoid disclosing company proprietary data.
[1]World refinery production for selected countries is given in table 24.
[2]Annual average price per pound. The published list price of tellurium was suspended Jan. 5, 1981. Prices beyond 1980 are yearend prices quoted by one producer.

DOMESTIC PRODUCTION

Commercial-grade tellurium was recovered by Asarco, at Amarillo, TX, from copper anode slimes, a byproduct of electrolytic copper refining. Although AMAX Inc. discontinued production of tellurium at its Carteret, NJ, copper refinery in 1982, it remained a major consumer of tellurium for use in tellurium copper alloys.

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

Apparent consumption of tellurium increased for the second consecutive year, and was nearly double the 1983 level. The increase occurred in all end uses and was due to the continued improvement of the domestic economy. Tellurium consumption by end use was estimated as iron and steel products, 45%; nonferrous metals, 21%; chemicals, including rubber manufacturing, 21%; and other, including xerographic and electronic applications, 13%.

The principal end use of tellurium was as an alloying metal in the production of free-machining steels. The addition of up to 0.1% improves machinability. Similarly, the addition of tellurium to copper alloys improves their machinability as well as their corrosion resistance.

Tellurium catalysts were 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. Telluride salts can be used as an antioxidant in counteracting the formation of sludge in lubricating oils. Other tellurium compounds were 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 (MCT) is the most widely used infrared-sensing material for thermal imaging devices, used in military applications such as night vision and navigation systems. U.S. military applications accounted for most of the detector-grade, 99.99999%-pure tellurium that is consumed in the market economy countries.

PRICES

With increased consumption, prices for commercial-grade tellurium reversed from the decline that began in 1980. In 1984, the producer price for commercial-grade tellurium, quoted on a daily basis, ranged from $11.00 to $11.50 per pound. 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

Imports increased about threefold over that of 1983 and were at the highest level since 1981. Data on tellurium exports were not available. Canada was the major import source in 1984.

Table 22.—U.S. imports for consumption of tellurium in 1984, by class and country

Class and country	Quantity (kilograms of contained tellurium)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	4,003	$68,764
Canada	20,382	369,745
Germany, Federal Republic of	1,019	17,367
Japan	1,825	103,338
Netherlands	1,300	23,884
United Kingdom	5,892	105,026
Total	34,421	688,124
Compounds:		
Belgium-Luxembourg	724	21,112
Canada	200	5,753
Germany, Federal Republic of	23	3,408
United Kingdom	14	6,572
Total	961	36,845
Grand total	35,382	724,969

Table 23.—U.S. import duties for tellurium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
Tellurium metal	632.48	1.5% ad valorem	Free	25% ad valorem.
Compounds	421.90	4.2% ad valorem	3.7% ad valorem	Do.

WORLD REVIEW

Estimated production of tellurium outside of the United States declined slightly from the 1983 level. Production was only about 20% of estimated world refinery capacity.

Noranda Mines was Canada's largest producer of tellurium at its CCR Div., where copper anodes from three Canadian smelters were refined. Tellurium was recovered from the anode slimes, which contained about 2% tellurium.

Cominco was the leading world producer of high-purity tellurium at its plant in Trail, British Columbia. It was also the largest producer of detector-grade tellurium.

Table 24.—Tellurium: World refinery production, by country[1]

(Kilograms of contained tellurium)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Canada[3]	8,974	21,297	16,500	23,500	15,100
Fiji	11,350	--	--	--	--
India	200	220	[e]220	[e]200	225
Japan	68,700	61,700	62,800	54,800	62,700
Peru	20,920	21,310	20,726	15,116	14,150
United States	W	W	W	W	W

[e]Estimated. [p]Preliminary. 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 4, 1985.

[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 was not reported, and available information was inadequate for formulation of reliable estimates of output levels. Moreover, the other major copper-refining nations such as Chile, Zaire, and Zambia may produce refined tellurium, but output in these nations was conjectural.

[3]Refinery output from all sources, including imports and secondary sources.

[4]Pilot plant production.

TECHNOLOGY

The Selenium-Tellurium Development Association sponsored the Third International Symposium on industrial use of selenium and tellurium, in Stockholm, Sweden, in October.

A report to the National Materials Advisory Board assessed MCT materials technology. MCT semiconductors are among the most important semiconductors for defense and space applications. MCT is the principal material used for infrared detection systems. The U.S. Department of Defense research in 1984 was placing emphasis on developing the technology to produce larger arrays containing greater numbers of detectors in the field of view.

THALLIUM[37]

Historically, the commercial domestic source for the production of thallium was flue dusts and residues generated during the smelting of certain zinc ores. In 1984, domestic requirements for thallium continued to be met by imports and withdrawals from stocks. Asarco, the sole domestic refiner of thallium, has not sold thallium metal and thallium compounds since 1981.

Legislation and Government Programs.—The Hazardous and Solid Waste Amendments of 1984, Public Law 98-616, which was signed by the President on November 8, set limits on the disposal of toxic materials such as thallium in landfills. Land disposal of liquid wastes containing thallium metal or thallium compounds at concentrations greater than or equal to 130 milligrams per liter, thallium content, was prohibited. This law was to take effect 32 months after enactment.

CONSUMPTION AND USES

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.

PRICES

Metal traders reported that the price of imported thallium metal, 99.99% pure, was $35 per pound.

WORLD REVIEW

World production data for thallium were not available. The U.S. reserves of thallium contained in zinc ores were estimated at 70,000 pounds. Rest-of-world reserves contained in zinc ores were estimated to be 760,000 pounds of thallium.

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[1]Prepared by Daniel Edelstein, physical scientist.

[2]Federal Register. Environmental Protection Agency. National Emission Standards for Hazardous Air Pollutants, Proposed Standards for Inorganic Arsenic. V. 49, No. 184, Sept. 20, 1984, pp. 36877-36879.

[3]———. Environmental Protection Agency. National Emission Standards for Hazardous Air Pollutants, Proposed Standards for Inorganic Arsenic. V. 49, No. 55, Mar. 20, 1984, pp. 10278-102280.

[4]———. Environmental Protection Agency. Creosote, Pentachlorophenol, and Inorganic Arsenicals; Notice of Intent To Cancel; Notice of Determination, Notice of Availability of Position Document. V. 49, No. 138, July 13, 1984, pp. 2866-28689.

[5]ASARCO Incorporated (New York). ASARCO News. June 27, 1984.

[6]Wolfe, J. R. The Hydrometallurgical Recovery of Arsenic From Smelter Flue Dusts. Ch. in Arsenic: Industrial, Biomedical, Environmental Perspectives, ed. by W. Lederer and R. Fensterheim. Van Nostrand Reinhold Co. Inc., New York, 1983, pp. 10-15.

[7]U.S. Department of Agriculture. The Biologic and Economic Assessment of Pentachlorophenol, Inorganic Arsenic, Creosote. Volume 1: Wood Preservatives. USDA Tech. Bull. 1658-1, Nov. 4, 1980, pp. 339-341.

[8]Roskill Information Services Ltd. (London). The Economics of Arsenic. 5th ed., 1984, pp. 18, 35.

[9]Lei, K. P. V., and T. G. Carnahan. Leaching Sulfide Minerals by Oxidative Electrolysis in Membrane Cells. Ch. in Proceedings of the International Symposium on Electrochemistry in Mineral and Metals Processing, ed. by P. E. Richardson, S. Srinivason, and R. Woods. Electrochem. Soc. Inc., Pennington, NJ, 1984, pp. 374-390.

[10]The Washington Post. 5th Generation Spurs a Global Computer Race. July 12, 1984, pp. D1, D6.

[11]Robinson, P. Gallium Arsenide Chips. BYTE, v. 9, No. 12, Nov. 1984, pp. 211-227.

[12]American Metal Market. New Gallium-Arsenide Crystal Developed. V. 92, No. 49, Mar. 12, 1984, p. 21.

[13]Seattle Times. U.S. To Fund Arsenic Study Near Asarco. Sept. 30, 1984.

[14]The Montana Standard. Anaconda Co. To Pay for Smelter Studies. Sept. 5, 1984.

[15]Prepared by W. Timothy Adams, physical scientist.

[16]Emerson, M. Tantalum. Eng. and Min. J., v. 186, No. 3, Mar. 1985, pp. 104-105.

[17]Chemical & Engineering News. Technology. Selective Catalysts Yield Higher Alcohols. V. 62, No. 38, Sept. 17, 1984, pp. 42, 44.

[18]Prepared by Patricia A. Plunkert, physical scientist.

[19]Federal Register. Determination, National Defense Stockpile Required for Germanium. V. 49, No. 131, July 6, 1984, p. 27815.

[20]———. Nonferrous Metals Manufacturing Point Source Category; Effluent Limitations Guidelines, Pretreatment Standards and New Source Performance Standards. V. 49, No. 125, June 27, 1984, pp. 26352-26483.

[21]Chemical Week. Upping the Fiber-Optic Ante. V. 135, No. 6, Aug. 8, 1984, pp. 13-14.

[22]———. Optic Fibers Startup. V. 135, No. 13, Sept. 26, 1984, p. 23.

[23]Wire Technology. Siecor Plant Operating. V. XII, No. 7, Nov.-Dec. 1984, p. 63.

[24]Work cited in footnote 21.

[25]Wall Street Journal. Sante Fe, Norfolk Plan Fiber-Optics System Along Rights of Way. V. CCIV, No. 52, Sept. 13, 1984, p. 22.

[26]Jordan, C. L. Union Pacific OK's Right of Way for Four Fiber Optics Systems. Am. Met. Mark., v. 92, No. 65, Apr. 3, 1984, pp. 1, 11.

[27]Japan Metal Journal. V. 15, No. 10, Mar. 11, 1985, p. 5.

[28]Luke, P. N. Gold-Mask Technique for Fabricating Segmented-Electrode Germanium Detectors. IEEE Trans. Nucl. Sci., v. NS-31, No. 1, Feb. 1984, pp. 312-315.

[29]Financial Times (Frankfurt ed.). Mar. 16, 1984, p. 23.

[30]Nadkarni, R. A., and R. I. Botto. Determination of Germanium in Coal Ashes by Inductively Coupled Plasma Atomic Emission Spectrometry. Appl. Spectrosc., v. 38, No. 4, 1984, pp. 595-598.
[31]Prepared by James F. Carlin, Jr., physical scientist.
[32]Smith, S. A., and R. Watts. Critical Materials Assessment Program. Solar Cells. Elsevier Publishing Co., Netherlands, v. II, 1984, pp. 41-49.
[33]Mahajan, S., V. G. Keramidas, and J. E. Wernick. InP and InGaAsP Semiconducting Materials for Optical Communications. J. Met., Aug. 1984, pp. 37-44.
[34]Prepared by John W. Blossom, physical scientist.
[35]Prepared by Neldon L. Jensen, physical scientist.
[36]Prepared by Neldon L. Jensen, physical scientist.
[37]Prepared by Patricia A. Plunkert, physical scientist.

Table 25.—U.S. imports for consumption of thallium in 1984, by country

Country	Compounds			Unwrought and waste and scrap	
	Gross weight (pounds)	Content[e] (pounds)	Value	Gross weight (pounds)	Value
Belgium-Luxembourg	896	717	$17,387	762	$11,888
Canada	--	--	--	8	3,889
Germany, Federal Republic of	1,198	958	60,935	--	--
United Kingdom	50	40	832	50	787
Total	2,144	1,715	79,154	820	16,564

[e]Estimated.

Table 26.—U.S. import duties for thallium

Item	TSUS No.	Most favored nation (MFN)		Non-MFN
		Jan. 1, 1984	Jan. 1, 1987	Jan. 1, 1984
Unwrought metal	632.50	1.9% ad valorem	Free	25% ad valorem.
Compounds	422.00	4.2% ad valorem	3.7% ad valorem	Do.

Other Nonmetals

By Staff, Division of Industrial Minerals

CONTENTS

ASPHALT (NATIVE)[1]

Native asphalt was produced by five companies in two States, Texas and Utah. Bituminous limestone, used primarily as a paving material for street and road repair, was produced by White Uvalde Mines and by Azrock Industries Inc., Uvalde County, TX. In June, Azrock Industries was purchased by the R. L. White Co.

Gilsonite, a solidified hydrocarbon found only in Utah and Colorado, was mined by American Gilsonite Co., a division of Chevron Resources Co. (a subsidiary of Standard Oil Co. of California); by Ziegler Chemical and Mineral Corp.; and by 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.

Bituminous limestone and gilsonite production and value information are 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 the year. 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 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 last reported in 1983, all from the United Kingdom, totaled 1,543 pounds, with a customs declared value of $19,290. The high unit value of this imported material, $12.51 per pound, indicates that imports 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 chiefly in Somalia, Tanzania, and Turkey. The block material is used by companies in New York and Ohio for manufacturing smokers' pipes. Smokers' specialty houses have begun advertising mail-order kits with detailed instructions for do-it-yourself carving of meerschaum smoking articles. Turkish production in 1984 was estimated to be 300 unit boxes, 44 pounds each, of block meerschaum. Although Turkey has been a major producer of crude or block meerschaum, state laws have prohibited exports of uncarved material since 1975.

QUARTZ CRYSTAL[4]

In 1984, record-high U.S. production was set for both lascas and cultured quartz crystal. Lascas is the silicon dioxide feedstock material needed for cultured quartz production and for certain fused quartz end uses. The lascas record was aided by the addition of a new mine. Worldwide demand for cultured quartz crystal in electronic applications fueled the cultured quartz production record. Although overall consumption levels of natural quartz crystal continued to fall, imported natural quartz crystal was still required as seed material for growing cultured quartz crystal. The National Materials Advisory Board (NMAB) reviewed quartz crystal requirements for the National Defense Stockpile and reported its findings to the Federal Emergency Management Agency (FEMA).[5]

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, representing 100% of total production shown in table 1. Of the 28 operations that consumed quartz crystal, 27 responded, representing approximately 100% of total consumption, also shown in table 1. Consumption for the remaining nonrespondent was estimated using reported prior year production levels adjusted by trends in employment and other guidelines.

Table 1.—Salient U.S. electronic- and optical-grade quartz crystal statistics

(Thousand pounds and thousand dollars)

	1980	1981	1982	1983	1984
Production:					
Mine[e 1]	400	175	200	600	2,500
Cultured	757	660	478	426	1,027
Exports:					
Natural:[2]					
Quantity	91	127	69	28	42
Value	$366	$490	$380	$156	$234
Cultured:[2]					
Quantity	219	125	115	80	277
Value	$3,209	$4,600	$3,500	$3,258	$11,021
Lascas:					
Quantity	NA	NA	NA	[3]339	[e]1,600
Imports of Brazilian lascas:[2]					
Quantity	816	389	417	153	569
Value	$402	$233	$245	$121	$373
Consumption:					
Natural (electronic- and optical-grade)	17	14	16	13	7
Cultured (lumbered)	393	282	99	112	77
Cultured (as grown)	372	327	383	312	229
Total	782	623	498	437	313

[e]Estimated. 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.—At yearend, the National Defense Stockpile total inventory was 1.9 million pounds of natural quartz crystal with a goal of 600,000 pounds. Effective October 19, 1984, the U.S. Department of Defense Authorization Act (Public Law 98-525) set a limit for disposal of 100,000 pounds of quartz crystal and determined that amount as excess to the current requirements of the stockpile. Total sales of natural quartz crystal by the General Services Administration were 127,546 pounds.

Under a contract with FEMA, NMAB reviewed the technology and major applications of cultured and natural crystalline and fused quartz with the aim of providing background information and advice for decisions regarding the composition and quantities of quartz for the National Defense Stockpile. The final report recommended that the current stockpile of natural quartz crystals be reduced considerably, but that large crystals be retained as seeds for cultured crystal growth. Some additional quartz should also be retained for special crystal requirements and as feedstock for unique and essential silica glass applications. Also recommended was the monitoring of (1) the supply-demand situation for cultured quartz, especially with respect to the early forecast of possible increases in the demand for technologically advanced materials, and (2) the viability of U.S. cultured quartz and device suppliers. Finally, the report recommended that additional Government support be given to research and development on the preparation, properties, and production scaleup of technologically advanced material.[6]

DOMESTIC PRODUCTION

The first full year of operation for the new mine in Arkansas, operated by Geomex Mines Services Inc., was the primary reason for the 1984 lascas production record. The other U.S. lascas producer, Coleman Crystal Inc., was the major supplier of lascas to the U.S. cultured quartz crystal industry.

The cultured quartz producers operated at near full capacity levels for most of the year because of the strong worldwide demand in piezoelectric applications of quartz crystal. Seven companies produced cultured quartz crystal in the United States. 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, and AT&T Technologies Inc., North Andover, MA, produced for both internal consumption and the domestic fabrication industry. The other three growers, Bliley Electric Co., Erie, PA, Electro Dynamics Corp., Shawnee-Mission, KS, and P. R. Hoffman Co., Carlisle, PA, produced only for internal consumption.

CONSUMPTION AND USES

U.S. consumption of lascas by the seven growers was about 1.3 million pounds, a 98% increase from the 677,000 pounds reported in 1983. The substantial increase occurred because the quartz crystal industry operated near full capacity levels in 1984 after recovering from a 2-year recession.

Quartz crystal was consumed by 28 companies in 11 States. Of these companies, 22 consumed only cultured quartz crystal, 2 consumed only natural quartz crystal, and 4 consumed both natural and cultured material.

Cultured quartz crystal is the primary quartz material used in electronic applications. The piezoelectric effect is achieved when a suitable electrical signal is applied to a quartz wafer or blank with appropriate electrodes, and the wafer then vibrates mechanically throughout the bulk of material at a characteristic natural resonance frequency. The quartz resonators are uniquely suitable for military-aerospace and commercial band-pass filter applications that require very high selectivity or in oscillator applications that require very high stability. In addition, for many applications requiring only moderate stability, a quartz resonator offers a unique combination of high performance, small size, and low cost. Quartz resonators are also used for many less demanding applications such as providing timing signals for watches, clocks, and microprocessors in industrial, automotive, and consumer products.

For very high frequencies (above 100 megahertz), the quartz wafer becomes too thin for practical use. At these higher frequencies, structures that use surface vibrations, in which the frequency is determined by electrode dimensions rather than wafer thickness, are becoming more important. These structures are called surface wave or surface acoustic wave (SAW) devices. In 1984, SAW devices amounted to only a few percent of the total industry usage.

Imported natural quartz crystal continued to be required as seed material for growing quartz crystal. It was also used in pressure transducers for highly sensitive quartz pressure gauges, which have become the petroleum industry's standard for accurate and precise pressure measurements in oil and gas wells.

STOCKS

Reported industry cultured quartz crystal stocks totaled approximately 53,000 pounds at the beginning of the year and increased to about 134,000 pounds by yearend. The increase was attributed to a slowdown in sales during the fourth quarter.

PRICES

The average reported value of lascas consumed for production of cultured quartz crystal was $0.57 per pound, 5 cents per pound below that of 1983. The average value of as-grown cultured quartz, based on reported sales of 264,435 pounds, was $24.18 per pound, up about 11% from that of 1983. The average value of lumbered quartz, which is as-grown quartz that has been processed by sawing and grinding, was $54.90 per pound, an increase of about 12% from that of 1983. The lumbered quartz average value was based on reported sales of 329,757 pounds.

FOREIGN TRADE

Sawyer Research Products and Thermo Dynamics, the two largest growers of cultured quartz crystal, accounted for all of the cultured quartz crystal exports. Japan received 79% and the Republic of Korea received 11% of the export total reported by the Bureau of the Census.

Most of the natural quartz crystal exports were bought from the National Defense Stockpile and were in the 700- to 1,000-gram weight class or lower. This quartz was consumed primarily in nonpiezoelectric uses such as quartz carvings and figurines.

Imports of Brazilian lascas, designated "Crude Brazilian Pebble," reached their highest level since 1980 in response to the strong industrial demand for cultured quartz crystal.

STAUROLITE[7]

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 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 1984 by E. I. du Pont 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% Al_2O_3 (minimum), 18% Fe_2O_3 (maximum), 3% ZrO_2 (maximum), 5% TiO_2 (maximum), and 5% SiO_2.

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).

Quantitative production data are not released for publication, but the 1984 production of staurolite increased 12% from that of 1983; shipments decreased 4% in tonnage and increased 66% in price per ton. Domestic productive capacity remained at about 135,000 short tons per year.

Staurolite had been produced in India in small quantities and sometimes by other nations as well.

STRONTIUM[8]

The U.S. strontium industry continued restructuring in 1984. FMC Corp., for many years the leading domestic producer of strontium compounds, closed the company's plant at midyear. Because of the decreased U.S. capacity for manufacturing strontium compounds, imports of celestite ($SrSO_4$), the principal source of strontium, decreased slightly. Celestite was not mined in the United States. Overall, strontium demand increased in its principal end uses requiring increases in imports of strontium carbonate ($SrCO_3$) and nitrate $Sr(NO_3)_2$. In a major foreign development, a large Mexican celestite mining company was constructing a $SrCO_3$ plant. The Federal Republic of Germany, the world's largest manufacturer of $SrCO_3$, was expected to complete a 33% expansion in annual capacity by early 1985.

Domestic Data Coverage.—Domestic production data for strontium are developed by the Bureau of Mines from a voluntary survey of U.S. operations. Of the two operations to which a survey was sent, both responded, representing 100% of total production. However, because of the small survey size, production and stock data were withheld from publication to avoid disclosing company proprietary data.

The strontium survey is also used to calculate the distribution of primary strontium compounds by end use. Of the 15 operations to which a survey request was made, 14 responded, representing an estimated 98% of the end-use data shown in table 3. Consumption for the nonrespondent was estimated using reported prior year consumption levels adjusted by trends in employment and other guidelines.

Table 2.—Major producers of strontium compounds in 1984

Company	Location	Compounds
Barium and Chemicals Inc	Steubenville, OH	Various.
Chemical Products Corp	Cartersville, GA	Carbonate.
Mallinckrodt Inc	St. Louis, MO	Various.
Milwhite Co. Inc	Houston, TX	Sulfate.
Mineral Pigments Corp	Beltsville, MD	Chromate.
Wayne Chemical Co	Milwaukee, WI	Do.

DOMESTIC PRODUCTION

Strontium minerals had not been produced commercially in the United States since 1959. After the midyear 1984 closure of FMC's Modesto, CA, plant, Chemical Products Corp. (CPC), Cartersville, GA, was the remaining major producer of $SrCO_3$ from imported celestite. A number of U.S. firms manufacture strontium compounds from $SrCO_3$.

CONSUMPTION AND USES

The major use in the United States was in the manufacture of color television tubes, which contained 5% to 7% strontium oxide supplied as $SrCO_3$. In 1984, the decline in consumption for this end use was attributed to the closure of a large television picture tube plant in 1983.

Another major use of $SrCO_3$ was in the manufacture of ferrite ceramic magnets, which were made from iron oxides and $SrCO_3$. Strontium ferrites were 15% $SrCO_3$ by weight and had a higher coercivity than barium ferrites in terms of unit weight, size, and cost. In recent years, strontium ferrites have been gradually replacing barium ferrites. $SrCO_3$ was also used in the electrolytic production of zinc, in which $SrCO_3$ was added to the electrolyte to precipitate lead ions from solution.

$Sr(NO_3)_2$ used in pyrotechnics and signals continued as the second largest end use. FMC, formerly the only U.S. producer of $Sr(NO_3)_2$, sold its manufacturing equipment to CPC, which planned to add $Sr(NO_3)_2$ to the company's product line in 1985. The brilliant red color that strontium imparts to a flame promoted the use of $Sr(NO_3)_2$ in railroad fusees, other signal flares, and in pyrotechnics for entertainment.

Strontium compounds of lesser importance included strontium chromate, which was used as a corrosion inhibitor in pigment; strontium phosphate, which was used in the manufacture of fluorescent lights; and strontium chloride, which was used in the manufacture of toothpaste for sensitive teeth. Small quantities of strontium compounds were also used in electronic components, glass, oil well drilling muds, pharmaceuticals, plastics, radarscopes, and welding fluxes.

Table 3.—U.S. estimated distribution of primary strontium compounds, by end use

(Percent)

End use	1982	1983	1984
Electrolytic production of zinc	3	r3	6
Ferrite ceramic magnets	r8	r9	11
Pigments and fillers	r5	r4	8
Pyrotechnics and signals	15	14	14
Television picture tubes	62	64	53
Other	(1)	(1)	1
Unidentified	r7	r6	7
Total	100	100	100

rRevised.
[1]Less than 1/2 unit.

PRICES

The average value of imported strontium minerals at U.S. ports was $87.87 per short ton, or $13.45 per ton more than that of 1983. Prices for strontium minerals are usually determined by direct negotiations between buyer and seller and are seldom published.

FOREIGN TRADE

Celestite imports declined slightly from their 1983 level with Mexico supplying about 96% of the 1984 reported total. Considering the anticipated impact on U.S. strontium compound production as a result of FMC's plant closure, the decline was relatively small. A partial explanation of why the impact was not greater was that CPC expanded its capacity early in 1984, and FMC's plant closure was at midyear. Additionally, the U.S. $SrCO_3$ market rallied in 1984, and CPC operated at or near full capacity during much of the year.

Foreign competition for the U.S. strontium compound market intensified. On a $SrCO_3$ basis, imports more than quadrupled their 1983 levels. Most of the increase occurred for $SrCO_3$ and $Sr(NO_3)_2$. The leading suppliers of $SrCO_3$, in descending order, were the Federal Republic of Germany and China. $SrCO_3$ imports were reported from China for the first time since 1979. The leading exporters to the United States of $Sr(NO_3)_2$ were Italy and Spain. Because FMC had been the only U.S. producer of $Sr(NO_3)_2$, the sharp increase in imports of this compound was predictable.

Table 4.—U.S. imports for consumption of strontium minerals[1] by country

Country	1983 Quantity (short tons)	1983 Value (thousands)	1984 Quantity (short tons)	1984 Value (thousands)
Madagascar	(2)	$1	(2)	$1
Mexico	47,007	3,080	46,873	3,940
Spain	2,789	626	1,978	352
Total	49,796	r3,707	348,852	4,293

rRevised.
[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	1983 Pounds	1983 Value	1984 Pounds	1984 Value
Strontium carbonate, not precipitated:				
Canada	--	--	436	$345
Germany, Federal Republic of	39,683	$11,047	39,683	11,233
Mexico	--	--	84,000	23,880
Spain	--	--	39,683	9,423
Total	r39,683	r11,047	163,802	44,881
Strontium carbonate, precipitated:				
Canada	--	--	158,733	66,935
China	--	--	829,547	253,331
Germany, Federal Republic of	938,007	290,620	5,586,138	1,577,834
Mexico	--	--	354,200	130,219
United Kingdom	5,143	8,007	--	--
Total	943,150	298,627	6,928,618	2,028,319
Strontium chromate:[1]				
Belgium	--	--	5,291	5,941
Canada	53,010	59,131	--	--

See footnotes at end of table.

Table 5.—U.S. imports for consumption of strontium compounds and metal, by country —Continued

Country	1983 Pounds	1983 Value	1984 Pounds	1984 Value
Strontium chromate:[1] —Continued				
France	235,284	$240,994	222,665	$224,149
Germany, Federal Republic of	3,337	5,588	13,228	19,340
Spain	28,660	31,034	147,647	161,879
United Kingdom	10,155	10,788	4,698	13,574
Total	330,446	347,535	393,529	424,883
Strontium nitrate:				
Italy	815,414	351,230	970,517	417,918
Spain	45,194	15,622	865,619	325,233
Total	860,608	366,852	1,836,136	743,151
Strontium compounds, n.s.p.f.:				
Belgium	--	--	441	390
Germany, Federal Republic of	18,963	21,132	22,391	22,913
Japan	24,246	13,698	157,364	109,954
Netherlands	366	4,453	7,726	11,598
Spain	39,683	14,028	--	--
United Kingdom	16,983	21,411	--	--
Total	100,241	74,722	187,922	144,855
Strontium metal, unwrought: Canada	1,991	22,790	1,424	17,980

[r]Revised.
[1]Imported as strontium chromate pigment (TSUS 473.19).

Source: Bureau of the Census.

WORLD REVIEW

Canada.—Anticipating a strengthening market for celestite, in October, the Nova Scotia Department of Mines and Energy invited tenders on a block of claims that included the former celestite producing deposit at Lake Enon in Cape Breton County. Bids were to be accepted up to July 2, 1985. Kaiser Celestite Mining Ltd. mined these deposits from 1970 to 1976 and produced over 270,000 tons of celestite. Measured and indicated celestite ore reserves totaled 770,000 tons occurring in two zones that average 45% to 50% and 60% to 70% $SrSO_4$, respectively.[9]

Germany, Federal Republic of.—Kali Chemie AG, the world's largest producer of $SrCO_3$, announced plans to increase its total annual $SrCO_3$ capacity by 33% in early 1985. The company's expansions were scheduled for plants in Bad-Hoenningen, in the Rhine River region, and Sapad, in Livorno, Italy.[10]

Mexico.—Cía Minera La Valenciana S.A., owner of the world's largest celestite mine, announced that the company was constructing a $SrCO_3$ plant at Torreon. The plant, as planned, was to have a $SrCO_3$ capacity of 12,000 tons per year and was scheduled to open by yearend 1985. The company was expected to continue as the major celestite supplier to CPC.[11]

Table 6.—Strontium minerals: World production, by country[1]

(Short tons)

Country[2]	1980	1981	1982	1983[p]	1984[e]
Algeria[e]	[r]6,000	[r]6,000	[r]6,000	[r]6,000	6,000
Argentina	295	342	855	742	660
Iran[e 3]	6,100	5,500	5,000	[r]5,100	5,100
Italy	1,161	7,382	3,607	[r e]3,600	3,500
Mexico	44,931	45,574	34,917	41,343	44,000
Pakistan	276	325	300	149	170
Spain	20,944	39,683	38,581	[r e]38,000	37,500
Turkey[e]	17,600	16,500	16,500	[4]42,808	38,600
United Kingdom	7,386	16,000	19,800	13,200	13,200
Total	[r]104,693	[r]137,306	125,560	150,942	148,730

[e]Estimated. [p]Preliminary. [r]Revised.
[1]Table includes data available through June 4, 1985.
[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[12]

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 1984 increased by 16%. Specific data are withheld to avoid disclosing company proprietary data. The three producers, in descending order of output, were NYCO, a division of Processed Minerals Inc., Essex County, NY; R. T. Vanderbilt Co. Inc., Lewis County, NY; and Pfizer Inc., Riverside County, CA.

NYCO's new Lewis Mine, with estimated reserves of 6 million tons, replaces the older underground mine, which was near depletion. At the new minesite, the company installed a 300-short-ton-per-hour portable crushing system. The crushed ore is trucked 14 miles to the mill at Willsboro, NY. Garnet residue, previously treated as waste, has now found a growing market in sandblasting, road paving material, and ice control.[13]

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 friction products such as brake linings.

In China, the first wollastonite deposit was discovered in 1975 in Hubei Province. Most of the wollastonite minerals were acicular and comparatively pure; major associated minerals were andradite, diopside, and quartz. After the first deposit was discovered, 17 other deposits were found in 11 provinces.[14]

Oy Partek AB, of Finland, shipped about 5,000 tons of wollastonite in 1983 to European ceramic markets and produced 10,000 tons for internal use. In India, Wolkem Pvt. Ltd. shipped 18,000 tons of ore in 1983 to grinders in Europe and Japan.[15]

The American Paint & Coatings Journal, December 31, 1984, quoted the price of paint-grade wollastonite, carloads, f.o.b. plant, as $164 per ton for acicular material; $117 per ton for 325 mesh; and $134 per ton for 400 mesh. Chemical Marketing Reporter, December 31, 1984, quoted prices for truckloads, f.o.b. plant, as $174 per ton for general grade; $125 per ton for 325 mesh; and $142 per ton for 400 mesh.

ZEOLITES[16]

Natural zeolites production in 1984 was about one-half that of 1983 at about 2,400 metric tons.

An in-depth analysis of the reasons for the failure of the natural zeolite industry to achieve expected goals was given at an industrial minerals conference.[17] The presentation indicated that the tremendous potential of the industry is part of the problem and that the marketers are, by and large, treating natural zeolites as a commodity and merely hanging out an "available" sign. It was emphasized that most of the industry's problems were caused by wrong marketing approaches, such as attempting to sell the natural zeolites for replacement of materials that were in some cases both better for the use and cheaper than the zeolites. To be successful, marketing approaches should treat the zeolite like the "speciality chemicals" they truly are, and address very specific markets that require their special properties. Clinoptilolite was so efficient at removing ammonia from the effluent at waste water treatment plants that frequent recharging was unnecessary and the envisioned large and recurring market did not develop.

A second paper on zeolites gives an in-depth description of the location, geology, mineralogy, history, and utility of the Campanian tuff of southern Italy.[18] It was concluded that large deposits of chabazite-rich tuff, exploitable for numerous industrial and agricultural processes, are present in the region. The rock constituting the various deposits is nearly homogeneous and often contains an elevated amount (50%) of zeolite. The zeolites have interesting properties, especially for adsorption operations, including good thermal stability, elevated rehydration kinetics, and acceptable water vapor adsorption capacity.

A Mississippi newspaper reported that University of Mississippi geologists had discovered a "respectable reserve" of zeolites in the northern portion of the State.[19] It was suggested that the zeolites could be used to purify the water in catfish farming, thereby doubling the catfish population per unit of water.

A chemical magazine outlined the differences between market perceptions for zeolites as a major detergent ingredient in the United States and other countries.[20] At present, in the United States, six States—Indiana, Michigan, Minnesota, New York, Vermont, and Wisconsin—ban the use of phosphates in home laundry detergents, and all six also limit the phosphate content to the equivalent of 8.7% phosphorus in automatic dishwashing detergents. Additionally, localities have their own bans. Dade County, FL, which includes Miami; Chicago and many of its suburbs; and Akron, OH, and some of its suburbs have total bans. Other areas have opted for limits. Connecticut, Florida, Maine, and about 15 municipalities limit phosphorus content to 8.7% in household laundry detergents. According to the article, the expected zeolite boom was based on such legislative bans or limits on the use of phosphates in detergents.

In the United States, detergent-grade zeolite capacity is dominated by Ethyl Corp., whose plant at Pasadena, TX, went on-stream in the late 1970's with a capacity of about 100,000 tons per year. In September 1982, PQ Corp. put on-stream its 30,000-ton-per-year plant in Kansas City, KS.

Industry observers say that market share loss for zeolite-based products led Proctor & Gamble Corp. (P&G) to reformulate the products it had been marketing in phosphate-limit areas. Producers of zeolites in the United States had high hopes that the product market would quickly expand throughout the rest of the industry if the P&G formulation was successful. However, P&G's product reformulation back to a level of 8.2% phosphorus, just under most of the limits of 8.7% phosphorus, resulted in underutilization of some nearly new zeolite plants.

Mining Magazine reported that detailed geological exploration has revealed that the zeolite occurrence found near Ratka, Hungary, is the richest such deposit in Europe.[21] Clinoptilolite reserves are about 100 million tons. About 17 product types have been marketed for various purposes. In addition to domestic markets, Austria, the Federal Republic of Germany, and Sweden are the principal users of Hungarian zeolites. Production in Hungary amounts to 15,000 tons per year. To meet increasing demand, more production capacity is being constructed.

In Canada, there is a federal limit on the use of phosphates in household detergents set at 2.2% phosphorus.

Some European countries, notably Sweden, have decided the best way to tackle water eutrophication is through tertiary sewage treatment systems. Most other countries that have a perceived problem, however, have turned to phosphate limitations. For most of these countries, the limits—and by and large they are limits not bans—are complex formulas dependent upon such factors as water hardness. For example, in the Federal Republic of Germany, a decree has set the maximum amount of phosphates in detergents with scheduled reductions, in phases. In the Netherlands, there has been a voluntary two-stage reduction in phosphate levels by the industry.

In Norway, the industry and the Government worked out an agreement to limit phosphate content in household laundry detergents to 12% sodium tripolyphosphate.

However, there is a total ban on the phosphates for automatic dishwashing detergents.

As recently as August 1983, production capacity for detergent zeolites in Europe was at least 210,000 tons per year.

Although only some of Japan's Prefectures have instituted bans on phosphate use, detergent makers decided upon total product reformulations because of the country's marketing patterns. As a result, within only 2 years, more than 90% of the detergents produced and sold in Japan are phosphate-free, using zeolites instead.

It was noted in a later issue of the same magazine that the European zeolite industry had one basic problem—it was too big.[22] New producers, anticipating good growth in markets such as desiccants and adsorbents, fluid-cracking catalysts (FCC), and detergents, have entered the market. With growth temporarily slowed, considerable overcapacity exists in the industry.

In Europe, FCC probably account for the second largest use of zeolites, following detergents. Although the market for FCC is roughly the same size as that for detergent zeolites, zeolites make up a part of the catalyst, anywhere from 5% to 40%. European consumption of FCC will amount to about 40,000 tons this year, less than one-fourth of the more than 170,000 tons used in the United States, and slightly less than one-half the amount used by the rest of the world. FCC demand is increasing about 5% per year. For the time being, however, the catalyst industry has significant overcapacity.

The most recent entry into the European FCC market was Union Carbide Corp., which acquired the Dutch-based Katalistiks Co. In 1983, Katalistiks started up a 60,000- to 80,000-ton-per-year plant in Savannah, GA, to add to its Dutch capacity. With this purchase, Union Carbide is now active in both the European and the U.S. markets.

This market is increasingly becoming internationally competitive. In addition to Katalistiks' move into the United States, Akzo Zout Chemie Nederland BV is building an FCC plant in Houston, with about 45,000 tons per year of capacity, scheduled to begin operating in 1985. Akzo also has just announced plans to build another FCC plant of 25,000 tons capacity in Brazil.

In those European countries where there are no regulations limiting phosphate use in detergents, zeolites remain the chemicals of choice. One of the key points is relative cost. If zeolites can be incorporated into a product on a sound economic basis, they will be attractive to the soap industry. On a 100% dry basis, zeolites cost about 37 cents per kilogram in Europe, and phosphates cost 55 to 63 cents per kilogram. However, relatively more zeolite is used for a given formulation, and transportation costs mount up quickly, a disincentive unless the detergent plant is near a source of zeolites.

Adsorbent zeolites have the most stable, mature market of all zeolites. The outlet as desiccants and adsorbents is probably the oldest for zeolites. Just as in the United States, this market is the smallest of Europe's three major markets for zeolites. In the United States, about 80% of this portion of the market is for desiccants, with the remaining 20% going for adsorbent applications. In Europe, however, adsorbent uses predominate.

Despite the existing overcapacity, the West German chemical company Degussa AG announced plans to expand production capacity for its MS 440 zeolite molecular sieve at the end of 1985 at the company's plant at Wesseling, near Cologne. The plant will supply European manufacturers of insulating glass. Also, Yugoslavia's first zeolite production facility will shortly come onstream at the Birac alumina factory in Zvornik. The plant will produce about 60,000 tons per year of zeolite, which will be used to replace sodium tripolyphosphate in the manufacture of detergents.

TECHNOLOGY

The Harshaw/Filtrol Partnership, formed in late 1983 by combining the assets of Harshaw Chemical Co. and the Filtrol Corp., is now marketing a new product that is more effective in decolorizing cooking oil. This new product is a blend of a bleaching earth clay with magnesium-lanthanum exchanged Y-zeolite. The effect of this zeolite addition is to remove free fatty acids from bleached vegetable oil while retaining the decolorizing efficiency for removing pigments.[23]

The Xorbox Div. of Greene & Kellogg Inc. announced new small tonnage systems with a single zeolite adsorbent bed for oxygen generation for industrial applications. They are designed to produce the oxygen purity, flow rates, and pressures best suited for a variety of applications.[24] These five systems range in capacity from 2,000 to 40,000 standard cubic feet per hour. Assembly and startup of the plant, which is said to require only minimal attention from plant personnel, reportedly can be accomplished in less than 3 days.

The systems, which were developed by Xorbox with support from the Gas Research Institute to provide sources of low-cost oxygen in small-to-moderate volumes, will be tested on a glass-melting furnace at Ford Motor Co.'s Glass Div., Nashville, TN, plant. the use of oxygen from the generator to enrich gas-fire combustion is expected to increase both the energy efficiency of the melting process by up to 20% and the product output by up to 40%.

The many applications of zeolites, with particular reference to the Mobil Oil Corp.'s ZSM-5 catalyst, have been reviewed.[25] The application of zeolites as catalysts came some years after industry put the other zeolitic properties to use. The economic impact of zeolites as catalysts, however, dwarfs these large-volume applications. The catalytic properties of zeolites and their potential usefulness to the petrochemical processing industry were unrecognized until Mobil scientists began to study these minerals. Their work led, in 1962, to the first commercial application of a catalytic zeolite, cracking heavy crude petroleum fractions.

The cracking catalyst patented by Mobil has provided refiners with the capability to produce 20% more gasoline from a barrel of crude. Today, 90% of the refineries in market economy countries use this technology. Of all the shape-selective zeolites synthesized for catalytic applications, the most versatile so far is Mobil's proprietary zeolite ZSM-5 catalyst, which possesses the following desirable properties: catalytic activity that may be tailored for a given reaction, exceptionally long life, and a shape-selective pore system that enhances the yield of wanted products while reducing the yield of unwanted products.

A recent application is a ZSM-5 cracking catalyst that provides refiners with a method to provide higher octane, lead-free gasoline. The ZSM-5 chemistry also is at the heart of the methanol-to-gasoline (MTG) process that catalytically converts methanol to high-octane gasoline.

In the short span of 10 years, 10 diverse ZSM-5 catalyst processes have been identified and developed. Five of these have been scaled up and are operating commercially in 35 reactors throughout the world. Several of the remaining five are on the threshold of commercial reality.

An improved version of the ZSM-5 catalyst was reported.[26] Higher MTG yields are possible with an asbestos-based catalyst, according to research at Concordia University (Montreal, Canada). By crystallizing zeolite ZSM-5 on asbestos fibers, a mixed catalyst is obtained that increases product selectively. In tests, olefin production is raised from 10% to 15% (for pure ZSM-5) to almost 60%, while paraffin generation is cut from 45% to less than 5%. The concentration of aromatic liquids produced is about the same (40%) with both catalysts.

Zeolite substitutes continue to be a subject of interest. A British magazine speculates that zeolites leading position may now be threatened by an even more adaptable family of chemicals—pillared clays.[27] The clays could prove to be very inexpensive. The family of minerals from which they are made, smectite, is found in large deposits. Depending on the purity of the raw material, however, pillared clays may require significant processing, and the production costs would probably be similar to those of zeolites.

Refining the heavier fractions of oil is the largest potential market for pillared clays; however, a serious drawback must be overcome. At present, pillared clays cannot be reused, because the heat and water needed to reactivate them results in the collapse of the pillars.

Another product that was a direct outgrowth of zeolite research has reached the commercial stage.[28] Union Carbide has opened a facility in Mobile, AL, for the commercial manufacture of its newly developed molecular sieves. The sieves, made of aluminophosphate and silicoaluminophosphate, have a microporous crystalline structure that enables them to adsorb impurities from liquids and gases and to separate gases of different molecular size.

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[1]Prepared by Wilton Johnson, mineral specialist.
[2]Prepared by James P. Searls, physical scientist.
[3]Prepared by Sarkis G. Ampian, physical scientist.
[4]Prepared by John E. Ferrell, physical scientist.
[5]National Materials Advisory Board. Quartz for the National Defense Stockpile. Natl. Acad. Sci., Washington, DC, NMAB-424, Jan. 1985, 99 pp.
[6]Work cited in footnote 5.
[7]Prepared by Harold A. Taylor, Jr., physical scientist.
[8]Prepared by John E. Ferrell, physical scientist.
[9]Nova Scotia Department of Mines and Energy. Invitation to Tender. Mineral Development Property, Macrae Celestite Deposit, Enon, Nova Scotia, Canada. Oct. 1984.
[10]Chemical Marketing Reporter. Kali-Chemie Plans To Expand Barium, Strontium Carbonate; Higher Exports to U.S. Are Seen. V. 26, No. 6, Aug. 6, 1984, pp. 5 and 29.
[11]Latin American Mining Letter (London). Mexican Firm To Produce Strontium Carbonate. V. 4, No. 5, Mar. 6, 1985, p. 4.

[12]Prepared by Michael J. Potter, physical scientist.

[13]Herod, S. NYCO Strengthens Operation With New Mine, Crushing Plant. Pit & Quarry, v. 76, No. 12, June 1984, pp. 36, 38, and 40.

[14]Huang, Z. W. The Geology of Industrial Minerals and Rocks in China. Paper in Ontario Geological Survey Miscellaneous Paper 114, ed. by S. E. Yundt (19th Forum on the Geology of Industrial Minerals Proceedings). Ministry of Natural Resources, Ontario, Canada, 1983, p. 179.

[15]Choate, L. W. Wollastonite. Min. Eng., v. 36, No. 5, May 1984, p. 537.

[16]Prepared by Robert A. Clifton, physical scientist.

[17]Eyde, D. T., and E. H. Eyde. Natural Zeolites. What's the Score? Proceedings of the 6th Industrial Minerals International Conference, Toronto, 1984. Met. Bull., pp. DTE 1-6.

[18]de' Genero, M., C. Colello, R. Aiello, and E. Franco. Italian Zeolites 2. Mineralogical and Technical Features of Campanian Tuff. Ind Miner. (London), No. 204, Sept. 1984, pp. 97-109.

[19]Leader Call (Laurel, MS). New Mineral for Catfish. Aug. 1, 1984, commodity section.

[20]Layman, P. L. Brisk Detergent Activity Changes Picture for Chemical Suppliers. Chem. & Eng. News, v. 62, No. 4, Jan. 23, 1984, pp. 17-35.

[21]Mining Magazine (London). Industrial Minerals Production in Hungary. V. 150, No. 3, Mar. 1984, pp. 193-194.

[22]Layman, P. L. European Zeolite Makers Bank on Catalysts, Detergents. Chem. & Eng. News, v. 62, No. 28, July 9, 1984, pp. 14-15.

[23]Industrial Minerals (London). Zeolite in Bleaching Earth. No. 202, July 1984, p. 17.

[24]Glass Industry. Oxygen Generation. V. 65, No. 12, Dec. 1984, pp. 8-10.

[25]Meisel, S. Multifarious Uses of Synthetic Zeolites. Eur. Chem. News Process Rev., Nov. 1984, pp. 22 and 27.

[26]Chemical Engineering. Chementator. V. 91, No. 9, Apr. 30, 1984, p. 17.

[27]The Economist (London). Catalysts. Clays Rebound. V. 290, No. 7330, Feb. 25, 1984, p. 85.

[28]Chemical Engineering. Companies. V. 91, No. 16, Aug. 6, 1984, p. 34.

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